APPENDIX 1

Summary
(OMB Fact Sheet)

Summary (OMB Fact Sheet)

Summary Watershed Project Plan-Environmental Assessment Document
for
Lower Grand River Watershed
Kent County, Michigan

Congressional District MI-03

Authorization: Public Law 83-566 Stat. 666 as amended (16 U.SC. Section 1001 et. Seq.) 1954
Sponsor: City of Grand Rapids

Proposed Action: Improve aquatic habitat in the Lower Grand River where it flows through downtown Grand Rapids, Kent County, Michigan.

Purpose and Need for Action: The purpose of the proposed Project, which aligns with Watershed Protection (NWPM 500.3B(ii)), is to restore the rapids in the lower reach of the Grand River (300 feet upstream of Bridge Street to Fulton Street), improve public safety, restore aquatic habitat diversity and suitability for native Great Lakes fish and mussel species, and enhance river access and use. The need for the proposed Project action arises from the degraded condition of the river, including construction of low-head dams and removal of natural substrate, which impacts native and listed species of fish and mussels, and alters habitat. Four low-head dams were constructed circa 1927 downstream of the 6th Street Dam to maintain channel width during low flow periods to prevent concentration of the raw sewage that was discharged into the river in that era. The original purpose of these dams is no longer relevant in the context of healthy river ecology, and raw sewage is no longer discharged to the river from the City of Grand Rapids.

Description of the preferred alternative/plan: Primary factors in the selection of the Preferred Alternative were that it met the project's purpose and needs by addressing river and habitat degradation, restoring beneficial habitat to TES species, and removing or reducing dam safety concerns, while minimizing effects. The new design will result in improved aquatic habitat; removal of the safety risks caused by the four existing low-head dams; improved fish passage hydraulics. Thus, once constructed, the Project will have positive effects on regulated resources. The Preferred Alternative meets the Purpose and Need for the Project while providing the most environmental and social benefits.

Describe the number and kinds of project measures: Project measures include the following two practices: 1) Stream Habitat Improvement (395). Definition: Maintain, improve or restore physical, chemical and biological functions of a stream, and its associated riparian zone, necessary for meeting the life history requirements of desired aquatic species. Its purpose is to provide suitable habitat for desired aquatic species. This practice will be implemented on 7 acres within the project reach of the river, installation of boulder arches, constructed riffles, emergent habitat boulder fields, and bank vanes that will create more diverse habitat similar to the historic rapids; 2) Aquatic Organism Passage (396). Definition: Modification or removal of barriers that restrict or impede movement of aquatic organisms. Its purpose is to improve or provide passage for aquatic organisms. This practice will be used to remove four low-head dams and provide fish passage.

Resource Information:
Latitude and Longitude: Lat 42.968502, Long -85.675251
Eight-Digit Hydrologic Unit Number: 04050006

Climate and topography: The area has a predominantly humid continental climate, with very warm and humid summers, cold and snowy winters, and autumn and spring seasons that are quick but mild. Mean precipitation within the Grand River watershed is approximately 31 inches, whereas annual snowfall can range from as low as 30

inches to more than 100 inches, depending on proximity to the lake (Hanshue and Harrington, 2017). Based on records obtained from 1981 to 2010, the mean annual total precipitation and mean annual temperature within Grand Rapids are 38.1 inches and 48.5 degrees Fahrenheit (°F), respectively (GLISA 2018). The topography is influenced by glacial deposition of sediment and the effect of water deposition and drainage over time. Watershed topography is undulating and dissected by water courses with occasional small plains studded with bogs and small lakes. The watershed ranges from fairly rugged topography in the entrenched main stem of the Grand River (in the Grand Rapids area) to a low, flat plains area along the lower reaches of the river toward Grand Haven.

Watershed information: This project is within the lower, downstream section of the larger Grand River watershed, known as the Lower Grand River Watershed. The Grand River is Michigan's longest river, with a combined drainage area of 14,256 km2 (5,504 mi2). It begins in northern Hillsdale County as a series of lakes and ends at Grand Haven, Michigan, in Lake Michigan. Hanshue, S. K., and A. H. Harrington, 2017 (H&H, 2017) divided the river into five mainstem valley segments based on common channel and landscape features: headwaters, upper, middle, lower, and mouth segments (Figure 1). Ecological benefits from the Project will be realized throughout the Grand River watershed, specifically the segment downstream of the Project. Over 20% of Project benefits would accrue to agricultural areas as approximately 60% of the Grand River watershed from the Project Area downstream to Lake Michigan is agricultural land (including forested agricultural lands), and the proportion of agricultural lands in the upstream portion of the watershed is similar, if not higher (H&H, 2017)

Project Benefit Area – Land Use

Benefit Area	Use	Percentage	Area (acres)
Watershed Information	Project and Impact Watershed Areas, Combined	100%	483,450
	Downstream Impact Watershed	87%	422,970
	Project Impact Analysis Watershed	13%	60,480
Land Use	Agricultural/Forest	55%	233,090
	Open Land	1%	3,189
	Wetland	12%	47,127
	Water	9%	39,226
	Urban	23%	100,338
Land Ownership	Private	84%	
	State/Local	15%	
	Federal	1%	

Population and demographics: Within the Plan analysis watershed, population 182,463 – of which: 49% is male and 51% is female, 83% are White alone, not Hispanic or Latino, 10% African American, and 7% other nationalities, 90% are educated at a high school or college level, and 90% employment rate for those over the age of 16 years old.

Population Demographic Information

Demographic	City of Grand Rapids	Kent County	State of Michigan
Population	196,904	659,083	10,034,118
Median household income ($)	65,660	77,028	66,986
Percentage minority residents	38%	29%	27%
Percentage age 65 and over	18%	21%	25%
Median age	33.1	35.9	40.3
Percentage in poverty	15.8%	10.6%	13.4%
Unemployment rate[1]	3.1%	3.1%	4.0%
Top three industries by number of positions	1. Educational services / health care / social assistance 2. Manufacturing 3. Entertainment / visitor services		

Source: U.S. Bureau 2022

[1]Michigan Labor Market Information 2024

Relevant Potential Resource Concerns Identified through Scoping

Item / Concern	Rationale for Relevancy and Inclusion in Plan-EA
Aesthetics/Scenic beauty	Bankside clearing for river access associated with construction of cofferdam and instream work would reduce aesthetic value temporarily.
Air quality and noise	Direct impacts to air quality and noise from machinery emissions and airborne dust may slightly degrade air quality and increase ambient noise levels during construction activity. Indirect impacts to noise is expected to be concentrated around the Project Area. Indirect impacts on air quality are expected to be less than measurable and to be spread across the greater Grand Rapids metropolitan area,. Both would occur over a long period.
Threatened and endangered species (TES)	TES are present within the Project Area and therefore, analysis of effects is required by ESA.
Health and human safety	Dam hydraulics are safety risk.
Fishery habitat	In-stream work would affect habitat.
Shellfish bed habitat	In-stream work would affect habitat.
Water quality	Increased sedimentation, turbidity, and other water quality impacts are possible.
Invasive species	Sea lamprey are present and could potentially breach in-place barrier and access upstream portions of the watershed.
River flow	Removal of dams and installation of substrate enhancement materials would change hydraulics.
Fish Passage	In-stream work and change in hydraulics could potentially affect fish passage.
Land use, recreation, and visual resources	Dam removal and rapids restoration would alter recreation access and safety.
Wetlands	Wetland delineation survey confirms there are wetlands present within the Project Area.
Water and Riverine Resources	Sediment transport and flood control are potential concerns.
Soils & Geology	Soil erosion is a potential issue.
Terrestrial Vegetation and Wildlife	Proposed Project activities would potentially generate impacts to terrestrial vegetation and wildlife resources
Socioeconomics	Consideration of Project impact on overall economic benefits factor into decision making.
Cultural resources	SHPO and tribal consultation is being conducted as required by the National Historic Preservation Act (NHPA). Analysis of effects to cultural resources reflects the importance of local culture and national context.
Flood control and Protection	Dam removal and substrate enhancement would change river hydraulics. Ability of existing flood protection barriers currently protecting development along the riverbanks must not be negatively impacted.
Civil rights	Consideration of Project impact on civil rights issues factor into decision making.
Essential fish habitat	In-stream habitat restoration work will increase fish habitat.
Fish and wildlife (including coordination requirements)	Project coordination with state and federal agencies led to the development of the Biological Assessment and issuance by USFWS of the Biological Opinion.
National Economic Development (NED) P&G	As a non-water resource project, a NED is not required.
Natural areas	The in-stream habitat restoration will result in an increase in natural areas.
Riparian areas	Access to the river will be required to perform in-stream work and restored following implementation.
Waters of the United States, including special aquatic sites	In-stream project is not a special aquatic site, and permitting authority is under State of Michigan
Wild and scenic rivers	In-stream improvements take place within the Lower Grand River.

Alternative plans considered: Alternatives that did not align with the proposed Project purpose and need, would not likely meet fish passage requirements, involved other unacceptable environmental effects that would have prevented permitting, or were not feasible due to site constraints have been eliminated from detailed study and are not carried forward. Those alternatives included the removal of the low-head dams only; substrate

enhancement with no dam removal; restoration of original rapids to former natural conditions; and dam removal with substrate enhancement and whitewater recreation.

Briefly describe the components of each alternative: Alternatives considered for detailed study included the Proposed Action and a No Action Alternative. In the **Preferred Alternative**, the four dams would be removed. Hydraulic gradient would be controlled, fish passage improved, and aquatic habitat enhanced. Specific restoration activities include riverbed grading, installation of boulder arch structures, constructed riffles, emergent habitat boulder fields, and bank vanes. The **No Action Alternative** would leave the current conditions as they are. One alternative considered but subsequently eliminated from detailed study consisted of **removing the low-head dams only** and not adding any substrate to enhance habitat or distribute the hydraulic gradient. Removal of the four low-head dams would reduce or eliminate public safety hazards related to these features; however, without substrate enhancement, the removal of these features alone would not distribute the gradient of the reach in a controlled manner. Another alternative considered was to perform **substrate enhancement but not remove the low-head dams**. This alternative would not fully meet the purpose of enhancing habitat diversity, as the natural flow regimes disrupted by the existing low-head dams would remain disrupted. Another alternative that was considered but subsequently eliminated from further detailed study consisted of **fully restoring the original rapids to former natural conditions**. The river in downtown Grand Rapids is currently confined to an armored channel that is approximately half of its estimated natural width. In addition, major developments along both sides of the riverfront render an expansion of the current channel width infeasible. As such, this alternative is not feasible and was eliminated from further detailed study. The final alternative that was considered and eliminated was **dam removal with substrate enhancement and whitewater recreation**. Under this alternative, a series of four boulder drop structures with connected riffles were considered to control the hydraulic grade after dam removal with substrate enhancements between them. In addition, rock vanes along the edge of the channel would protect river access points. Of the total 31.5-acre project area, this option would affect 22 acres, nearly two-times the area of the preferred alternative.

Include mitigation measures: The project includes 0.01 acres of unavoidable wetland loss. This loss impact area is minimal and under the threshold typically requiring wetland mitigation. The low flow wetted area, flow diversity, and habitat diversity will be positively affected as a result of the Project. The project will result in more habitat; therefore, mitigation for instream impacts is not required. State and federal TES mussel species will be directly and indirectly affected along with other species of mussels not listed as threatened or endangered. A Biological Opinion was issued by USFWS, which outlines appropriate mitigation measures. As part of the proposed conservation measures, a mitigation fund would be established to offset the take for the mussels that were unable to be translocated under the USFWS Project. The objective of the mitigation fund would be to fund projects that provide a direct benefit to mussels to achieve the USFWS “no net loss” policy and offset any potential effects from mussels that were unable to be translocated. The work performed through the mitigation fund would help inform future conservation and habitat restoration efforts. On March 4, 2021, NRCS provided MI SHPO with an evaluation of the NRHP eligibility of the four low-head dams on the Lower Grand River Habitat Restoration Project, finding that the dams are eligible and will be adversely affected. SHPO asked that NRCS include input from local parties in their mitigation design, and public discussions of mitigation options and development of a mitigation plan have been completed. A Memorandum of Agreement (MOA) was developed to document the agreed upon mitigation measures and how each will be implemented.

Project Cost by Purpose

Works of Improvement	Number		Estimated Costs		
	Unit	Non-Federal Land	PL 83-566 Authority	Sponsor Funds	Total
			Non-Federal Land	Non-Federal Land	
Stream Habitat Improvement (395)	Acres	7	$7,113,132.27	$7,113,132,27	**$14,226,264.54**
Aquatic Organism Passage (396)	Number	4	$3,913,563.16	$3,913,563.16	**$7,827,126.32**
			$11,026,695.43	$11,026,695.43	**$22,053,390.86**

Project monetary benefits in terms categories shown in::

- 390-NWPM, Part 506, Subpart B, Section 506.19, "Economic Table 5—Estimated Average Annual Flood Damage Reduction Benefits" – N/A
- 390-NWPM, Part 506, Subpart B, Section 506.20, "Economic Table 5a—Estimated Average Annual Watershed Protection Damage Reduction Benefits" – N/A
- Number of direct beneficiaries (Onsite – Offsite): Improved habitat diversity and suitability over 2,756 feet and 30 acres of the Grand River; increased Great Lakes native fish and mussel diversity and productivity; protection of threatened and endangered fish and mussel species including the lake sturgeon, river redhorse, and snuffbox mussel; scour protection for the existing bridge structures.
- It was determined that no businesses would be adversely affected by restoration outcomes. Substantial development interest after construction was found (namely real estate developers) due to increased shoreline availability in close proximity to the river. These increases in business opportunities were found to mostly serve recreational users and monetary benefits associated with those were captured in monitization of recreational uses.

Describe other beneficial effects in physical terms - Implementation of the Preferred Alternative will restore the rapids by creating and restoring in-stream habitat in the Grand River. This effort would revitalize an approximately 2,756-foot stretch of the river flowing through the City of Grand Rapids by restoring aquatic connectivity and improving habitat for fish and aquatic life, including Michigan threatened and endangered species and the federally-listed endangered mussel *Epioblasma triquetra* (Snuffbox). Removal of the existing low-head dams will restore hydaulics in the river and alleviate many safety concerns.

Benefit to Cost Ratio (authorized rate) – N/A

Benefit to Cost Ratio (current rate) – N/A

Net beneficial effects (NED) – N/A

Funding schedule (budget year + 5)

Funding in FY 2024-2025 (10/1/2024 – 9/30/2025)	$11,026,695.43
Funding in FY 2025-2026 (10/1/2025 – 9/30/2026)	$11,026,695.43
Funding in FY 2026-2027 (10/1/2026 – 9/30/2027)	$0.00
Funding in FY 2027-2028 (10/1/2027 – 9/30/2028)	$0.00
Funding in FY 2028-2029 (10/1/2028 – 9/30/2029)	$0.00
	$ 22,053,390.86

Federal funds: $11,026,695.43
Non-Federal funds: $11,026,695.43

Period of analysis: The Period of Analysis represents the Project Life, anticipated at 50 years.

Environmental effects, impacts:

Environmental Effects and Impacts

Resource Area	Potential Unavoidable Adverse Impact of the Proposed Action
Air Quality and Noise	• Temporary increases in dust, combustion/exhaust pollutants, and noise during construction
Soils and Geology	• Temporary shallow soil disturbance by construction equipment and activities in staging areas and at the river banks
Water and Riverine Resources	• Temporary increase in bed mobility and downstream turbidity and sediment transport during construction
Wetlands	• Potential minor adverse impact on wetland communities from increased foot traffic and littering on wetlands adjacent to the river during the operational phase
Terrestrial Vegetation and Wildlife	• Temporary impacts on terrestrial wildlife from noise and vibration during construction • Damage to vegetation and wildlife through the planned removal of several trees during construction
Aquatic Species and Habitat	• Temporary impacts on both listed and other unionid mussel species during construction resulting from mussels being physically crushed as a result of machinery use and placement of substrates, and to a lesser extent from increased turbidity, shear stress or water velocity • Temporary impacts on fish species during construction as a result of physically crushing fish that are not able to easily escape during construction, temporary habitat loss, increased turbidity, and temporary loss of spawning areas
Floodplain Management	•Slight increases in water surface elevation for 2-year to 50-year flood events, but contained within the existing flood protection system
Land Use, Recreational and Visual Resources	• Temporary restrictions on river access for recreational use during construction • Temporary impairment of visual quality during construction
Socioeconomics	• Temporary hindrances to river-oriented activities could result in slightly fewer customers for businesses near the river during construction
Cultural Resources	• Removal of the low-head dams considered eligible for listing on the National Register of Historic Places (NRHP)--to be mitigated • No other impacts as currently proposed, but if the Project design changes to include grading in areas (and to depths) that may contain culture-bearing soil horizons, potential impacts could be mitigated through further testing, avoidance, and presence of a qualified archaeological monitor during construction activity
Public Health and Safety	• New hydraulic features would present different safety risks and new safety hazards
Urban Dynamics	• Increased congestion due to improved safety

Major conclusions: Only 1% of the river habitat in the lower peninsula of Michigan comprises rapid-type habitat, which is important to the life cycle of many aquatic species (Daugherty et al., 2009). Rapid-type habitat is defined as a river area with a relatively steep energy gradient (6% or more), coarse bed substrates, and non-uniform distribution of flow velocities. The ecosystem processes of the rapids-type habitat present within the project reach have been degraded by dams, channelization, dredging, and urban development for over 150 years. High gradient areas have been eliminated and fragmented in many Michigan watersheds and their rehabilitation is highly desirable (Dodge, 1998; Wesley, 2005).

Controversial Issues: None

Issues to be resolved: None

Evidence of Unusual Congressional or Local Interest: This effort is being viewed as a transformational project for the City of Grand Rapids and an asset to the region.

Watershed Program planning must comply with applicable Federal, State and local laws, regulations and Executive Orders. A complete list included below:

Applicable Regulation
Public Laws
Public Law 96-95, the Archaeological Resources Protection Act of 1979
The Clean Air Act (42 U.S.C. Sections 7401 to 7671q)
Public Law 92-500, the Clean Water Act, as amended
Public Law 92-583, the Coastal Zone Management Act of 1972, as amended
Public Law 104-231, the Electronic Freedom of Information Act Amendments of 1996
Public Law 93-205, the Endangered Species Act of 1973
Public Law 97-98, the Farmland Protection Policy Act of 1981, as Amended (FPPA)(7 U.S.C. Section 4201 et seq.)
Public Law 104-127, the Federal Agriculture Improvement and Reform Act of 1996
Title 33, U.S. Code, Chapter 15, Section 701b-11, "Flood protection projects navigation and navigable waters"
Public Law 101-624, the Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA)
Public Law 99-198, the Food Security Act of 1985 (FSA)
Public Law 89-487, the Freedom of Information Act of 1966
Public Law 93-502, the Freedom of Information Act, as amended in 1974
Public Law 99-570, the Freedom of Information Reform Act of 1986
Public Law 94-265, the Magnuson-Stevens Fishery Conservation and Management Act
The Migratory Bird Treaty Act of 1918 (16 U.S.C. Sections 703 to 712, 40 Stat. Section 755)
Public Law 91-190, the National Environmental Policy Act of 1969 (NEPA)
Public Law 89-665, the National Historic Preservation Act of 1966 (NHPA), as amended
The Protection of Bald and Golden Eagles Act of 1940 (16 U.S.C. Sections 668a to d, 54 Stat. Section 250)
Public Law 86-523, the Reservoir Salvage Act of 1960
The Rivers and Harbors Act of 1899 (33 U.S.C. Section 403, 30 Stat. Section 1121)
Public Law 95-192, the Soil and Water Resources Conservation Act of 1977
Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. Section 4601 et seq.)
Public Law 90-542, the Wild and Scenic Rivers Act of 1968
Public Law 101-601, the Native American Graves Protection and Repatriation Act
Code of Federal Regulations
7 CFR Part 622, "Watershed Projects"
7 CFR Part 650, "Compliance with NEPA"
7 CFR Part 3015, "Uniform Federal Assistance Regulations"
36 CFR Part 800, "Protection of Historic Properties"

Executive Orders, Secretarial Orders, and Presidential Memoranda
EO 10913, amending EO 10584, Prescribing rules and regulations relating to the administration of the Watershed Protection and Flood Prevention Act
EO 11514, Protection and Enhancement of Environmental Quality
EO 11747, Delegating Certain Authority of the President Under the Water Resources Planning Act, as amended
EO 11988, Floodplain Management
EO 11990, Protection of Wetlands
EO 12322, Water Resources Projects
EO 12372, Intergovernmental Review of Federal Programs
EO 12962, Recreational Fisheries
EO 13007, Indian Sacred Sites
EO 13045, Protection of Children from Environmental Health Risks and Safety Risks
EO 13089, Coral Reef Protection
EO 13112, Invasive Species
EO 13175, Consultation and Coordination with Tribal Governments
EO 13186, Responsibilities of Federal Agencies to Protect Migratory Birds
EO 13287, Preserve America
Secretarial Order 3206, American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act
Presidential Memorandum, Government-to-Government Relations with Native American Tribal Governments (April 29, 1994)
Presidential Memorandum, Tribal Consultation (November 5, 2009)
Presidential Memorandum (M-16-01), Incorporating Ecosystem Services into Federal Decision Making (October 7, 2015)
NRCS Policy
Title 120, General Manual (GM), Part 404, “Land Treatment Long-Term Contracting”
Title 180-GM, Part 409, “Conservation Planning Policy”
Title 190-GM, Part 410, “Compliance with NEPA”
Title 400-GM, Part 400, “Public Participation Policy”
Title 410-GM, Part 405, “American Indians and Alaska Natives”
Title 420-GM, Part 401, “Cultural Resources (Archeological and Historic Properties)”
Title 440-GM, Part 401, “Providing Services to State and Local Government”
USDA Regulations
DR 1350-001, “Tribal Consultation” (2008)
DR 1340-007, “Policies on American Indians and Alaska Natives” (2008)
DR 9500-013, “Conducting Analyses under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies” (2016)

APPENDIX A

Public Plan, Summary, Comments and Responses

- Public Outreach Plan, Summary and Comments
  - Public Participation Plan
  - Lower Grand River Watershed Project Plan Comments
  - NRCS Public Comment Presentation
- Presentations and Tours Tracking Sheet
- Memorandum for Record_Redacted, June 2024
- SHPO Letter to NRCS; 1/18/2024
- RRO Response Letter to SHPO; 12/14/2023
- SHPO Letter to NRCS; 11/20/2023
- NRCS-Mi LGRWHR ER20-876 Section 106 Case Study-Updated 3-2-2022
- Final Mitigation Plan GRWW 102621
- SHPO Letter of Concurrence with Adverse Effect; 03/23/2021
- SHPO Letter to NRCS; 12/17/2020
- June 2020 NRCS submission to SHPO that includes, including 2018 Project Field View Summary - redacted
- Initial Tribal Consultation Letter – 07-03-2019

APPENDIX A

Public Plan, Summary, Comments and Responses

Public Outreach Plan, Summary & Comments

PUBLIC PARTICIPATION PLAN

INTRODUCTION

The purpose of the Public Participation Plan (PPP) is to outline methods for encouraging the involvement of citizens, organizations and other interested parties in the development of the Grand Rapids Watershed Project Plan (WPP). The objective of this PPP is to:

1. To create awareness among the public about the rapids restoration project and alternatives considered.
2. To educate the public about the purpose and need for the draft Grand River WPP goals and objectives.
3. To establish a process which encourages members of the public and other interested parties to participate in the development of the Grand River WPP.
4. To ensure all interested stakeholders can review and comment on the draft Grand River WPP.

PUBLIC PARTICIPATION EVENTS

Public participation events will be hosted in three (3) locations within the project area to provide opportunities for the public to obtain information, ask questions, and express any concerns they may have regarding the proposed project. These events may include community/business forums, public meetings or other scheduled community events such as farmer's markets. Any concerns brought forth through this process will be noted in the WPP and addressed as necessary.

ADVERTISEMENT OF PPP EVENTS

The public and other interested parties will be notified of the WPP and the PPP events using one or more of the following tools:

- Printed Information – Printed flyers about the WPP and the PPP event dates.
- Web Sites – Information about the WPP and the PPP event dates will be made available for existing websites and online calendars.
- Social Media – Information about the WPP and the PPP event dates will be made available for use on Twitter, Facebook, Instagram or other social media outlets.
- Press and Media – Information about the WPP and the PPP event dates will be provided to local press and media for print, radio or online dissemination.

The above tools will be used for distribution of notices through partner and stakeholder agencies and organizations including, but not limited to:

- Grand Valley Metro Council
- City of Grand Rapids
- Grand Rapids White Water
- West Michigan Environmental Action Council
- West Michigan Sustainable Business

- Grand Rapids Public Library
- West Grand Neighborhood Organization
- Grand Rapids Community Foundation
- Lower Grand River Organization of Watersheds
- Grand Rapids Press
- The Grand Rapids Times
- MLive.com
- Radio: WBLU, WYCE, WGRD, WFGR

PPP EVENT ENGAGEMENT TOOLS

An Open House format will be used to introduce the purpose and need for the WPP, introduce the rapids restoration project, and offer opportunities to ask questions and express concerns. Content will be focused around the following four aspects of the project.

- Physical
- Biological
- Economical
- Social

PPP OUTCOMES

The questions and concerns received through the public participation events will be documented for WPP planning efforts. Additional information documented for each public participation event will include the date, type and purpose of the activity, as well as the names of the participating organizations and the public. Questions and concerns received at the events will be used to focus the scope of the WPP, and specific concerns will be addressed in the WPP.

Lower Grand River Watershed Project Plan Comments

Date of Event	Citizen or Organization	Name:	Comments
9/18/18	Citizen	Vern Jones	Very informative! Love this Project, Thanks.
9/18/18	Citizen	Irene Jones	Great info…
9/18/18	Citizen	Anne Larson	Great information! Spoken so we could understand. Thank you.
9/18/18	Citizen	Megan Blauwkamp	Wish there was more time for questions and open discussion.
9/18/18	Citizen	Jan Erlewein	Great information! Thank you.
9/18/18	Citizen	Jody Ringnalda	Very informative! I appreciate the invitation to this lunch and learn!
9/18/18	Citizen	Wanita Provenzo	Information provided on the numerous organizations involved and what involvement they provide/provided was great
9/18/18	Organization	Family Futures	I've heard about this project for years as a resident. I am very excited for it!
9/18/18	Citizen	JR Vidro	Restoration of habitat for mussels-good thing. Won't that basically get wiped out once there are thousands of people in the river stiring them up/harvesting?
9/18/18	Organization	Family Futures	I personally like the education aspect and the environmental aspects of this project. As far as the recreational aspect, I think there needs to be something done to break the stigma of the "dirty river". I'm sure you have something planned for this, but I feel this is needed. In addition, I think the recreational aspects (as well as the activities in the river and the activities done ont he edges of the river) will be a great asset to Grand Rapids. I am excited to see this project succeed.
9/18/18	Citizen		Very intersting; especially all the research that is taking place to ensure safety of endanagered species; very important to share this info with as may residents as possible to eliminate misconceptions based on "hear-say"
9/18/18	Anonymous		The presentation was very informative, but I think there should be more time left at the end for the community to ask questions they may have
9/18/18	Anonymous		I thought the presentation was very informative. I hope the project can go forward without opposition
9/18/18	Citizen	Jessa Challa	Thoughts-valuing the rapids and connecting to the community; why is this project important to connect the communty? How will it impact the westside of the river and the community there? How will the project include current residence and our diversity? Is there information provided in Spanish? Rerouting the Dash or the Rapid bus systems to include lower income communities? Public restrooms? Having core values will lead the community to value the rpaids and lead to valuing the environment, leading to the community being more self-aware of its impact on the environment. THis project needs to value every aspect and demographic of its community in order for its community to value it.
9/28/18	Organization	John Gebhart	I don't know much of the end project short of putting the rapids back, but I am excited for the project and anything that makes Grand Rapids a better palce to live for my kids and bring in additional income
11/1/18	Organization	Mathison Architects	Very excited for the new opportunities to engage with the river, one of our greatest resources in this area
12/31/18	Citizen	Nikki Macedo	I was at a community event and saw the project boards (ex. Tour on farmers market)
2/15/19	Citizen	Sandra Sanders	I was at a community event and saw the project boards (ex. Tour on farmers market)
9/12/19	Citizen		I was at a community event and saw the project boards (ex. Tour on farmers market)
9/12/19	Citizen		Excited to see the change. I was at a community event and saw the project boards (ex. Tour on farmers market)
9/14/19	Citizen		I was at a presentation about the project (ex. Business forum, meeting or public meeting)
9/14/19	Citizen		I was at a presentation about the project (ex. Business forum, meeting or public meeting)
9/14/19	Citizen		I was at a community event and saw the project boards (ex. Tour on farmers market)
9/14/19	Citizen		I was at a community event and saw the project boards (ex. Tour on farmers market)
9/14/19	Citizen	Joey Parks	I was at a community event and saw the project boards (ex. Tour on farmers market)

Lower Grand River Watershed Project Plan Comments

Date of Event	Citizen or Organization	Name:	Comments
9/14/19	Citizen	Jenny Ferrell	I was at a community event and saw the project boards (ex. Tour on farmers market)
9/14/19	Citizen		I was at a community event and saw the project boards (ex. Tour on farmers market)
9/15/19	Citizen		I'm very concerned about the safety of water contact with the Grand River. The highly contaminated Rouge River empties into the Grand just North of the restoration proejct. Known to contain unsafe levels of PFAS, this must be affecting the Grand as well. No one maskes body contact with the Grand at this time. People used to swim and tube in the Grand. Contamination is the reason they don't. Returning to the river to it's roots with rapids is great but what will be done to mitigate the current contamination and make it swimmable? I was at a community event and saw the project boards (ex. Tour on farmers market)
9/15/19	Citizen	Joe Simon	I was at a presentation about the project (ex. Business forum, meeting or public meeting)
9/15/19	Citizen		I was at a community event and saw the project boards (ex. Tour on farmers market)

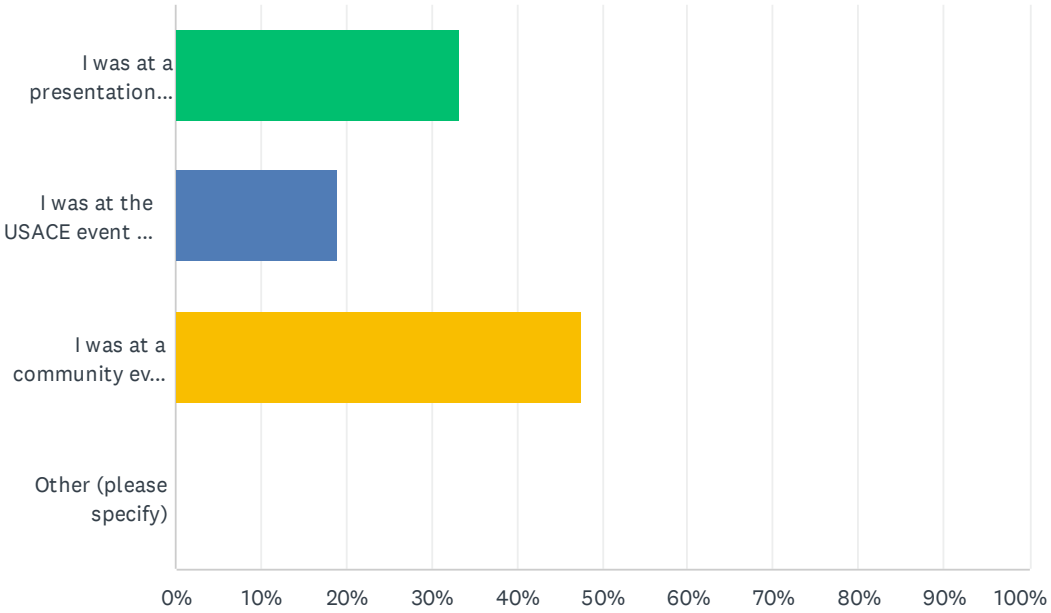
Q1 Please leave any questions, concerns or comments for us on the Lower Grand River Watershed Project Plan. We are eager to get your feedback!

Answered: 9 Skipped: 12

#	RESPONSES	DATE
1	Nice progress so far	9/15/2019 8:48 AM
2	I'm very concerned about the safety of water contact with the Grand River. The highly contaminated Rogue River empties into the Grand just North of the restoration project. Known to contain unsafe levels of PFAS, this must be affecting the Grand as well. No one makes body contact with the Grand at this time. People used to swim and tube in the Grand. Contamination is the reason they don't. Returning the river to it's roots with rapids is great but what will be done to mitigate the current contamination and make it swimmable?	9/15/2019 8:43 AM
3	Excited to see the change!	9/14/2019 8:31 AM
4	No comments at this time.	2/15/2019 9:52 AM
5	In addition to removing the dam(s) (or not) - is there another alternative?	12/31/2018 2:24 PM
6	Very Excited for the new opportunities to engage with the river, one of our greatest resources in this area.	11/1/2018 1:36 PM
7	I don't know much of the end project short of putting the rapids back, but I'm excited for the project and anything that makes Grand Rapids a better place to live for my kids and bring in additional income.	9/28/2018 9:02 AM
8	The presentation was very informative, but I think there should be more time left at the end for the community to ask questions that they have.	9/18/2018 1:19 PM
9	I thought the presentation was very informative. I hope the project can go forward without opposition.	9/18/2018 1:16 PM

Q2 Where did you learn about the Lower Grand River Watershed Project Plan?

Answered: 21 Skipped: 0



ANSWER CHOICES	RESPONSES	
I was at a presentation about the project (example: business forum, meeting or public meeting)	33.33%	7
I was at the USACE event on April 8, 2019 and saw the project boards	19.05%	4
I was at a community event and saw the project boards (example: farmers market or tour)	47.62%	10
Other (please specify)	0.00%	0
TOTAL		21

#	OTHER (PLEASE SPECIFY)	DATE
	There are no responses.	

NRCS Public Comment Presentation

10/3/22

Participant Id	Full Name	Role
Kaila.Akina@glt-nsn.gov	Kaila Akina	Attendee
Tyler.Jennifer@epa.gov	Tyler, Jennifer (Blonn)	Attendee
cfreiburger@glfc.org	Chris Freiburger	Attendee
tim.redder@usda.gov	Redder, Tim - FPAC-NRCS, East Lansing, MI	Event Team Member
courtney.cromley@gvmc.org	Courtney Marek	Attendee
dan.zay@usda.gov	Zay, Daniel - NRCS, East Lansing, MI	Event Team Member
tlewandowski@ectinc.com	Tonya M. Lewandowski	Event Team Member
matt@grandrapidswhitewater.org	Matt Chapman	Event Team Member
jacquie.payette@erm.com	Jacquie Payette	Event Team Member
edelong@grand-rapids.mi.us	DeLong, Eric	Attendee
pete_hrodey@fws.gov	Hrodey, Peter	Attendee
Kaila.Akina@glt-nsn.gov	Kaila Akina	Attendee
LWalter@glfc.org	Lisa Walter	Attendee
edward.quates@usda.gov	Quates, Edward - NRCS, East Lansing, MI	Attendee
MatousekB@michigan.gov	Matousek, Bethany (EGLE)	Attendee
mstaal@grand-rapids.mi.us	Staal, Michael	Attendee
cadkins@grand-rapids.mi.us	Adkins, Ciarra	Attendee
jsteffen@grand-rapids.mi.us	Steffen, Jay	Attendee
nicholas.williams@usda.gov	Williams, Nicholas - NRCS, East Lansing, MI	Attendee
deckerc@gvmc.org	Cara Decker	Attendee
Elizabeth.Binoniemi-Smith@glt-nsn.gov	Liz Binoniemi-Smith	Attendee
Lakota.Hobia@glt-nsn.gov	Lakota Hobia	Attendee
dgreen@grand-rapids.mi.us	Green, David	Attendee
melissa.gutierrez@usda.gov	Gutierrez, Melissa - NRCS, East Lansing, MI	Attendee
tburkman@grand-rapids.mi.us	Burkman, Tim	Attendee
jessica_barber@fws.gov	Barber, Jessica (Jess)	Attendee
dgreen@grand-rapids.mi.us	Green, David	Attendee

APPENDIX A

Public Plan, Summary, Comments and Responses

Presentations & Tours Tracking Sheet

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
9/27/13	Forest Hills Eastern Middle School	Classroom Presentation/Watershed Module	4 classes, 6-8th graders	90
10/23/13	City GR Development Center	Design Team Meeting/Project update	City Planners, Engineers, etc.	12
10/24/13	Rockford Construction	State Agencies Project update	State Department heads	35
10/29/13	City Hall Conference Room	Commission 3-on-1 meetings	City Commissioners	12
10/30/13	Rockford Construction	Urban Waters Federal Partnership/Technical meeting	Federal Agencies	50
11/6/13	Riverfront Hotel Banquet Room	Michigan Society of Professional Engineers Monthly Luncheon	Engineers	40
11/8/13	DeVos Building, GVSU Downtown	Place-Based Education Conference Speaker	Educators	25
12/12/13	Rockford Construction	Great Lakes Fisheries Commission/Project update	GLFC Staff	3
12/12/13	Rockford Construction	UMMM/Local Officials' awareness of project	Urban Mayors and Managers, Township Supervisors	40
1/10/14	City of GR Commission Chambers	Department head meeting/project update	City Department Heads	35
1/21/14	MSU Secchia Center	MSU Facilities and Planners/land use	MSU Project Admin	10
1/23/14	GVSU - Allendale	Classroom Presentation/ideas for student research projects	Aquatic Ecology Class	24
2/28/14	Kent County Commission Chambers	Project update and riverfront property use discussion	Kent County Commissioners	
4/2/14	University Club	West Michigan Environmental Leaders Network/ Gain project support from environmental leaders	Environmental Leaders in West Michigan	40
5/1/14	Washington D.C			
5/2/14	Grand Rapids Public Museum	LGROW Spring Forum/Project Update	LGROW	75
5/6/14	Grand Rapids Public Museum	International Downtown Association Midwest Urban District Forum	Conference attendees from the Midwest	25
5/8/14	House BBQ	Sail and Power Squadron Meeting	Boaters from Grand Rapids Area	30
5/22/14	Old Public Museum	Share about history and aquatic life of rapids	Students in Public Museum Exhibit Development Program	23
6/10/14	Grand Rapids City Commission	City Commission Resolution of Support for Grand Rapids Whitewater	Grand Rapids City Commissioners and public in attendance	30

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
6/11/14	GVSU - Siedman & bus Tour	Grand River Corridor Plan Steering Committee Meeting	Grand River Corridor Plan Steering Committee	60
6/12/14		Rowers Meeting	Board Meeting of Grand Rapids Rowing Association	10
6/19/14	West Michigan Environmental Action Office Building	West Michigan Environmental Action Council Board Meeting	West Michigan Environmental Action Council Board	15
6/21/14	Outdoor Music and Beer Festival in Grand Rapids	Founders Fest	talked one on one with people about the project using banner	100
6/25/14	Barnes and Thornburg LLP	West Michigan Ladies Environmental Tea Meeting	Women in the environmental field	30
9/9/14	DeVos Building Healing our Water Conference	Transforming your River into Main Street Conference Session		
9/10/14	DeVos Building Healing our Water Conference	Plenary Session HOW Conference	Conference Attendees	150
9/13/14	Outdoor Chili and Beer Festival	Cottage Bar Chili Cook-off	brief introduction of the project to people in attendance at Cottage Bar Cook-off; talked one on one with people about the project using banner	200
9/17/14	Trinity Lutheran Church	Joyful Days Speaker Series	Church members, mostly retired community	50
11/17/14		West- Grand Community Meetings, Forward Process		8
11/20/14	Seidman College of Business GVSU	River Restoration, River Corridor, and Downtown Plan Steering Committees		100
11/24/14	GR Steelheaders	River Restoration, River Corridor, and Forward	GRSteelheaders Chapter Members	40
12/3/14	Residence Inn Arlington, VA	UWFP		40
12/9/14	Cornerstone Church	Heritage Hill Neighborhood Meeting, Forward Process		15

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
12/16/14	Cook Library	GR Forward presentation at Grandville Avenue Arts & Humanities (GAAH) Parent Meeting		30
1/13/15	GR Steelheaders	River Restoration	Steve Heintzelman, Bob Strek and Nate ?	3
6/29/15	GR Steelheaders Monthly Meeting	River Restoration, River Corridor and GR Forward	GR Steelheaders Chapter Members	40
9/8/15	Belknap Commons	Neighbors of Belknap Lookout GR Forward Draft Plan Review	Neighborhood meeting	
9/17/15	Fettig (265 Leonard)	Fettig Open House	Business Clients, Staff, Community Members	75
9/17/15	Cornerstone Church	Heritage Hill GR Forward Draft Plan Review	Neighborhood meeting	12
9/22/15	Riverside Middle School	Creston Neighborhood GR Forward Draft Plan Review	Neighborhood meeting	5
9/23/15	Sibley Elementary	JBAN/SWAN/West Grand Neighborhoods GR Forward Draf Plan Review	Neighborhood meeting	14
9/29/15	United in Christ Ministries	Black Hills Neighborhood GR Forward Draft Plan Review	Neighborhood meeting	2
9/30/15	Forest Hills Eastern Middle School	Classroom Presentation/Watershed Module	6 classes, 6-8th graders	130
10/1/15	Planning Department	GR Forward Presentation	GR Rowing Club Members	20
10/1/15	City Development Center	GR Rowers GR Forward Draft Plan Review	Grand Rapids Rowing Association	11
10/6/15	Cook Library	GR Forward presentation at Grandville Avenue Arts & Humanities (GAAH) Parent Meeting	Neighborhood meeting	25
10/7/15	50 Monroe NW	GR Forward Presentation at ArtPrize Lounge	General Public	5
10/9/15	Monroe Community Church	North Monroe Business Association GR Forward Overview	Neighborhood meeting	15
10/13/15	Alliance for Investment	GRWW Update to Alliance members	Alliance for Investment Members	15
10/13/15	Planning Department	GRForward & GRWW Update to Rowers	GR Rowing Club Members	20
10/19/15	Lowell City Hall	City Commission meeting	City Commissioners, Department Heads, public	20

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
10/21/15	Cascade Twp. Library	Township Board Meeting	City Commissioners, Department Heads, public	12
10/27/15	Norton Shores City Hall	City Commission Meeting	City Commissioners, Department Heads, public	25
10/30/15	Downtown Market	Ft. Wayne Guest- GRWW/City Partnership Update	Members of Ft. Wayne city government & business community	45
11/2/15	Plainfield Township Hall	Township Board meeting	Board Members, Department Heads, Public	15
11/3/15	GVSU - Siedman	River Corridor Final Meeting	River Corridor Steering Committee Members	45
11/10/15	Varnum	Lunch & Learn	Staff	45
11/19/15	Kent County Commission Chambers	Special Order of Business	County Commissioners, staff from other departments, media, public	40
11/25/15	East Congregational Church	Golden K Kiwanis Club	Club members	35
12/2/15	Lansing Community College	MI Natural Resources Trust Fund	MNRF Board & Public	60
1/27/16	Westminster Presbyterian Church	Weekly Churchmen's Luncheon	Churchmen's Group	45
3/9/16	Grandville Banquet Center	Grandville/Jenison Chamber Meeting	Chamber Members	50
3/16/16	GVMC	UWFP Location Update	UWFP Members	35
3/17/16	GR Chamber of Commerce	Chamber Regional Issues	Chamber Members	15
4/7/16	GVMC	Eileen Boekestein's Class	Students	20
4/19/16	GRPM	Kent Garden Club Earth Day Lecture	General Public/Garden Club	30
5/1/16	Sunnybrook Country Club	Kenowa Ambucs	Ambucs members	25
5/6/16	Cascade Twp. Library	LGROW Spring Forum/Project Update	General Public	75
6/19/16	River Tour	Association of Flood Plane Managers Conf	Conference Attendees	50

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
6/20/16	River Tour	Association of Flood Plane Managers Conf	Conference Attendees	40
6/22/16	DeVos Place	Association of Flood Plane Managers Conf	Conference Attendees	45
6/30/16	Pierce Cedar Creek Institute	Ecological Effects of Dam Removal	Students/General Public	75
7/12/16	Ludington State Park	Great Lakes Fishery Trust SAT Meeting	GLFT SAT Members	15
7/13/16	Frey Foundation	Presentation to local funders	Steve Wilson, Julie Ridenoure, Kate Schmidt, Mark Van Putten	5
7/13/16	MDNR Lansing Office	Presentation to Acting Director Moritz	Director Moritz, Jay Wesley, Chief Dexter	4
8/4/16	GRPM	Groundswell Summer Institute	Teachers	30
8/14/16	GRPM	River City Wild Ones	Club members	25
8/24/16	GRFD	Project Briefing w/ FD Leadership	GRFD Leadership	5
8/24/16	GRPD	Project Briefing w/ PD Leadership	GRPD Leadership	4
9/10/16	Gillette Bridge	Tribute on the Grand Dinner	Tribute On the Grand Guests	344
9/17/16	Cottage Bar	Chili Cook Off	General Public	75
9/28/16	Fish Ladder	LA Ride	LA Ride participants	30
9/30/16	Forest Hills Eastern Middle School	River Day	Students	100
10/3/16	GVSU - Siedman	RPI Community Forum	General Public	110
10/6/16	Forest Hills Eastern Middle School	River Day	Students	100
10/13/16	OtherWay Ministries	West Fulton Business Association	Business Association Members	25
10/25/16	Grove	West Michigan Environmental Leaders Network/ Gain project support from environmental leaders	Members	30
10/25/16	Rockford Brewery	Rouge River Partners	General Public/Members	30
10/26/16	GVSU Allendale	Environmental Science Class	Students	15

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
11/3/16	GVMC	Senator Peters Staff Update	Senator's staff	5
11/7/16	KDL-Comstock Park	Community Presentations	General Public	30
11/9/16	Kendall College of art & Design	Career Symposium	Kendall Design Students	25
11/28/16	St. Alphansus Church	Senior Lunch Group	Church Senior Group	20
11/30/16	GVMC	GVSU Stream Ecology Class	GVSU Students	30
12/6/16	WMEAC	Trout Unlimited Board Meeting	TU Board Members	15
12/8/16	Pieatros	King Arthur Round Table	Round Table Members	10
1/25/17	Rockford Construction	WMELN Happy Hour	Environmental Leaders in West Michigan	35
1/30/17	Reserve	MI Legislators Lunch Briefing	West Michigan Elected Officials	15
2/2/17	Grand Rapids Public Museum	West michigan Eco-Trouism Seminar	Parks & Recreation staff	15
3/4/17	East Lansing	Quiet Water Symposium	Paddle enthusiasts	50
3/6/17	Wege Foundation	Wege Foundation Trustees Briefing	Trustees	6
3/9/17	Founders Brewing	Tribute on the Grand Sponsor Preview	Potential Sponsors	30
3/9/17	Roselle Park, Ada	West Michigan Conservation Network	Conservation partners	30
3/13/17	Village of Saranac	Village Council Support for Water Trail	Village Council, general public	20
3/20/17	Walker VFW	Retired Railroad Employees	Retired railroad employees	30
4/1/17	GVSU - Grand Rapids	Knight Journalism School Seminar	Environmental Journalists	20
4/11/17	Raybrook Estates	Educational Program for Residents	Residents of Raybrook Estates	25
4/13/17	Wege Foundation	Wege Foundation Trustees Walking Tour	Trustees	3
4/22/17	Blandford Nature Center	Earth Day Collaborative Collective	Earth Day people	300
4/25/17	Womens' City Club	Kent Garden Club Earth Day Lecture	Kent Garden Club members	45
5/9/17	Amway Ballroom	River Rally Workshop	Rally Attendees	40
5/9/17	3101 River House	River Rally VIP reception	River Rally staff & event partners	50
5/10/17	Lyon Square	Project Tour for River Rally	Rally Attendees	15

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
5/11/17	Amway Ballroom	River Rally Plenary Session	Rally Attendees	300
5/18/17	Emerald A Room @ Amway	MI Infrastructure Conference		15
5/25/17	Kent County Commission Chambers	Kent county Special order of Business	Kent County Commissioners & General Public	35
6/5/17	Grand River edges	Service Learning project	High School Students	60
6/6/17	Kent Innovation High	Service Learning project	High School Students	30
6/22/17	Sony Lakeside Park	Paddle for A Purpose	Event Attendees	25
6/23/17	The BOB	WMELN Lunch	WMELN Members	18
6/24/17	Riverside Park, GR	Grand River Water Festival	Festival goers	250
6/27/17	GVMC	River Restoration Design Review with members of the local angling community. Q/A open dialogue	GR Steelheaders local/state members, local anglers	5
6/28/17	City Development Center	City of Grand Rapids Design Team	City Staff	21
7/27/17	Eberhard Center	Michigan Transportation planners Association	Transportation planners	125
7/27/17	Grand River edges	Michigan Transportation planners Association	Transportation planners	50
7/27/17	Grand River	Michigan Transportation planners Association	Transportation planners	12
		ASCE		
8/3/17	Grand Rapids Public Museum	Groundswell Summer Institute	Teachers/Educators	20
8/3/17	Holland Home	Senior Educational Programming	Holland Home Residents	40
8/10/17	University Club	Downtown Rotary Club	Rotarians	45
9/7/17	Kent County Commission Chambers	GVMC Board Meeting	GVMC Board Members	30
9/19/17	Forest Hills Eastern Middle School	Middle School River Unit	Middle School Students	100
9/20/17	Forest Hills Eastern Middle School	Middle School River Unit	Middle School Students	100
9/28/17	Kkent County Commission Chambers	Project Update and Funding Request	Kent County Commissioners and Guests	30

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
10/5/17	Rosa Parks Circle	C.A. Frost Class Tour	Students	20
10/10/17	Grand Rapids Community Foundation	Monthly Foundation CEO Roundtable	Foundation CEO's	18
10/12/17	Kent Innovation High	River Restoration Discussion	Kent Innovation High School Students	40
10/18/17	DGRI Goal #1 Alliance	Quarterly River Meeting	DGRI Alliance Members and DGRI Staff	15
10/19/17	GVMC	West MI Planners Conference	West MI Planners	30
10/30/17	Diamond Ave Hall	Grand Rapids Steelheaders Chapter Meeting Project Update & Listening Session	Chapter members	50
10/30/17	Founders Brewing Centennial Room	Guidepoint Financial Client Appreciation Night	Clients	50
11/14/17	City Hall Conference Room	City Commission Meeting	City Commission General Assembly	50
11/14/17	Calvin College Prince Center	American Society of Civil Engineers	ASCE members	45
11/5/17	Watermark Country Club	Forest Hills Business Association		15
12/11/17	Kendall College of Art & Design	West MI Sustainable Business Forum	Forum Members	45
1/11/18	Roosevelt Community Church	Latino Communty Coalition		30
1/22/18	Beacon Hill	Resident Enrichment Event	Residents of Beacon Hill	12
1/22/18	Centinnial Room-Founders	Legislative Update	West Michigan Elected Officials & DGRI/GRWW Stakeholders	35
1/29/18	Huron Tribe's Office on State Street	Anishinaabe Community Meeting - Grand River Corridor	Anishinaabe Community Members	25
2/8/18	Lansing Michigan	United Tribes Meeting	United Tribe Members	35
2/13/18	Founders Brewing Centennial Room	Tribute on the Grand Sponsor Preview	Potential Sponsors	25
2/15/18	Wege Student Center-Aquinas College	Economicology Forum	General Public	150
2/21/18	Thousand Oaks	Associated Builders & Contractors, Inc.	ABC Members	75
2/21/18	Plymouth Christian High School	Career Day	High School Students	96
2/21/18	Walker City Hall	West MI Mayors Meeting	Mayors and City Managers	20
3/19/18	Grand Valley State University	Planning, Geography & Geology Classes	Planning, Geography & Geology Students	60

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
3/27/18	Amway Grand Plaza	Pure Michigan Governors Conference on Tourism	Conference Attendees	10
3/27/18	Grand Rapids Art Museum	The Future of Water	W.MI League of Conservation Voters & General Public	100
4/11/18	GRWW Office	Grand Rapids Steelheaders	Executive Board	3
4/19/18	Roselle Park, Ada	River Update	Ada residents	25
4/21/18	Orvis	Orvis Get Outside Event	General Public	45
4/24/18	DeVos Place	Experience Grand Rapids Toast the Town	Community Leaders & Influencers	300
4/27/18	Bauerwood Elementary School	Watershed Unit Presentation	6th Graders	100
5/3/18	GVSU Eberhard Center	Michigan Society of Professional Engineers	Conference attendees	30
5/7/18	Founders Brewing	National Association of Clean Water Agencies		40
5/11/18	Cascade Township Library Wisner center	Grand River Spring Forum	LGROW peeps	102
5/14/18	Riverside park, Grand Rapids	Canoemobile	GRPS 8th graders	106
5/16/18	Amway Grand Plaza	National Working Waterfronts Conference	Conference Attendees	10
9/18/18	Riverview Center (GVMC office building)	Lunch & Learn for building tenants	Building Tenants, a few general public	50
9/22/18	Amway Grand Plaza	Michigan Association of Planner/MML Conference	Conference attendees	17
10/5/18	Fulton Street Farmers Market	Watershed Project Plan public input on alternatives	Market goers	10
10/25/18	Kent County Drain Commissioner's office	MACDC Northwest District Meeting	Drain Commissioners, attorneys, engineers	55
11/1/18	DeVos Place	River For All Reveal		225
11/6/18	USFWS NCTC	USFWS Urban Bird Program Conference	Conference Attendees	20
11/16/18	GRWW Office	Tour w/ DWH		5
11/28/18	GR Chamber of Commerce	Bronx River Aliance Presentation		50

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
11/28/18	LINC Up	Bronx River Aliance Community Meeting		30
11/28/18	GRPM	Bronx River Aliance Youth Programming Breakfast		25
3/19/19	Linear Restaurant	Greater Regional Alliance of Realtors		15
3/21/19	Rockford Construction	Steve Volkers Group Project Update	Steve Volkers Group Realtors & general public	35
3/8/19	DeVos Place	USACOE Publi Scoping Meeting for Upper Reach EIS	General Public	300
4/10/19	GRWW Office	Donor Cultivation Tour		5
4/11/19	LaGrave Church	LaGrave CRC Primers Group	Primers Group Members	75
4/22/19	GRCC M-Tec Center	Youth Programming Meeting	Local Nonprofits	25
4/22/19	YMCA-MFB	YMCA Staff Retreat	GR YMCA Executive Staff	30
4/22/19	Raybrook Estates	General Presentation	Residents	45
4/25/19	GRWW Office	Donor Cultivation Tour		5
5/2/19	GRCC M-Tec Center	Business Development Opportunities	Contractors & Business Owners	35
5/9/19	Weston Book Hotel	HOW Conference Presentation	Conference Attendees	5
5/13/19	Berkshire Hathaway Home Services	Presentation to Members	Berskshire Hathaway Members	25
5/13/19	Bridgewater Place	Experience Grand Rapids Event		15
5/16/19	Northview Senior Center	Northview Seniors Monthly Presentation	General Public	50
5/17/19	Blandford Nature Center	LGROW Spring Forum/Project Update	General Public	100
5/16/19	Rockford Senior Citizens Groups	Rockford Seniors Group	General Public	45
6/10/19	Ford Museum	Project Update	Executive Board	10
6/11/19	GVSU Eberhard Center	IMAGIN Conference Keynote	Conference Attendees	75
6/14/19	Amway	Family Business Alliance	Meeting attendees	15

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
7/16/19	GRWW Office	Donor Cultivation Tour		15
7/16/19	GRWW Office	Donor Cultivation Tour		10
7/25/19	Plante Moran	Patio Party	Plante Moran Staff	40
7/29/19	GRWW Office	Walking Tour	Lt Governor, local deligation	10
8/20/19	555 Monroe	Backyard Collective Event	Conservation Alliance Members	75
8/21/19	GRAM	Panel on Parks	General Public	75
9/6/19	GVSU Eberhard Center	Native Water Blessing Ceremony	General Public	60
9/13/19	Amway	Michigan Forest Association	Conference attendees	20
9/18/19	GVSU - Siedman	Making Waves Event	Students/General Public	20
9/20/19	YMCA-MFB	YMCA Sevice Club	Service Club Members	22
9/26/19	Rockford Construction	Next Generation Leadership Group	Guests of Mike V	30
9/26/19	GLI	GLI River Update	General Public	50
9/30/19	E&Y	Project Update/Current Report	E&Y Members	8
10/3/19	42 North Partners	Project Update/Current Report	42 North Partners	15
10/22/19	Rockford Construction	Staff Update	Staff Members	45
10/23/19	Lyon Square	River Governance w/HR&A	Governance Group	12
10/24/19	Comstock Park	Comstock Park Rotary	Rotarians	16
10/24/19	Pieatros	King Arthur Round Table	Group Members	10
11/6/19	Kendall College of Art & Design	Collaborative Design class	College students	5
11/8/19	GVSU Eberhard Center	Executive Staff Update		10
11/12/19	GVMC	GVSU Honors class	College students	12
11/26/19	Highland Group	Staff Update	Staff	7

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
12/3/19	Eagle Eye Event Center East Lansing	Watershed & Stormwater Conference	Conference Attendees	75
1/13/20	GVMC	GVSU Aquatic Ecology Class	College students	26
1/16/20	Aquinas College	Aquinas Life Long Leranign	Class participants	150
1/7/20	Stifel	Current Report/Project Update	Employees	15
1/23/20	Riverhouse	Project Update	Riverhouse Residents	35
1/27/20	Diamond Ave Hall	Steelheaders Meeting	Steelheader Membership	50
1/28/20	OST	Project Update	Employees	50
1/29/20	Plaza Towers	Project Update	Residents	40
1/30/20	University Club	Downtown Rotary Club	Rotarians	75
2/7/20	Skype	Skype w/ Jenison 6th Graders	6th Gradres	100
2/13/20	WMCAT	Sol Dresser Photo Gallery Walk	General Public	
2/17/20	Blue Cross Blue Shield GR	Community Advisory Council Meeting	Community Advisory Council	15
2/29/20	MSU Pavilion	25th Annual Quiet Adventures Symposium	General Public from around the state	200
3/3/20	Fishbeck	Lunch & Learn for Fishbeck Employees	Employees	50
3/4/20	GVMC	Update to Plainfield Township	Plainfield Twp planners, staff	10
3/10/20	Watermark Country Club	Rotary Club of Ada	Rotarians	20
5/8/20	Zoom	LGROW's Grand River Spring Forum	Forum attendees (MS4s, watershed groups, environmental organizations, citizens	60
5/14/20	Kent County Complex - Zoom	Update to Drain Commissioner's office	Ken Yonker & Joel Morgan	2
5/16/20	Zoom	KDCAD Collaborative Design class update	Students	16
8/5/20	Zoom	BOMA Luncheon	Building Owners and Managers	22

PRESENTATION AND TOURS TRACKING SHEET

Date	Location	Event/Purpose	Audience	≈ # of Attendees
11/10/20	Zoom	Trout Unlimited National	TU staff (Burroughs, DeMol, Kotke)	3
2/8/21		Gun Lake Tribe		
5/5/21	Zoom	Lowell Rotary	Rotary members	15
1/19/22	River Walk	GVSU Aquatic Ecosystem Tour	Class members	16
3/26/22	Kiwanis Club	Club Lunch		20
3/27/22	Virtual	GVSU Grand Forum		50
5/17/22	Walking Tour	Joint Aquatic Science Meeting Project Tour		50
8/6/22	Walking Tour	Experience GR Walking Tour		30
8/11/22	Holland Rotary Club	Project Update for Club		25
11/14/22	Walking Tour	Council of Michigan Foundations Annual Meeting		
1/24/23	Plaza Towers	CLOMR Update to Residents		30
5/4/23	Walking Tour	GSA River Walk Tour Field Trip		40
6/20/23	Amway Grand Plaza	WMEA Presentation		100
10/17/23	Grand Rapids Lions Club	Club Lunch		30
11/29/23	New Community Church	Churchmen's Lunch Group		60
3/5/24	WMEAC	Trout Unlimited Chapter Meeting		15
3/20/24	GRPM	GRPM Board Meeting Update		15
5/8/24	DGRI	Grand River Network Board Meeting		20
			Approximate Number of People:	**11114**

APPENDIX A

Public Plan, Summary, Comments and Responses

Memorandum **of** Record (Redacted)

United States Department of Agriculture

Natural Resources Conservation Service

Michigan State Office

3001 Coolidge Road
Suite 250
East Lansing, MI
48823-6321

Telephone:
(517) 324-5270
Fax:
(855) 701-4363

www.mi.nrcs.usda.gov

25 June 2024

Memorandum for Record

Purpose: This memorandum serves as the administrative record for the decision made by the Michigan NRCS State Conservationist not to renegotiate and potentially amend the Memorandum of Agreement (MOA) between the Michigan State Office of the U.S. Department of Agriculture, Natural Resources Conservation Service and the Michigan State Historic Preservation Officer regarding the Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project.

On October 10, 2023, the NRCS reinitiated consultation with the Michigan State Historic Preservation Officer (SHPO) concerning changes to the funding, scope of work, and an expansion of the area of potential effects (APE) for the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project. The proposed Project has been updated to include the following activities:

- installing boulder clusters to diversify flow and restore lost habitat in the wetted channel;
- installing two grade control structures in the wetted channel to replace 60% of the existing grade control provided by the low-head dams in addition to improving aquatic habitat;
- installing three j-hook boulder structures in the wetted channel to enhance flow diversity and public access opportunities;
- and expanding the grading limits within the wetted channel that are associated with the demolition of existing low-head dams.

After additional coordination with state and federal regulatory agencies, the grading area associated with the demolition of the four low-head dams was expanded within the wetted channel of the Grand River from 130 feet north (upstream) to approximately 300 feet north (upstream) of the upstream face of the Bridge Street Bridge.

The NRCS' findings conclude that no further affects exist in the expanded APE that have not already been considered in the current memorandum of agreement. Additionally, the addition of boulder clusters, boulder structures, and grade stabilization structures in the wetted channel will also not have any added affects to historic properties. The NRCS recommended to the MI SHPO that no amendments to the existing memorandum of agreement were needed at this time.

The MI SHPO responded to the consultation request on November 20, 2023, with a request for further information. Specifically, the request was regarding how the

USDA is an equal opportunity provider and employer.

revised design will impact water flow and river hydrology in the APE and immediately down river from the APE. The MI SHPO, in particular, wanted to know how any hydrological changes made by the proposed project would impact riverbank erosion and stability. [redacted] The MI SHPO asked if a hydrological study had been conducted for the design changes and, if so, could that information be shared with them.

The NRCS provided this information to the MI SHPO on December 14, 2023. On January 18, 2024, the MI SHPO notified the NRCS that they agreed with our determination that the proposed changes to the APE would not have any added affects to historic properties that had not already been considered in the previous studies, which had already been addressed in the MOA, and that an amendment to the MOA was not needed at this time.

On December 19, 2023, the NRCS informed the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (a.k.a. Gun Lake Tribe) informing them of the changes to the funding, scope of work, and the expansion of the APE. The Tribal Historic Preservation Officer (THPO) of the Gun Lake Tribe responded with a request for a formal meeting between the applicant, NRCS, EGLE, and the MI SHPO. This meeting was held on March 26, 2024, via Microsoft Teams. The applicant discussed the proposed changes with the tribe [redacted] The NRCS representative stated that there were no downstream affects and that there was no reason to open the MOA for amendment. The THPO then asked if it would be possible to have the hydrological report that had been shared with the MI SHPO and to have a future meeting with the NRCS to discuss the potential for downstream affects. The NRCS representative agreed to send the hydrological study and then requested the THPO to review the study and then contact the NRCS to schedule a meeting if the Tribe felt that there were any potential affects downstream of the APE after reviewing the study.

Immediately after the March 26, 2024, the NRCS Cultural Resources Coordinator sent the Gun Lake THPO the hydrological study that had been previously shared with the MI SHPO. To date, the Gun Lake THPO has not contacted the NRCS to express interest in scheduling a meeting to discuss potential downstream affects.

On March 28, 2024, the MI NRCS cultural resources staff met with the NRCS National Water Management Center's cultural resources staff and the NRCS Deputy Federal

Preservation Officer (DFPO), Charles Carrig, to discuss the appropriate action to take regarding the MOA. The DFPO advised the Michigan Cultural Resources staff that it would not be prudent to open the existing MOA for further consultation and potential amendment at this time, provided that the NRCS had done their due diligence and documented that there were no downstream affects caused by the limited design changes to the project. Furthermore, he advised that, whatever decision the MI State Conservationist made about the existing MOA, this decision should be documented in a memorandum for record, which should be kept in the administrative record for the project.

After some deliberation and careful consideration of the advice received from the National Water Management Center's cultural resources staff, the NRCS DFPO, and the Michigan Cultural Resources staff, t Garry Lee, MI State Conservationist, determined on June 25, 2024 that the Memorandum of Agreement between the MI NRCS and the MI SHPO does not need to be opened up for consultation and potential amendment at this time and has authorized the State Cultural Resources Specialist, Dr. Quates, to draft and sign this memorandum for record.

If there are questions regarding this decision, all inquiries should be addressed to Dr. Duane Quates, MI NRCS Cultural Resources Specialist / Archaeologist by telephone at 517-324-5261 or by email at Edward.Quates@usda.gov.

Sincerely,



E.W. Duane Quates, Ph.D.
State Cultural Resources Specialist / Archaeologist
Michigan – Natural Resources Conservation Service

APPENDIX A

Public Plan, Summary, Comments and Responses

SHPO Letter to NRCS

1/18/2024

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
MICHIGAN STRATEGIC FUND
STATE HISTORIC PRESERVATION OFFICE

QUENTIN L. MESSER, JR.
PRESIDENT

January 18, 2024

DUANE QUATES
USDA NATURAL RESOURCES
CONSERVATION SERVICE
3001 COOLIDGE ROAD SUITE 250
EAST LANSING MI 48823-6362

RE: ER20-876 Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, (USDA-NRCS)

Dear Dr. Quates:

We have reviewed the information regarding the hydraulic modeling results for the Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, submitted to our office on December 14, 2023. Based on the information provided in "Table 1: Comparison of hydraulic modeling results downstream of project", it appears that there is no elevated risk of downstream erosion associated with this project. Based on this information, the State Historic Preservation Officer (SHPO) concurs with the determination of USDA-NRCS that **no *archaeological* properties are affected** within the area of potential effects of this undertaking.

The revised project information does not change our earlier concurrence (March 21, 2021) of **adverse effect** on the Grand Rapids, Grand River Beautification Dams, which appear to meet the criteria of listing in the National Register of Historic Places. We will continue to consult with the NRCS on implementation of the stipulations outlined in the Memorandum of Agreement among the NRCS, SHPO, the Michigan Strategic Fund, the City of Grand Rapids, Michigan, Grand Rapids Whitewater, Inc., and the Grand Valley Metropolitan Council that was executed on September 30, 2022.

We remind you that federal agency officials or their delegated authorities are required to involve the public in a manner that reflects the nature and complexity of the undertaking and its effects on historic properties per 36 CFR § 800.2(d). The National Historic Preservation Act also requires that federal agencies consult with any Indian tribe and/or Tribal Historic Preservation Officer (THPO) that attach religious and cultural significance to historic properties that may be affected by the agency's undertakings per 36 CFR § 800.2(c)(2)(ii).

The opinion of the SHPO is based on the materials provided for our review. If you believe that there is material that we should consider that might affect our finding, or if you have questions, please contact If you have any questions, please contact Scott Slagor, Cultural Resource Protection Manager, at 517-285-5120 or by email at slagors2@michigan.gov. For questions regarding archaeological resources, please contact Dr. Sarah Surface-Evans, Senior Archaeologist at 517-282-7959 or by email at frederickk1@michigan.gov.**Please reference our project number in all communication with this office regarding this undertaking**.

MICHIGAN SHPO STATE HISTORIC PRESERVATION OFFICE

300 NORTH WASHINGTON SQUARE • LANSING, MICHIGAN 48913
michigan.gov/**shpo** • (517) 335-9840

Finally, the State Historic Preservation Office is not the office of record for this undertaking. You are therefore asked to maintain a copy of this letter with your environmental review record for this undertaking. Thank you for this opportunity to review and comment, and for your cooperation.

Sincerely,



Ryan M. Schumaker
State Historic Preservation Officer

RMS:SSE:SES

APPENDIX A

Public Plan, Summary, Comments and Responses

RRO Response Letter to SHPO 12/14/23

RIVER RESTORATION.ORG
970.947.9568 P.O. Box 248, Carbondale, CO 81623

To whom it may concern, December 14, 2023

In response to a request from SHPO, included in a letter dated November 20, 2023, for more information on potential impacts to bank erosion and stability, we have presented a summary table of hydraulic modeling results downstream of the project. We compared hydraulic calculations approximately 300 yards downstream, 1 mile downstream, and 5 miles downstream between existing conditions and post project conditions.

These comparisons show that the project will not affect hydraulic conditions downstream of the project to result in any adverse impacts to bank erosion or stability. Hydraulic modeling of the river downstream of the project shows no changes in depth, velocity, or shear stress. To demonstrate this, these hydraulics parameters are compared at three cross sections in Table 1 below.

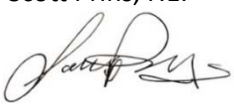
Table 1: Comparison of hydraulic modeling results downstream of project

Cross Section and Location	Flow Rate (cfs)	Calculated Flow Depth (ft)			Calculated Flow Velocity (ft/s)			Calculated Shear Stress (lb/sf)		
		Existing Conditions	Post Project Conditions	Diff.	Existing Conditions	Post Project Conditions	Diff.	Existing Conditions	Post Project Conditions	Diff.
2118+68.1 Downstream face of Fulton Street Bridge	2,500	3.96	3.96	0.00	1.8	1.8	0.00	0.05	0.05	0.00
	3,900	5.89	5.89	0.00	1.65	1.65	0.00	0.03	0.03	0.00
	5,000	7.18	7.18	0.00	1.65	1.65	0.00	0.03	0.03	0.00
	10,000	11.43	11.43	0.00	1.92	1.92	0.00	0.04	0.04	0.00
	18,000	15.75	15.75	0.00	2.42	2.42	0.00	0.05	0.05	0.00
2069+88 Downstream of Oxford Trails Railroad Bridge	2,500	8.44	8.44	0.00	1.26	1.26	0.00	0.02	0.02	0.00
	3,900	10.43	10.43	0.00	1.47	1.47	0.00	0.02	0.02	0.00
	5,000	11.73	11.73	0.00	1.6	1.6	0.00	0.02	0.02	0.00
	10,000	15.91	15.91	0.00	2.15	2.15	0.00	0.03	0.03	0.00
	18,000	20.03	20.03	0.00	2.91	2.91	0.00	0.06	0.06	0.00
1837+33.9 Near Johnson Park	2,500	10.98	10.98	0.00	1.32	1.32	0.00	0.02	0.02	0.00
	3,900	12.82	12.82	0.00	1.61	1.61	0.00	0.03	0.03	0.00
	5,000	14.01	14.01	0.00	1.8	1.8	0.00	0.02	0.02	0.00
	10,000	17.93	17.93	0.00	2	2	0.00	0.01	0.01	0.00
	18,000	21.67	21.67	0.00	2.07	2.07	0.00	0.02	0.02	0.00

As shown in Table 1, at all cross sections examined, there are no calculated changes in either flow depth, velocity, or shear stress at any flow rates. Based on these hydraulic modeling results, there is no anticipated adverse impact to erosion or stability of the channel or banks downstream of the project as a result of the proposed actions. Please let me know if you have any questions.

Kind Regards,

Scott Prins, P.E.



River Engineer
RiverRestoration.org

APPENDIX A

Public Plan, Summary, Comments and Responses

SHPO Letter to NRCS

11/20/23

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
MICHIGAN STRATEGIC FUND
STATE HISTORIC PRESERVATION OFFICE

QUENTIN L. MESSER, JR.
PRESIDENT

November 20, 2023

DUANE QUATES
USDA NATURAL RESOURCES
CONSERVATION SERVICE
3001 COOLIDGE ROAD SUITE 250
EAST LANSING MI 48823-6362

RE: ER20-876 Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, (USDA/NRCS)

Dear Dr. Quates:

We have reviewed the updated information regarding the Project Design for the Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, submitted on October 10, 2023. The information submitted has prompted us to ask for additional details, as the redesigned grade control structures, boulder structures, and boulder clusters represent a significant change from previously reviewed designs.

We request additional information regarding how the revised design will impact water flow and river hydrology in the area of potential effect (APE) and immediately down river from the APE. In particular, how will any hydrological changes made by the proposed project impact riverbank erosion and stability? [redacted] Without a hydrological study, we cannot assess how the design change will affect these cultural resources, many of which are located along the banks of the Grand River.

The requested additional information can be submitted through online through our Additional Information Portal.

Please note that the Section 106 review process cannot proceed until we are able to consider the information requested above. This letter does not clear the project. If you have any questions, please contact Scott Slagor, Cultural Resource Protection Manager, at (517) 285-5120 or by email at slagors2@michigan.gov. For questions regarding archaeological concerns, please contact Senior Archaeologist, Sarah Surface-Evans, surfaceevanss1@michigan.gov, (517) 282-7959. **Please reference our project number in all communication with this office regarding this undertaking.** Thank you for this opportunity to review and comment, and for your cooperation.

Sincerely,

Sarah Surface-Evans
Senior Archaeologist

SES:SSE

APPENDIX A

Public Plan, Summary, Comments and Responses

NRCS-Mi LGRWHR ER20-876 Section 106 Case Study- Updated 3-2-2022

February 2022

Case Study of Alternatives to Address Adverse Effects to the Grand River Beautification Dams in Grand Rapids, MI, as part of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project (SHPO ER20-876)

USDA Regional Conservation Partnership Program
Lower Grand River Watershed in Kent County, Michigan

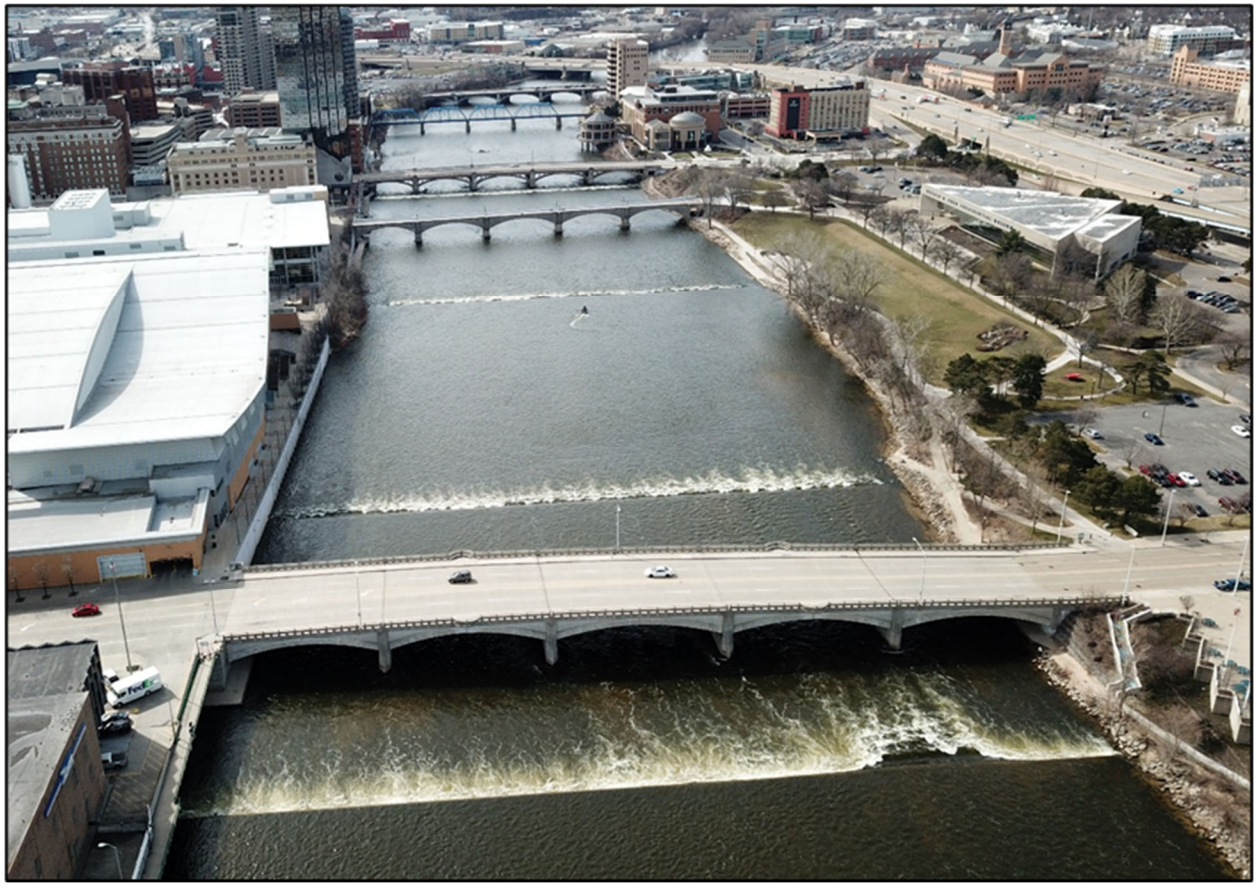


Image of the Grand River, City of Grand Rapids – Proposed Project Reach (looking downstream)

Prepared by:

Lead Federal Agency: Natural Resources Conservation Service

In Cooperation with: Grand Valley Metropolitan Council, Grand Rapids Whitewater, Environmental Consulting & Technology, Inc., Environmental Resources Management

Sponsoring Local Organization: City of Grand Rapids

The following information has been prepared for the State Historic Preservation Office regarding ER20-876 Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project using several existing documents that are also provided as attachments to this Case Study. The narrative below is structured by 36 CFR 800.11(e) required documentation. Attached documentation includes the following:

- *NRHP Evaluation document (ERM)*
- *DRAFT Environmental Assessment*
  - *Section 1 Introduction and Background*
  - *Section 2 Purpose and Need for Action*
  - *Section 4.8 Affected Environment – Cultural Resources*
  - *Section 5 Alternatives*
- *Tribal Consultations letters sent*
- Mitigation Plan *(Final Mitigation Plan GRWW 102621.pdf)*
- Copies or summaries of any views provided by ACHP, SHPO, consulting parties and the public.
  - ACHP response notification (6-21-2021)
  - *SHPO response letter to finding of Adverse Effect (3-23-2021)*

PROJECT DESCRIPTION

Description of the undertaking, specifying the federal involvement

*** Please reference the DRAFT Environmental Assessment (DRAFT EA) document, Section 1.2 for more information ***

A Regional Conservation Partnership Program (RCPP) grant was awarded by the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) to the Grand Valley Metropolitan Council (GVMC) in 2017 to improve aquatic habitat in the Lower Grand River (runs from Portland, at the confluence of the Looking Glass River, to Grand Haven, at the mouth of the river). This grant provides $8 million in funding for the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project. Of that amount, about $4.1 million was allocated to support instream habitat restoration of the Grand River where it flows through the City of Grand Rapids in Kent County under the USDA NRCS Watershed Protection and Flood Prevention Act, PL 83-566 program. Specifically, the $4.1 million would be used for revitalizing the rapids in downtown Grand Rapids from 130 feet upstream of Bridge Street to Fulton Street (the proposed Project).

The purpose of the proposed Project is to:

1. Restore aquatic habitat diversity and suitability for native Great Lakes drainage fish and mussel species, especially threatened, endangered, and special concern native species, in the Grand River from 130 feet upstream of Bridge Street to Fulton Street
2. Reduce or eliminate public safety hazards generated by the existing low-head dams; and
3. Install diversified hydraulic features that would improve aquatic habitat and scenic resources in the Grand River.

The need for the proposed Project action arises from the degraded condition of the river, which is an important natural resource for Grand Rapids and the State of Michigan, and several recognized safety problems associated with that degraded condition. Historic physical changes made to the Grand River as it flows through downtown Grand Rapids, including construction of four low-head dams and removal of natural substrate, have impacted native and listed species of fish and

mussels, and altered habitat. Studies have concluded that the diversity and productivity of fish and mussel communities in the Project Area and surrounding portions of the Grand River are currently much lower than what is possible.

The proposed Project would include the following activities:

- Demolition of four low-head dams (also referred to as "Beautification Dams")
- Restructuring the channel through excavation (dredging), grading, and importing boulders, cobble, and gravel substrate
- Installing additional scour protection on existing bridge structures and
- Installing four diversified hydraulic features

The Project is being funded by the NRCS under the watershed Protection and Flood Prevention Act (PL-566) and RCPP in combination with private and public funding obtained through project fundraising efforts. NRCS is the Lead Federal Agency. The Grand Valley Metropolitan Council (GVMC), in partnership with the City of Grand Rapids (the Sponsoring Local Organization (SLO), has prepared a Plan-EA pursuant to NRCS PL-566 requirements. In addition, a Biological Assessment was prepared in consultation with the U.S Fish and Wildlife Service (USFWS) and Michigan Department of Natural Resources (MDNR); the USFWS subsequently issued a Biological Opinion (BO) (issued October 22, 2020) covering multiple state and federal threatened and endangered species, including freshwater mussels.

Area of Potential Effect (APE)

* Tables & Figures referenced below can be found on pages 3-14 of the attached document "*4-6-2021 NRCS-LGRWHR consultation update United Tribes of MI.pdf*" (4-6-2021 Consultation Update letter), which was used along with the Draft EA to provide much of the information for this Case Study. *

The proposed Project's Area of Potential Effect (APE) is defined for direct effects as the Construction Area and Project Area (total direct APE of 48 acres), and for indirect effects as areas immediately adjacent to the Construction Area. Indirect effects, primarily visual, will only be considered for properties from which the channel modifications will be visible. The proposed Project includes the following 2 APE's:

- ❖ Construction Area – the area within the wetted channel of the Grand River from approximately 130 feet upstream of the Bridge Street Bridge to the upstream edge of the Fulton Street Bridge (see Figure 1); and

- ❖ Project Area – the areas where proposed Project activities would occur:
  - Portions of the land on both sides of the Grand River from the 6th Street Dam to Fulton Street (where construction access or staging areas would occur as shown on Figure 1)
  - The wetted channel of the river from 130 feet upstream of the Bridge Street Bridge to the upstream face of the Fulton Street Bridge (the Construction Area) and
  - Three recipient sites in the river for the placement of relocated unionid mussels. The three recipient sites are: mussel beds near Ada, Michigan; at Riverside Park just upstream of Grand Rapids; and between Plaster Creek and the M-11 (28th Street) Bridge (see Figure 1).

Potential impacts may result from demolition of four low-head dams; restructuring the channel through excavation, grading, and importing boulders, cobble, and gravel substrate; development and use of staging areas; and installing additional scour protection on existing bridge structures. Proposed earth disturbance is not planned beyond the confines of the active river channel except for construction access points and temporary staging areas on the banks. Temporary access ramps leading from the bank into the river are anticipated to be placed on the existing land surface. There will be little to no alteration or

grading and the sites of the temporary ramps will be restored to their original state upon completion; therefore, no impacts to historic properties from these temporary ramps are expected. The staging area located south of Bridge Street will have lighting fixtures and 6 to 8 inches of topsoil temporarily removed and stored. Geotextile blanket and stone will be placed to provide temporary driving and storage surfaces. Upon completion of the proposed Project, the stone and geotextile blanket will be removed, and the lighting fixtures and soil replaced. The staging area located northeast of I-196 will be utilized with limited alteration.

SECTION 106 REVIEW AND EVALUATION

Steps taken to identify historic properties

*** 4-6-2021 Consultation Update letter and DRAFT EA were used in preparation of this information ***

The early phases of Section 106 activities included a background search for previous cultural resource surveys and reported cultural resources. This search, conducted on February 21, 2018, included a 1-mile buffer for archaeological resources and a 2,000-foot buffer for historic and architectural resources. Results of this research have been revised based on the updated APE (see 4-6-2021 Consultation Update letter – Pages 3-14, Tables 1 and 2 and Figures 2 and 3). Background research is based on information provided by the Michigan State Historic Preservation Office (SHPO), including the Archaeological Site File. The 4-6-2021 Consultation Update Letter contains information on:

- Results from 2018 background research,
- 11-6-2018 Scoping Field View/Reconnaissance,
- Recommendations including that the mitigation process would be used to address the adverse effects to the 4 low-head dams

On December 17, 2020, SHPO requested a formal eligibility study of the four low-head dams to be removed by the proposed Project (DM 16 through DM 19). NRCS provided the NRHP Evaluation of Four Beautification Dams in the Grand River conducted by ERM dated February 18, 2021 (attached) to SHPO on March 4, 2021, with the finding that the four low-head dams are eligible for listing on the NRHP under criterion A & B, and that their removal will be an adverse effect. A letter with SHPO's concurrence that the dams are eligible for inclusion on the National Register with clarification on the applicable eligibility criteria of A and C was received on March 24, 2021.

In response to the SHPO's concurrence letter and request for information on survey size, "the acreage of the area surveyed as part of this effort for reporting purposes" is 48 acres.

Description of the affected historic properties

The following are excerpts from the NRHP Evaluation document. Please refer to that document and SHPO's response letter for citations, figures, and more information.

The four low-head or beautification dams were constructed in 1927 as part of a plan to beautify the river through downtown. The creation of canals on both sides of the river for power and Industrial use had led to low water levels in the river during dry periods, creating fetid pools and the growth of brush in the channel (Figure 2.0-5). The idea of a series of low-head dams on the Grand River in order to maintain water in the river bed and prevent the accumulation of trash and brush in the river was proposed by city planner Harland Bartholomew, whose firm was hired by the Grand Rapids Planning department in the early 1920s to develop a master plan for the city (GRPL 2017). The low-head dams would maintain the flow of the river and would "add greatly to the appearance and provide ample water surface for boating," according to Bartholomew (Bartholomew 1925; Biolchini 2019; GRPM ca. 1926).

The dams consist of four low-head concrete dams ranging from 1.5 to 3 feet in height and approximately 425 to 440 feet in length, located in the Grand River between the Interstate 196 Bridge and the Pearl

Street Bridge. The four dams together constitute the evaluated resource and are collectively referred to as the Beautification Dams in the Grand River. Details including specific dimensions and photographs of each can be found in section 4 of the NRHP Evaluation document.

The dams were also intended to prevent concentration of the raw sewage that was discharged into the river in that era. The original purpose of these dams is no longer relevant in the context of healthy river ecology, and raw sewage is no longer discharged to the river from the City of Grand Rapids. The dams impact the ability of fish and other creatures to thrive and limit fish and other aquatic organism passage.

Based on the NRHP Evaluation document and the SHPO response letter, the dams meet the requirements for listing in the National Register of Historic Places under Criterion A as a series of structures that conveys the long history of the City of Grand Rapids with the Grand River and for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids. Criterion C requirements are applicable to the dams since they are works of architecture and engineering and embody the distinctive characteristics of a type, period or method of construction.

Description of the undertaking's effects on historic properties.

While several archaeological resources are known to exist within the Project Area and vicinity, earth disturbance is not planned beyond the confines of the active river channel except for construction access points and staging areas. The NRCS field view supported the fact that the Project Area has been heavily urbanized and occurs within a portion of the Grand River that has been historically channelized for flood control purposes. Given the extensive existing land disturbance, and the fact that the majority of the planned activities are limited to the stream channel and some upland areas (for temporary staging and access), the Proposed Action is unlikely to result in impact to stratigraphically intact portions of the soil profile or, therefore, significant archaeological sites or potential culture-bearing soil horizons.

However, if the proposed Project design would change to include grading or significant earth disturbance in upland areas, further archaeological evaluation and possibly testing may be required prior to construction to avoid areas possibly maintaining deeply buried pre-contact or historic archaeological remains. Tribes and THPOs would be consulted if plans change to include such earthmoving or grading. A qualified archaeological monitor may be recommended. With the planned avoidance of Site [redacted] and no planned ground disturbance occurring in its vicinity, a finding of no adverse effects to archaeological historic properties is recommended.

Architectural resource assessment and survey identified both previously recorded resources as well as new resources. Three previously recorded resources, P23718, P23733, and P51124, were found to be significant under NRHP criteria. While these resources are adjacent to the proposed Project, a finding of no adverse effects to these resources is recommended due to a lack of visual change as well as a lack of physical changes that could impact resource integrity.

In addition to the three previously recorded resources, 16 new resources were identified during the field survey effort (Table 3). These resources consisted of six buildings (DM 1, DM 2, DM 3, DM 4, DM 7, DM 8), four bridges (DM 9, DM 11, DM 12, DM 13), one historic resource associated with the Grand River (DM 14), one riverwalk (DM 15), and four low-head dams (DM 16, DM 17, DM 18, DM 19). Of these resources, ten are considered to be ineligible for listing on the NRHP. Resources DM 11 and DM 12 are recommended

eligible for inclusion on the NRHP; however, due to lack of visual change from the Proposed Action, a finding of no adverse effects to these two resources is recommended. Any visual effects of the proposed Project are planned to be limited to the Grand River channel and properties adjacent to the Project area.
The Project plan as currently proposed requires removal of all four low-head dams evaluated and found to be eligible for listing. The removal of the dams, while causing an adverse effect, is an important part in realizing the Project purpose of improving aquatic habitat diversity and improving public health and safety. The Project plan does not allow for avoidance or minimization of adverse effects.

Explanation of why the criteria of adverse effects were found applicable or inapplicable;

As part of the Proposed Action, the four low-head dams would be demolished. Resources subject to direct effects (limited to the four low-head dams) has required additional study to determine NRHP significance, potential effect, and the potential need for mitigation of adverse effects to these structures. ERM's evaluation of the 4 low-head dams has resulted in NRCS' recommendation that they are eligible for the NRHP and SHPO has concurred with the determination of eligibility. Since removal of the dams is an integral part of the proposed undertakings and would be an adverse effect, the mitigation process is being used to address these adverse effects.

The proposed Project would have no effect on the remaining previously recorded and newly recorded architectural resources adjacent to the Project Area. Given that the proposed Project would include the demolition of low-profile dams whose structures are not currently visible above the water surface, and the restoration of rapids that are historic to the natural landscape of the area, there would be no adverse change in the historic viewshed of the identified resources. Additionally, any proposed staging areas for the proposed Project would not directly impact the resources identified within the viewshed, nor would they cause permanent impact on the immediate surroundings that may tie into the significance of that resource. However, should earthmoving, tree-clearing, or terracing activities be proposed as Project planning and design progresses, such viewshed changes may need to be re-evaluated in consultation with SHPO, THPOs and tribes.
A mitigation plan (*Final Mitigation Plan GRWW 102621.pdf*) has been developed to address the removal of the 4 low-head dams in cooperation with the applicant, SHPO, and any interested tribes. The plan addresses basic background of the adverse effects and how information will be provided to inform the public, with the end goal being development and execution of a Memorandum of Agreement.

Alternatives

The DRAFT EA prepared for the project addresses effects on resources and Section 5 specifically addresses alternatives to the removal of the 4 low head dams.
Alternatives considered for detailed study included the Proposed Action and a No Action Alternative. Several other alternatives were initially considered but subsequently eliminated from further study as described in Section 5.2. The Proposed Action includes the demolition of all four low-head dams and the creation of riffles, runs, glides, and pools in the Construction Area. Large substrates including boulders, cobbles, and gravel would be added to create rapids that would distribute the river's gradient and enhance fish and mussel habitat.

The No Action Alternative would leave the current conditions as they are. The low-head dams would be left in place, and the related public safety issues would remain. There would be no substrate enhancement; therefore, habitat quality would not be improved.

The alternatives have been assessed regarding their alignment with the defined Project purpose.
As stated earlier, the Project plan as currently proposed requires removal of all four low-head dams evaluated and found to be eligible for listing.

Summary of Consultation Efforts

SHPO has been involved in the project from 2018 up through the present by reviewing the initial information and field visit, assisting with ideas for additional consulting parties, and requesting more information on the history of the low head dams that led to the formal Evaluation and finding of Adverse Effect.
Prior to NRCS involvement in this project, Grand Rapids Whitewater conducted outreach and public meetings that included organizations listed in the attached document '***2014-2018 GRWW Consultation Efforts.pdf***'.

NRCS sent initial tribal & community consultation in July 2019 to the 12 federally recognized tribes (addressed to the cultural contact & tribal leader), 2 state historic tribes, and 1 tribal organization (United Tribes of Michigan) currently located in MI, and 5 environmental or community organizations listed in the attached spreadsheet (NRCS-MI LGRWHR ER20-876-Consultation.xlsx – 'Consultation-Groups Contacted' tab).

In April 2021 a consultation update was emailed to the cultural contact for each tribe contacted previously, the United Tribes of Michigan, and additionally to the Miami of Oklahoma. Information provided includes APE map, listing of documented sites and structures in the area, evaluation of the low head dams, finding of adverse effect, and invitation to provide comments and participate in the mitigation process. We received 4 responses, 1 with concerns in the area and a request to be kept informed, and the other 3 with interest in the area and the request to be notified in response to their offer to assist if something is discovered after the review and environmental evaluation have been completed or during construction. If there is a discovery, tribes request that construction will stop until any artifacts, significant properties or remains can be evaluated and tribes notified and contacted to assist as needed.

To address the response of concern, NRCS held a consultation meeting in May 2021 via Teams with the THPO staff to identify specific questions and concerns. The meeting was followed up by a site visit with Grand Rapids Whitewater, City of Grand Rapids, NRCS and the Tribe's THPO staff and Environmental Department representative in June 2021. Tribal concerns identified in May were discussed during the site visit/tour of the area and documented to be addressed in construction plans. Items discussed further with the Tribal representatives included requests to have a tribal monitor present and site monitoring plan to help address any potential discoveries during construction, protecting existing sites in the staging area prior to construction, more information on the extent of the physical disturbance within the river when the low-head dams are removed, and to determine what vegetation and aquatic species both in and near the river are being considered in development of the construction schedule. In response to

discussing the above issues, notes were provided to all parties that participated, the city provided a tree inventory of Ah-Nab-Awen park at the THPO's request. Arrangements for a tribal monitor are under development.

In October 2021 the draft mitigation plan was sent to the cultural contact or THPO for each of the 16 tribes/tribal organization contacted previously and inviting tribes to provide any comments. Letters were followed up by phone conversations where representatives were available.
A public comment period was held November 10, 2021, to December 10, 2021, to gather comments on the proposed mitigation measures to address the adverse effect of dam removal. The public comment period began with a public notice on the NRCS website and extensively shared via posting in a local news outlet (MLive), social media and email communications. The mitigation plan was posted online and made available in hard copy at Grand Rapids Public Library branches. Two public meetings were held online via Microsoft Teams. Meeting information directed interested parties to request to attend a meeting via a link on the NRCS website. Comments collected during the public comment period can be found on the "Public Comments" tab of the attached spreadsheet. 47 public comments were collected and 8 of those were related to or addressed the mitigation plan for the removal of the low-head dams. Several comments were related to the overall project and NEPA concerns and can be better addressed during the future NEPA public comment period.

The goal once mitigation measures are finalized, is execution of a Memorandum of Agreement to address removal of the dams and all associated concerns. NRCS, SHPO, GVMC, GRWW, the City of Grand Rapids, the Grand Rapids Public Museum, and any tribes or further interested consulting parties will be signatories of the MOA.

ACHP Notification & Response

The ACHP was provided with similar information regarding this project and the finding of adverse effect on the 4 low-head dams that are eligible for listing on the NRHP. The ACHP was notified on June 11, 2021, of the finding of adverse effect. The project was assigned ACHP Project Number 17025 in their response letter dated June 21, 2021. According to their response, the ACHP does not believe their "participation in the consultation to resolve adverse effects is needed." but may reconsider if the SHPO, a THPO, affected Indian tribe or other party requests their involvement. The ACHP has also offered to provide NRCS with advisory assistance upon request.

https://grandrapidswhitewater.org/ NRCS is involved in the "Lower Reach" area and undertakings of the project as referred to under "The Plan" tab.

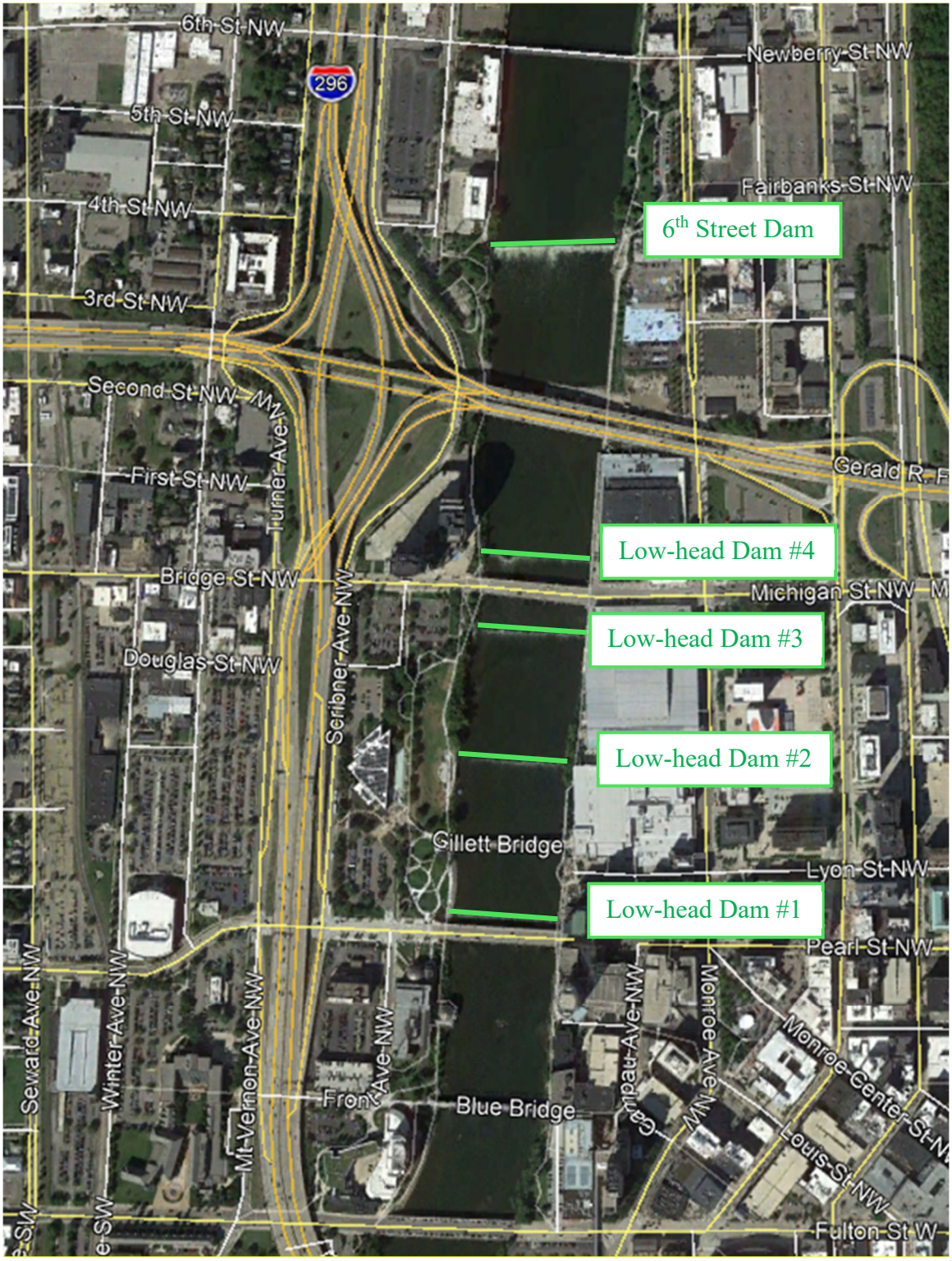
LEAD FEDERAL AGENCY CONTACTS

USDA-NRCS Michigan
3001 Coolidge Road, Suite 250
East Lansing, Michigan 48823

Federal Agency Official – Garry Lee, State Conservationist, garry.lee@usda.gov, 517-324-5277
Contact Person (Section 106 Review) – Duane Quates, Cultural Resources Specialist/ Archaeologist, Edward.quates@usda.gov, 517-324-5261
Contact Person (Section 106 Review) – Chris Valvano, Archaeologist, Christopher.Valvano@usda.gov, 517-324-5349

Contact Person (documents submitted) – Melissa Gutierrez, Cultural Resources Coordinator, melissa.gutierrez@usda.gov, 517-324-5251

Contact Person (NRCS FPO) – Erika Seibert, NRCS Federal Preservation Officer, Erika.seibert@usda.gov, 202-260-9099



Low-Head Dam Location Map

APPENDIX A

Public Plan, Summary, Comments and Responses

Final Mitigation Plan GRWW 102621

USDA United States Department of Agriculture
Natural Resources Conservation Service

Lower Grand River Watershed Habitat Restoration Project
Draft Mitigation Plan—Removal of Four Low-Head Dams

October 2021

Background and Context

On December 20, 2018, the Michigan State Historic Preservation Office (MI SHPO) was provided an initial request for Section 106 consultation regarding the Lower Grand River Watershed Habitat Restoration Project ("the Project"). On June 18, 2020, the Natural Resources Conservation Service (NRCS) submitted an update to that submittal. MI SHPO responded on June 29, 2020 with a request for additional information regarding the four low-head dams to be removed as part of the Project. NRCS provided the requested information on November 2, 2020. In response, MI SHPO requested that further additional information be provided about the dams to be removed by the Project, along with historical context that would help frame their potential eligibility for the National Register of Historic Places (NRHP).

On March 4, 2021, NRCS provided MI SHPO with an evaluation of the NRHP eligibility of the four low-head dams, finding that the dams are eligible and will be adversely affected. In a letter dated March 23, 2021, SHPO agreed with this evaluation, but clarified the applicable eligibility criteria. MI SHPO concurs that the four low-head dams are eligible for listing on the NRHP under Criterion A based on their role in the history of the city and the emergence of city planning. MI SHPO does not concur the association of the dams with city planner Harland Bartholomew warrants eligibility under Criterion B. In addition, MI SHPO finds that the dams are eligible under Criterion C, as the dams may embody the distinctive characteristics of a type, period, or method of construction. The Project as currently proposed requires removal of all four low-head dams and does not allow for avoidance or minimization of adverse effects; therefore, the adverse effect must be mitigated. Once a mitigation is agreed upon, a Memorandum of Agreement (MOA) will be developed to document the selected mitigation and its proposed implementation. The MOA will also incorporate an inadvertent discovery plan. Based on tribal responses specific to the Grand River Watershed Habitat Restoration consultation, as well as standard NRCS policy, if during the work, there is an inadvertent discovery made that involves any disturbance to a site of cultural, historic, or religious importance, work will stop and NRCS will contact tribal representatives and government agencies to determine further action. The MOA will be incorporated into the Environmental Assessment (EA) being prepared for the Project.

Because the four low-head dams are eligible based on their role in the history of Grand Rapids and the development of its waterfront, their role in early city planning, and possibly for their embodiment of distinctive characteristics of a type, period, or method of construction, the mitigation should align as closely as possible with these elements.

Because the plans on file for the dams show that they are constructed of solid concrete, their design and construction are unlikely to offer significant information. The plans do show a "Wilcox Angle Drain Valve" which has apparently never been operated or maintained. The purpose of this drain valve, and whether it was actually installed or was ever utilized, are unclear, but may be clarified through observation of dam removal.

Proposed Mitigation Measures

- Conduct selective monitoring of removal of dam 1 within the coffered de-watered area by a qualified architectural historian, who will work in coordination with a qualified archaeologist
    - Focus on identifying and documenting the form and content of the dam with sketch drawings and high-resolution photographs
    - Focus on how the dam was constructed and any evidence of maintenance or modifications post-construction
    - While monitoring dam removal, the architectural historian will also attempt to recover any diagnostic artifacts identified within the coffered area as feasible and safe within the constraints of construction site activities and schedule
    - The architectural historian (who will be on-site) will consult the archaeologist (who will be remote) to assure any diagnostic artifacts identified within the river bed are appropriately handled, as directed by NRCS
    - Coordinate with the Grand Rapids Public Museum for curation and display if significant cultural artifacts are recovered
- Include photos of the dam removal in the River Restoration Photo Monitoring Project (https://www.lgrow.org/river-restoration) and make available for incorporation into educational programming
- Coordinate with Grand Rapids Public Museum to assure that they have access to any documentation of the Project and removal of the dams that they would like to incorporate into their educational programming, collections, or exhibits
    - Interpretation of the dams, including their removal, is central to Grand Rapids Public Museum programs that reach 6,000 students annually, in partnership with the Lower Grand River Organization of Watersheds
- Update River For All interpretive signage in kiosks in public areas along river (https://www.riverforall.com/)
    - Content to be determined in coordination with River For All and Grand Rapids Public Museum, for example:
        - Design drawings and plans
        - Documentation of removal of dams
        - Historic photographs or articles

Once mitigation measures have been agreed upon by all interested parties, the mitigation plan will be documented in a Memorandum of Agreement; with signatories to include NRCS, MI SHPO, City of Grand Rapids, Grand Rapids White Water (project proponents), Grand Valley Metro Council (project sponsor), and other consulting parties as applicable.

APPENDIX A

Public Plan, Summary, Comments and Responses

SHPO Letter of Concurrence with Adverse Effect; 03/23/2021

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
MICHIGAN STRATEGIC FUND
STATE HISTORIC PRESERVATION OFFICE

MARK A. BURTON
PRESIDENT

RECEIVED
APR 09 2021
By

March 23, 2021

MELISSA GUTIERREZ
USDA NATURAL RESOURCES
CONSERVATION SERVICE
3001 COOLIDGE ROAD SUITE 250
EAST LANSING MI 48823-6362

RE: ER20-876 Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County (USDA/NRCS)

Dear Ms. Gutierrez:

Under the authority of Section 106 of the National Historic Preservation Act of 1966, as amended, we have reviewed the proposed undertaking at the above-noted location. We have recently reviewed the report entitled NRHP Evaluation of Four Beautification Dams in the Grand River, Grand Rapids, Michigan submitted to fulfill the U.S. Department of Agriculture's Natural Resource Conservation Service's (NRCS) cultural resource management obligations under Sections 106 and 110 of the National Historic Preservation Act of 1966, as amended.

After review of the eligibility information presented in the report, we concur with the recommendations for the four beautification dams as eligible under Criterion A as series of structures that conveys the long history of the City of Grand Rapids with the Grand River and for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown Grand Rapids. The dams may be individually eligible for listing in the National Register, or as a contributing of a larger historic district associated with the total design of Harland Bartholomew, depending on the extent of the implementation of Bartholomew's design and whether any larger, potential district possesses historic integrity. The lack of a larger historic district or loss of integrity of the larger district does not diminish the individual significance, and thus eligibility, of the dams.

We do not concur that the dams are eligible under Criterion B for their association with city planner Harland Bartholomew. Though Bartholomew may be a significant historical figure, National Register Bulletin 15 states, "architects, artisans, artists, and engineers are often represented by their works, which are eligible under Criterion C." Bulletin 15 further guides that rather than the works of architects, artisans, artists, and engineers, the "homes and studios... can be eligible for consideration under Criterion B, because these usually are the properties with which they are most personally associated" (emphasis added). For these reasons, the structures are not eligible under Criterion B.

Likewise, we do not concur with the recommendation of not eligible under Criterion C. Given these are works of architecture and engineering, they should be more thoroughly examined under Criterion C. We believe these dams embody the distinctive characteristics of a type, period or method of construction and are therefore eligible under Criterion C.

While there are some differences between the SHPO's opinion of eligibility above in terms of the applicable Criterion, it appears that SHPO and NRCS agree that the dams are resources eligible for inclusion in the National Register and requesting additional changes to the report now would be inappropriate. The only additional information that SHPO requires for the NRHP Evaluation report at this time is the acreage of the area surveyed as part of this effort for reporting purposes. Please be sure to include that in all future survey efforts as well.

Therefore, based on the information provided for our review, the State Historic Preservation Officer (SHPO) concurs with the determination of USDA/NRCS that the proposed undertaking will have an **adverse effect** on the Grand Rapids, Grand River Beautification Dams, which appear to meet the criteria for listing in the National Register of Historic Places.

This undertaking meets the criteria of adverse effect because: *the undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association,* 36 CFR § 800.5(a)(1). Specifically, the undertaking will result in physical destruction of or damage to all or part of the property.

Federal agencies are required to avoid, minimize, or mitigate adverse effects. Please note that if the federal agency and the SHPO concur that the adverse effect cannot be avoided, the Section 106 process will not conclude until the consultation process is complete, an MOA is developed, executed, and implemented, and, if applicable, the formal comments of the Advisory Council have been received, 36 CFR § 800.6. For more information on your responsibilities and obligations for projects that will have an adverse effect on historic properties under 36 CFR § 800.6, please review the enclosed materials.

We remind you that federal agency officials or their delegated authorities are required to involve the public in a manner that reflects the nature and complexity of the undertaking and its effects on historic properties per 36 CFR § 800.2(d). The National Historic Preservation Act also requires that federal agencies consult with any Indian tribe and/or Tribal Historic Preservation Officer (THPO) that attach religious and cultural significance to historic properties that may be affected by the agency's undertakings per 36 CFR § 800.2(c)(2)(ii).

The opinion of the SHPO is based on the materials provided for our review. If you believe that there is material that we should consider that might affect our finding, or if you have questions, please contact Brian Grennell, Cultural Resource Management Coordinatoe, at (517) 335-2721 or by email at GrennellB@michigan.gov. **Please reference our project number in all communication with this office regarding this undertaking.**

Finally, the State Historic Preservation Office is not the office of record for this undertaking. You are therefore asked to maintain a copy of this letter with your environmental review record for this undertaking. Thank you for this opportunity to review and comment, and for your cooperation.

Sincerely,

Martha MacFarlane-Faes
Deputy State Historic Preservation Officer

MMF:KAK:TAW:BGG

Enclosures

copy: Duane Quates, USDA/NRCS
Advisory Council on Historic Preservation
Jacquie Payette
Stephen Koster

APPENDIX A

Public Plan, Summary, Comments and Responses

Cultural Resources Memorandum of Agreement 9/30/2022

NRCS Agreement N2622MOU0012399

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
THE MICHIGAN STATE HISTORIC PRESERVATION OFFICER,
THE MICHIGAN STRATEGIC FUND,
THE CITY OF GRAND RAPIDS, MICHIGAN,
GRAND RAPIDS WHITEWATER, INC.,
AND THE GRAND VALLEY METROPOLITAN COUNCIL

REGARDING

Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

WHEREAS, the Natural Resources Conservation Service (NRCS) plans in cooperation with the Grand Valley Metropolitan Council (GVMC), the City of Grand Rapids (City) and Grand Rapids Whitewater, Inc. (GRWW) to carry out the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project (Project) located in the City of Grand Rapids, Michigan pursuant to the Watershed Protection and Flood Prevention Act of 1954, Public Law 83-566, as amended (WPFPA) (16 U.S.C. Sections 1001-1008, 1010, and 1012)through NRCS's Regional Conservation Partnership Program (RCPP) agreement number 1603 with GVMC; and

WHEREAS, the Project consists of (1) restoring aquatic habitat diversity and suitability for native Great Lakes drainage fish and mussel species, especially threatened, endangered, and special concern native species, in the Grand River; (2) reducing public safety hazards generated by the existing four beautification (low-head) dams (each, a "low-head dam", and, collectively as, the "low-head dams"); and (3) installing diversified hydraulic features that would improve aquatic habitat and aesthetics. Restoration of the site will require the demolition and removal of the low-head dams; and

WHEREAS, NRCS has determined that the removal of the low-head dams is an undertaking (Undertaking) subject to review under Section 106 of the National Historic Preservation Act (NHPA), as amended, 54 U.S.C. §306108 (Section 106), and its implementing regulations, 36 C.F.R. Part 800; and

WHEREAS, NRCS is the responsible federal agency with funding authority over the Undertaking pursuant to the WPFPA; and

WHEREAS, GVMC is the applicant for federal assistance through the RCPP and is responsible for ensuring the habitat restoration requirements of the RCPP agreement between the NRCS and the GVMC are met. GVMC will be signing this Memorandum of Agreement (MOA) as an invited signatory; and

WHEREAS, the City is the sponsoring local organization and permit applicant, and will be responsible for establishing contracts for demolition of the low-head dams and resulting habitat restoration and will be signing this MOA as an invited signatory; and

WHEREAS, GRWW is leading the design and engineering of the Project and will closely coordinate with the City and other partners to ensure the original intent of the design is accomplished and will be signing this MOA as an invited signatory; and

WHEREAS, the State Historic Preservation Officer is part of the State Historic Preservation Office (SHPO) which was transferred to the Michigan Strategic Fund (MSF) pursuant to Executive Order 2019-13; and

WHEREAS, NRCS has defined the Undertaking's Area of Potential Effects (APE) as the footprint of the low-head dam removal, an 840 m (2,756 feet) stretch of the Grand River flowing through the City from 40 m (130 ft) upstream of Bridge Street to Fulton Street and staging areas along the river; the low-head dams to be demolished are located between I-196 and Fulton Street and installation of substrate improvements within an area approximately 121,800 m^2 (30 acres) in size as further shown in the APE map attached hereto as Appendix A; and

WHEREAS, NRCS has determined, and the SHPO has concurred in their response letter regarding the Undertaking also referred to as SHPO Environmental Review 20-876, that the Undertaking will have an adverse effect on the low-head) dams in the Grand River due to their demolition and removal from the river. The low-head dams are eligible for listing on the National Register of Historic Places (NRHP) as documented in the NRHP Evaluation attached hereto as Appendix B, and NRCS has consulted with the SHPO and the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians Tribal Historic Preservation Officer (THPO) to develop this MOA pursuant to 36 Code of Federal Regulations Part 800 (36 C.F.R. Part 800), the regulations implementing Section 106 of the National Historic Preservation Act (54 U.S.C. § 306108); and

WHEREAS, the low-head dams are eligible for listing on the NRHP under the following eligibility criteria: Criterion A as a series of structures that conveys the long history of the City with the Grand River and for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown Grand Rapids and Criterion C, given that the low-head dams are works of architecture and engineering and embody the distinctive characteristics of a type, period or method of construction. The mitigation measures documented in the stipulations below must address the criteria that qualify the low-head dams for listing on the NRHP; and

WHEREAS, NRCS has reached out to the 12 Federally Recognized Tribes, and the two State Historic Tribes within Michigan as well as the Miami Tribe of Oklahoma with information and updates regarding the planned Undertaking. The Little River Band of Ottawa Indians, the Miami Tribe of Oklahoma, the Pokagon Band of Potawatomi, and the Saginaw Chippewa Indian Tribe of Michigan, responded to NRCS consultations and indicated that they should be contacted in the event a post review discovery is made; and

WHEREAS, the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians, [redacted] responded to NRCS consultations with interest and NRCS pursued consultation through the THPO**;** and

WHEREAS, NRCS has consulted with the Grand Rapids Public Museum (GRPM) regarding the effects of the Undertaking on historic properties and has invited GRPM to sign. GRPM will be signing this MOA as a concurring party; and

WHEREAS, in accordance with 36 C.F.R. § 800.6(a)(1), NRCS has notified the Advisory Council on Historic Preservation (ACHP) of its adverse effect determination with specified

documentation, and the ACHP has chosen not to participate in the consultation pursuant to 36 C.F.R. § 800.6(a)(1)(iii); and

WHEREAS, NRCS has provided the public the opportunity to comment on the Undertaking and proposed mitigation measures by issuing a public notice through local media, on the NRCS Michigan website, partner websites and posting at local public libraries. Two public meetings were held virtually on November 10th and 29th, 2021, to provide information on the original purpose and present mitigation measures to address the removal of the low-head dams. Over the course of 30 days, 47 public comments were received and provided to the SHPO. Seven comments specifically addressed the removal of the low-head dams. These seven were reviewed and considered in development of this MOA. Remaining comments addressed other issues not related to the low-head dams; and

WHEREAS, an architectural historian will be present to monitor and document the low-head dam removal since the historic structures eligible for listing on the NRHP are extant engineered structures. An archaeologist will not be onsite during low-head dam removal for monitoring below ground disturbance because the riverbed was significantly disturbed when the low-head dams were installed and planned ground disturbance for the Undertaking will be limited. Dredging or scraping of the river for demolition of the dams will not exceed the previous level of disturbance associated with construction of the dams. Ah-Nab-Awen Park, a staging area, has three to five feet of fill. An archaeologist will be available to respond in the event a post review discovery is made during construction in accordance with the Inadvertent Discovery Plan for Cultural Resources or Human Remains attached hereto as Appendix E (Inadvertent Discovery Plan); and

WHEREAS, the term "Signatory" is defined in this MOA to include both Signatories and Invited Signatories; and

WHEREAS, nothing in this MOA shall be construed as requiring a Signatory or Concurring Party to expend funds in violation of the Anti-deficiency Act, codified at 31 U.S.C. § 1341, as amended; and

WHEREAS, terms and parties not otherwise defined in this MOA shall have the meaning assigned to them in the Glossary of Terms attached hereto as Appendix G.

NOW, THEREFORE, NRCS, SHPO, MSF, the City, GRWW, and GVMC agree that the Undertaking shall be implemented in accordance with the following stipulations in order to take into account the effect of the Undertaking on historic properties.

STIPULATIONS

NRCS shall ensure that the following measures are carried out:

I. MONITORING OF LOW-HEAD DAM REMOVAL BY ARCHITECTURAL HISTORIAN

The City and GRWW will provide a qualified architectural historian to conduct monitoring of the removal of one of the low-head dams within the coffered de-watered area to document the resource as it exists in accordance with SHPO's Documentation Standards attached hereto as Appendix C (Documentation Standards). As the plans show that the low-head dams are identical in design and construction, observation of one removal is expected to provide sufficient information on construction of the low-head dams. Note that if the field conditions at the time of removal of the

first coffered low-head dam do not facilitate the desired observations, NRCS may request that the removal of the second low-head dam within a coffered area, also be monitored as described below. The architectural historian will be monitoring demolition of a low-head dam since the historic property being removed is an extant engineered structure. An archaeologist will not be onsite during monitoring because ground disturbance will be limited. Dredging or scraping for demolition of the dams will not exceed the previous level of disturbance associated with construction of the dams. Ah-Nab-Awen Park, a staging area, has three to five feet of fill. An archaeologist will be available to respond in the event a post review discovery is made during construction in accordance with the Inadvertent Discovery Plan. The monitoring will:

A. Focus on identifying and documenting the form and content of the low-head dam with sketch drawings and high-resolution photographs

B. Focus on how the low-head dam was constructed and any evidence of maintenance or modifications post-construction

C. Allow the City's architectural historian to attempt to recover any significant architectural elements identified within the coffered area as feasible and safe within the constraints of low-head dam removal site activities and schedule

D. Include application of the Inadvertent Discovery Plan as needed during all Project activities. During monitoring of removal of the low-head dams, the architectural historian on site will implement the Inadvertent Discovery Plan if needed and NRCS shall engage archaeological and tribal representative assistance as appropriate.

E. Allow the City's architectural historian to coordinate with NRCS to arrange for curation and display if significant architectural elements and/or archaeological remains are recovered.

The final report from the City's architectural historian shall follow the Documentation Standards and will be submitted to NRCS within 90 days of completion of the monitoring work. NRCS will then submit the final report to the SHPO for deposit in the State Archives of Michigan, and with the City's Community Archives and Research Center. The historic documentation developed from monitoring shall adhere to the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Fed. Reg. 44716 (Sept. 29, 1983)).

II. PRESENTATION OF INTERPRETIVE MATERIALS

The following actions will be completed within one year of completion of low-head dam demolition.

A. Interpretive Panel(s)

i. The City and GRWW, in consultation with NRCS, will provide interpretative panel(s) to be placed along the river walkway in Ah-Nab-Awen Park or on the GRPM grounds (Panel(s)).

ii. The Panel(s) will be constructed on a durable outdoor product with UV resistant, graffiti resistant, and burn resistant material. Examples can be found at: http://www.pulsedesign.com/outdoor-interpretive-signs-historic-preservation-site-educational-exhibits

iii. The City and GRWW in consultation with NRCS and the other consulting parties will develop an interpretive design to describe the content of the Panel(s).

iv. Content, including text and images, for the Panel(s) will be reviewed by NRCS, in consultation with the SHPO, to ensure the content meets the Secretary of the Interior's Professional Qualifications Standards. NRCS will provide a draft image of all Panel(s)

to the signatories for comment for a period of 30 days. NRCS will consider all timely comments in developing final designs and text for the Panel(s).

v. The City and GRWW will install the Panel(s) during site restoration of Ah-Nab-Awen Park. The City shall ensure maintenance of the Panel(s). A digital copy of the Panel(s) will also be provided to the SHPO and the City for archiving.

B. River Restoration Photo Monitoring Project

i. GVMC is collecting photos of the current conditions and future low-head dam removal locations in the River Restoration Photo Monitoring Project. (https://www.lgrow.org/river-restoration)

ii. GVMC will create a timelapse video from these photos to document the entire low-head dam removal and watershed restoration process and make the video available to the public. The final product will be archived with the State Archives of Michigan and the City.

C. Museum Collections, Exhibits

The City will coordinate with a local historical institution to assure they have access to any appropriate documentation of the Project and removal of the low-head dams that they would like to incorporate into their educational programming, collections, or exhibits. Educational materials and exhibits shall comply with Federal Curation Regulations found at 36 C.F.R. § 79 as attached hereto as Appendix D (Federal Curation Regulations).

III. QUALIFICATIONS STANDARDS

NRCS shall ensure that all work carried out pursuant to this MOA shall be done by or under the direct supervision of historic preservation professionals who meet the Secretary of the Interior's Professional Qualifications Standards found at 36 C.F.R. § 61 (SOI Standards). NRCS shall ensure that all consultants retained for services pursuant to the MOA Agreement meet the SOI Standards.

The Section 106 regulations (36 CFR § 800.4(c)(1)) acknowledge that Indian tribes and Native Hawaiian organizations (NHOs) possess "special expertise" in assessing the eligibility of historic properties that possess religious and cultural significance to them. Individuals recognized by a tribe or NHO as possessing this special expertise do not have to meet the SOI Standards for purposes of Section 106 review.

IV. CURATION STANDARDS

Any artifacts collected and accessioned will be curated according to the Federal Curation Regulations.

V. PROJECT MODIFICATIONS AND CHANGES

Neither the NRCS, GVMC, the City nor GRWW shall alter any plan, scope of services, or other document that has been reviewed and commented on pursuant to this MOA (except to finalize documents commented on in draft form), without first affording the signatories to this MOA the opportunity to review the proposed change and determine whether it shall require that this MOA be amended. If one or more such signatory determines than an amendment is needed, the signatories to this MOA shall consult in accordance with Stipulation XIV to consider such an amendment.

VI. COMPLIANCE WITH OTHER FEDERAL, STATE, TRIBAL AND LOCAL LAWS

A. NRCS shall coordinate its compliance with Section 106 with other applicable federal, state/tribal, and local laws and reviews as appropriate.

B. Historic and prehistoric human remains from non-federal, non-tribal lands are subject to protection under Michigan burial/unmarked grave/cemetery law(s), the Michigan Attorney General's Opinion No. 6585 and Michigan Penal Code, Act 328 of 1931 Chapter XXVI, Section 750.160. As such, if human remains are discovered during removal of the low-head dams and watershed restoration, work in that portion of the Project shall stop immediately. The remains shall be covered and/or protected in place in such a way that minimizes further exposure of and damage to the remains, and NRCS shall immediately consult with the SHPO and THPO. If the remains are found to be Native American, in accordance with applicable law, a treatment plan shall be developed by NRCS and SHPO in consultation with appropriate federally recognized Indian tribes. NRCS shall ensure that any treatment and reburial plan is fully implemented. If the remains are not Native American, the appropriate local authority shall be consulted to determine final disposition of the remains. Avoidance and preservation in place is the preferred option for treating human remains.

VII. POST-REVIEW DISCOVERIES

If properties are discovered that may be historically significant or unanticipated effects on historic properties found, once notified of the discovery, NRCS shall continue to implement the Inadvertent Discovery Plan.

VIII. COMMUNICATION AMONG MOA PARTIES

Electronic mail (email) will serve as the official correspondence method for all communications regarding this MOA and its provisions. A list of all Signatory contacts and email addresses is attached hereto as Appendix F (Contact Information). Contact Information may be updated without an amendment to this MOA. It is the responsibility of each Signatory or Concurring Party to immediately inform NRCS of any change in name, address, email address, or phone number of any point-of-contact. NRCS shall forward updated Contact Information to all Signatories and Concurring Parties by email.

IX. ANTIDEFICIENCY ACT

NRCS's obligations under this MOA are subject to the availability of appropriated funds, and the stipulations of this MOA are subject to the provisions of the Anti-deficiency Act. NRCS shall make reasonable and good faith efforts to secure the necessary funds to implement this MOA in its entirety. If compliance with the Anti-deficiency Act alters or impairs NRCS's ability to implement the stipulations of this MOA, NRCS shall consult in accordance with the amendment and termination procedures found at Stipulations XIV and XV of this MOA.

X. EMERGENCY SITUATIONS

Should an emergency situation occur which represents an imminent threat to public health or safety, or creates a hazardous condition, NRCS shall immediately notify the SHPO, THPO and the ACHP of the condition which has initiated the situation and the measures taken to respond to the emergency or hazardous condition. Should the SHPO, THPO or the ACHP desire to provide technical assistance to NRCS, they shall submit comments within seven (7) calendar days from receipt of the notification, if the nature of the emergency or hazardous condition allows for such coordination.

XI. DURATION

This MOA will expire if its terms are not fully carried out within five (5) years from its execution. Prior to such time, NRCS may consult with the other Signatories to reconsider the terms of this MOA and amend it in accordance with Stipulation XIV below.

XII. AGREEMENT MONITORING AND REPORTING

A. On each anniversary following the execution of this MOA, until it expires or is terminated,

NRCS shall provide all Signatories and Concurring Parties to this MOA a summary report detailing work undertaken pursuant to its terms. Such report shall include any scheduling changes proposed, any problems encountered, and any disputes and objectionsreceived in NRCS's efforts to carry out the terms of this MOA.

B. The City, GRWW, and GVMC shall submit quarterly summary reports (Quarterly Reports) to NRCS detailing (1) any scheduling changes proposed, (2) any problems encountered, (3) any disputes and objections received and (4) all efforts to carry out the responsibilities and terms of this MOA.

C. NRCS shall create annual reports based on the Quarterly Reports and distribute to all Signatories and Concurring Parties.

XIII. DISPUTE RESOLUTION

Should any Signatory or Concurring Party to this MOA object (Objection) at any time to any actions proposed or the manner in which the terms of this MOA are being implemented, NRCS shall consult with such Signatory or Concurring Party to resolve the Objection. If NRCS determines that such Objection cannot be resolved, NRCS will:

A. Forward all documentation relevant to the Objection, including the NRCS's proposed resolution, to the ACHP. The ACHP shall provide NRCS with its advice on the resolution of the Objection (Advice) within thirty (30) days of receiving adequate documentation (Advice Period).

1. If the ACHP provides its Advice within the Advice Period, NRCS shall prepare a written response (Response) prior to reaching a final decision on the Objection (Final Decision) that takes into account any timely advice or comments regarding the Objection from the ACHP, Signatories and Concurring Parties, and provide them with a copy of the Response. NRCS will then proceed according to its Final Decision.

2. If the ACHP does not provide its Advice within the Advice Period, NRCS may make its Final Decision and proceed accordingly. Prior to reaching the Final Decision, NRCS shall prepare a Response that takes into account any timely comments regarding the Objection from the Signatories and Concurring Parties, and provide them and the ACHP with a copy of the Response.

B. NRCS's responsibility to carry out all other actions pursuant to the terms of this MOA that are not the subject of the Objection remain unchanged.

XIV. AMENDMENTS

This MOA may be amended when such an amendment is agreed to in writing by all Signatories. The amendment will be effective on the date a copy signed by all the Signatories is filed with the ACHP.

XV. TERMINATION

If any Signatory to this MOA determines that its terms will not or cannot be carried out (Objecting Signatory), the Objecting Signatory shall immediately consult with the other Signatories to attempt to develop an amendment pursuant to Stipulation XIV, above. If, within thirty (30) days (or another time period agreed to by all Signatories), an amendment cannot be reached, any Signatory may terminate the MOA upon written notification to the other Signatories.

Once the MOA is terminated, and prior to work continuing on the Undertaking, NRCS must

either (a) execute a new MOA pursuant to 36 CFR § 800.6 or (b) request, take into account, and respond to the comments of the ACHP under 36 CFR § 800.7. NRCS shall notify the Signatories as to the course of action it will pursue.

XVI. USDA STIPULATIONS

A. The Signatories and their respective agencies will handle their own activities and utilize their own resources, including the expenditure of their own funds, in pursuing these objectives. Each signatory will carry out its separate activities in a coordinated and mutually beneficial manner.

B. Nothing in this MOA shall obligate either the Department of Agriculture or any of the Signatories to obligate or transfer any funds Specific work projects or activities that involve the transfer of funds, services or property among the Signatories and their respective agencies will require execution of separate agreements and be contingent upon the availability of appropriated funds. Such activities must be independently authorized by appropriate statutory authority. This MOA does not provide such authority. Negotiation, execution and administration of each such agreement must comply with all applicable statutes and regulations.

C. This MOA is not intended to, and does not create, any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity, by a party to this MOA against the United States, its agencies, its officers, or any person.

Execution of this MOA by the NRCS, SHPO and MSF and implementation of its terms is evidence that NRCS has taken into account the effects of this Undertaking on historic properties and afforded the ACHP an opportunity to comment.

SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
THE MICHIGAN STATE HISTORIC PRESERVATION OFFICER,
THE MICHIGAN STRATEGIC FUND
THE CITY OF GRAND RAPIDS, MICHIGAN,
GRAND RAPIDS WHITEWATER, INC.,
AND THE GRAND VALLEY METROPOLITAN COUNCIL REGARDING
Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

Natural Resources Conservation Service

GARRY LEE Digitally signed by GARRY LEE
Date: 2022.09.14 17:38:14
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_____Date: _____

Garry Lee, State Conservationist

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SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
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THE MICHIGAN STRATEGIC FUND
THE CITY OF GRAND RAPIDS, MICHIGAN,
GRAND RAPIDS WHITEWATER, INC.,
AND THE GRAND VALLEY METROPOLITAN COUNCIL REGARDING
Removal of Four Beautification (Low-Head) Dams in the Grand River,
Grand Rapids, Kent County, Michigan, a component of the Lower Grand River
Watershed Habitat Restoration and Farmland Conservation Project

Michigan State Historic Preservation Office

DocuSigned by:
Martha MacFarlane-Faes Date: 9/30/2022
178C0ED7954D456
Martha MacFarlane-Faes, Deputy State Historic Preservation Officer

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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

Michigan Strategic Fund

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Valerie Hoag
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Date: 9/30/2022

Valerie Hoag, Fund Manager

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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

INVITED SIGNATORIES:

The City of Grand Rapids, Michigan

DocuSigned by:
By: _____ Date: _____
E607110D861A4E2...
Rosalynn Bliss, Mayor

DocuSigned by:
Attest: _____ Date: _____
D9E73BB4D3CD44E...
Joel Hondorp, City Clerk

Approved as to form:

DocuSigned by:
AFFIX
Mayor's Signature
Dept. of Law
_____ Date: _____
FD57E7E3FAE0466...
City Attorney

SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
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THE MICHIGAN STRATEGIC FUND
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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

INVITED SIGNATORY:

Grand Rapids WhiteWater, Inc.

_____ Date: _____
Steve Heacock, President & CEO

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SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

INVITED SIGNATORY:

Grand Valley Metropolitan Council



_____Date: _____

John Weiss, Executive Director

SIGNATORY PAGE

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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

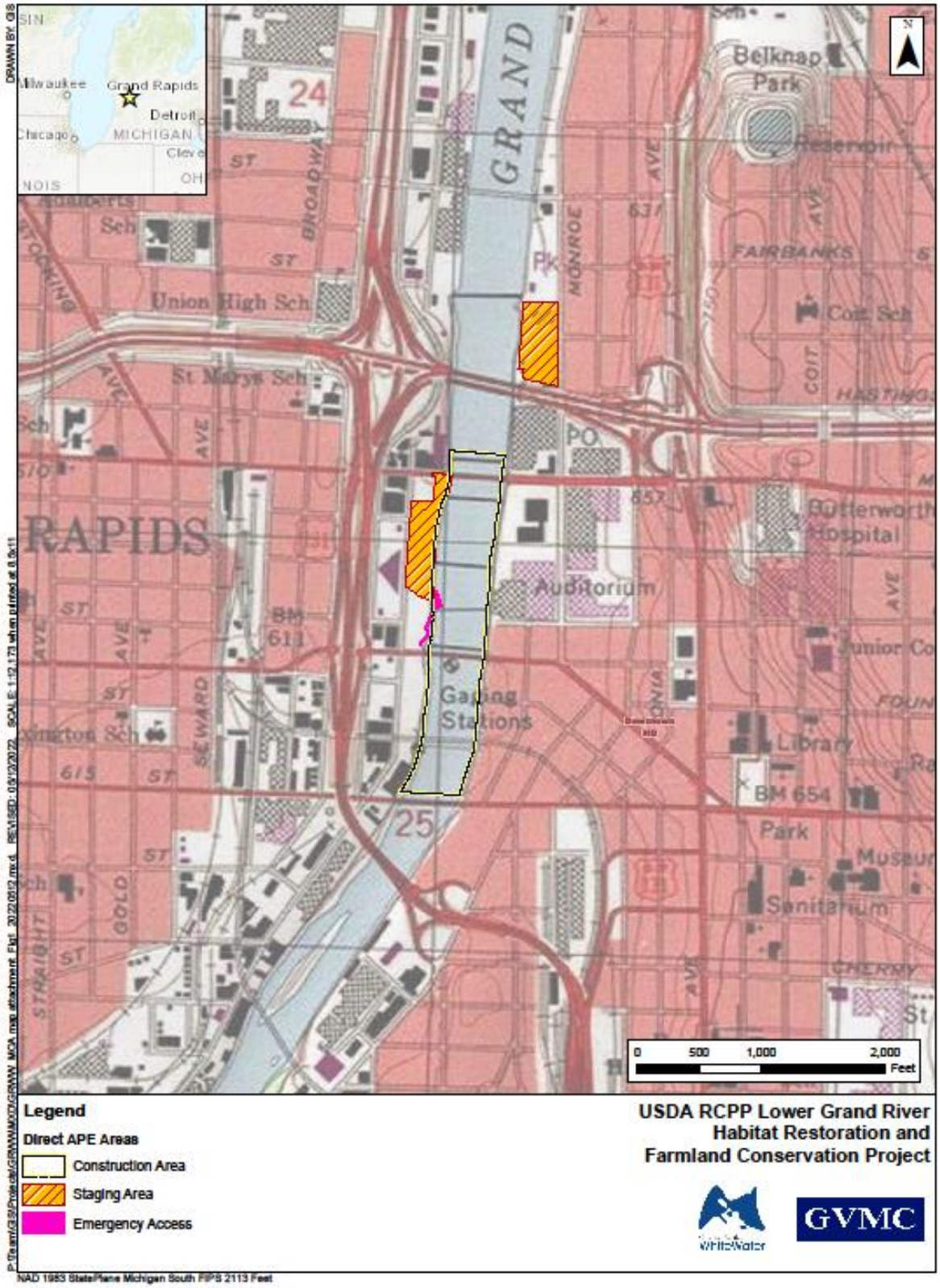
CONCURRING PARTY:

Grand Rapids Public Museum

Dale A. Robertson Date: 9/14/22

Dale A. Robertson, President & CEO

Appendix A - *APE Map*



Appendix B – *NRHP Evaluation*
(49-page document)



NRHP Evaluation of Four Beautification Dams in the Grand River, Grand Rapids, Kent County, Michigan

February 18, 2021

Project No: 0476625

The business of sustainability

ERM

Signature page

February 18, 2021

NRHP EVALUATION OF FOUR BEAUTIFICATION DAMS IN THE GRAND RIVER, GRAND RAPIDS, KENT COUNTY, MICHIGAN



Jeffrey L. Holland
Historian



Emily Tucker-Laird
Architectural Historian

ERM
3352 128th Avenue
Holland MI 49424

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ABSTRACT

The Michigan State Historic Preservation Office (MI SHPO) has requested a National Register of Historic Places (NRHP) evaluation of the eligibility of four low-head dams in the Grand River in Grand Rapids, Michigan that would be affected by the Grand Rapids Whitewater Project (Project), which proposes the removal of these dams. With the support of the City of Grand Rapids and Grand Rapids Whitewater (GRWW), Environmental Resources Management (ERM) prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are eligible for the NRHP, and if so, whether the Project may result in adverse effects to these cultural resources. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) is the lead federal agency with funding authority over the undertaking.

The Project spans approximately 0.7 miles along the downtown portion of the Grand River, and includes the removal of four low-head, historic-aged dams associated with the early industrial and commercial growth of Grand Rapids, as well as other changes in the river. Another dam in the Grand River upstream of the Project, the Sixth Street Dam and Fish Passage, has already been recommended eligible for the NRHP, and has been addressed as a separate undertaking. This report evaluates the four dams located from just north of Bridge Street to just north of Pearl Street. In order to evaluate the significance of the dams, ERM collected information on the dams and their context within the history of Grand Rapids from experts knowledgeable in local history, city planning, and historical public works. Documents, maps, and photographs were collected from the Grand Rapids City Archive and Record Center, the Grand Rapids Public Museum, the Grand Rapids Public Library, and the Grand Rapids Historical Commission.

Based on the information gathered, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are potentially eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. ERM also recommends that the Project would have an adverse effect on the properties. The Project plan as currently proposed requires removal of all the dams and does not allow for avoidance or minimization of adverse effects. ERM recommends that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project on the four low-head dams.

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Acronyms and Abbreviations

Name	Description
ACHP	Advisory Council on Historic Preservation
APE	Area of Potential Effects
Ca.	Circa
CFR	Code of Federal Regulations
ERM	Environmental Resources Management
GRCARC	Grand Rapids City Archive and Record Center
GRHC	Grand Rapids Historical Commission
GRPL	Grand Rapids Public Library
GRPM	Grand Rapids Public Museum
GRWW	Grand Rapids Whitewater
MI SHPO	Michigan State Historic Preservation Office
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
Project	Grand Rapids Whitewater Project
USGS	United States Geological Survey

1. INTRODUCTION

1.1 Overview

Michigan State Historic Preservation Office (MI SHPO), in the course of consultation regarding the Project, has requested an evaluation of National Register of Historic Places (NRHP) eligibility of four low-head dams in the Grand River in Grand Rapids that would be affected by the Project, which proposes the removal of these dams in an effort to restore the river to a more natural state. With the support City of Grand Rapids and Grand Rapids Whitewater (GRWW), Environmental Resources Management (ERM) prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are potentially eligible for the NRHP, and if so, whether the Project may result in adverse effects to these cultural resources.

The Project requires funding authorization from the NRCS, and must comply with the provisions of the National Environmental Policy Act (NEPA) of 1970 and the National Historic Preservation Act (NHPA) of 1966. The need for federal authorization requires Project review under Section 106 of the NHPA, as amended. Section 106 of the NHPA (54 United States Code § 306108) requires federal agencies, including NRCS, to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment. Historic properties are defined as cultural resources that are listed or eligible for listing in the NRHP (36 Code of Federal Regulations [CFR] 60). GRWW, as a non-federal party, is assisting the Natural Resources Conservation Service (NRCS) in meeting its obligations under Section 106 by preparing the necessary information, analyses, and recommendations as authorized by 36 CFR § 800.2(a)(3).

On December 20, 2018, ERM, on behalf of NRCS, submitted a request for initial consultation regarding the Lower Grand River Watershed Habitat Restoration Project. On June 18, 2020, NRCS submitted an update to that submittal. MI SHPO responded on June 29, 2020 with a request for more information regarding the four low-head dams to be removed as part of the river restoration. Additional information was provided on November 2, 2020, to which MI SHPO responded with a request for further information regarding the known history and current condition of the four low-head dams (December 17, 2020, ER20-876). MI SHPO requested that additional information be provided about the dams to be removed by the Project, along with historical context that would help frame their potential eligibility for the NRHP. The current report was prepared to satisfy that request.

The Project includes the following:

- The Construction Area—the area within the wetted channel of the Grand River from approximately 130 feet upstream of the Bridge Street Bridge to the upstream edge of the Fulton Street Bridge
- The Project Area—the areas where Project activities would occur:
  - Portions of the land on both sides of the Grand River from the 6th Street Dam to Fulton Street (where construction access or staging areas would occur)
  - The wetted channel of the river from 130 feet upstream of the Bridge Street Bridge to the upstream face of the Fulton Street Bridge (the Construction Area)
  - Three recipient sites in the river for the placement of relocated unionid mussels. The three recipient sites are mussel beds near Ada, Michigan; at Riverside Park just upstream of Grand Rapids; and between Plaster Creek and the M-11 (28th Street) Bridge.

The Project's Area of Potential Effect (APE) is defined for direct effects as the Construction Area and Project Area, and for indirect effects as areas immediately adjacent to the Construction Area. Direct effects on the four low-head dams scheduled for removal are the subject of this report. Proposed earth

disturbance is not planned beyond the confines of the active river channel except for construction access points and temporary staging areas on the banks.

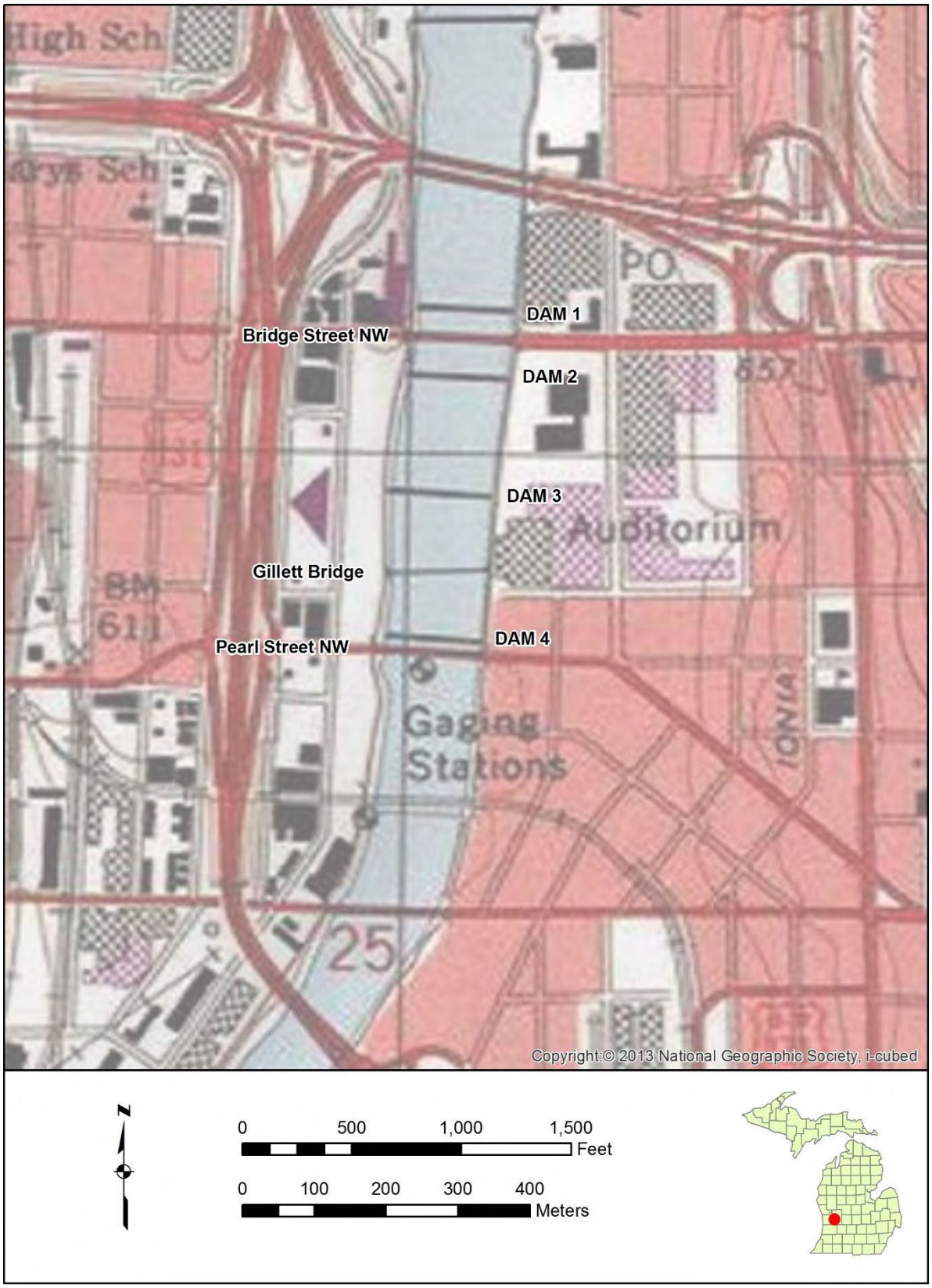

Figure 1.1-1: Topographic Map Showing Location of Dams



Figure 1.1-2: Current Aerial Imagery of Beautification Dams

The Project spans approximately 0.7 miles along the downtown portion of the Grand River, and includes the removal of four low-head, historic-aged dams associated with the twentieth century commercial growth of Grand Rapids, as well as other changes in and near the river (Figures 1.1-1 and 1.1-2). Another dam in the river at Grand Rapids, the Sixth Street Dam and Fish Passage, was constructed earlier than the other four, and was originally intended for water power. It was repaired and improved in 1926 as part of the planned improvements to the river recommended by city planner Harland Bartholomew. This dam has already been determined eligible for the NRHP (Robinson et al. 2020; B. Grennell to C. Sedlacek, letter dated 6 October, 2020). The current report evaluates the four dams located from just north of Bridge Street to just north of Pearl Street. In order to evaluate the significance of the dams, ERM collected information on the dams and their context from online sources and experts knowledgeable in local history, city planning, and historical public works. Documents, maps, and photographs were collected from the Grand Rapids City Archive and Record Center (GRCARC), the Grand Rapids Public Museum (GRPM), the Grand Rapids Public Library (GRPL), and the Grand Rapids Historical Commission (GRHC).

The four dams were constructed in 1927 as part of a plan to beautify the river through downtown. The creation of canals on both sides of the river for power and industrial use had led to low water levels in the river during dry periods, creating fetid pools and the growth of brush in the channel. The construction of low-head dams to create run-of-the-river pools had been recommended by Harlan Bartholomew as part of the 1925 City Plan (Bartholomew 1925). The proposed undertaking would entail removal of all four dams to reinstitute rapids in the riverbed, improving aquatic habitat diversity, improving public health and safety, expanding use of the river, and improving recreational use of the river. This report will evaluate the potential NRHP eligibility of the four Beautification Dams proposed for removal as part of the Project.

1.2 Management Recommendations

Based on the information gathered, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. ERM also recommends that the Project would have an adverse effect on the properties. The Project as currently proposed requires removal of all the dams and does not allow for avoidance or minimization of adverse effects. ERM recommends that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project

2. HISTORIC CONTEXT

When settlers began to congregate around the Baptist Mission on the west bank of the Grand River and the trading post established by Louis Campau on the east side of the river at what is now Grand Rapids in the 1820s, the river was described as a mile-long cascade of rapids that was 300 yards wide and dropped a total of 10 to 15 feet. A map made in 1830 (Grand Rapids Public Library 1830) shows the rapids that spanned the length of the city's street grid (Figure 2.0-1). The potential water power that the river could provide was immediately recognized, and by at least 1833, the river was being used for power. In 1835, the first dam was constructed on the river. The stone wing dam was located near Eleventh Street to the north of the Project area, and diverted water into the East Side Power Canal to provide waterpower to a sawmill and gristmill. The canal was extended for a mile along the river and was completed in 1842, providing power to a number of industries until it was abandoned in 1925. In 1849, a log and stone dam was constructed across the width of the river in an attempt to expand the canal for navigation. The canal project was a failure, but the horseshoe-shaped dam near Sixth Street remained until after 1878 (Figure 2.0-2) (Biolchini 2019; Robinson, et al. 2020).



Figure 2.0-1: Map of Grand Rapids in 1830 Showing the Rapids through the City (North is to the right) (GRPL)

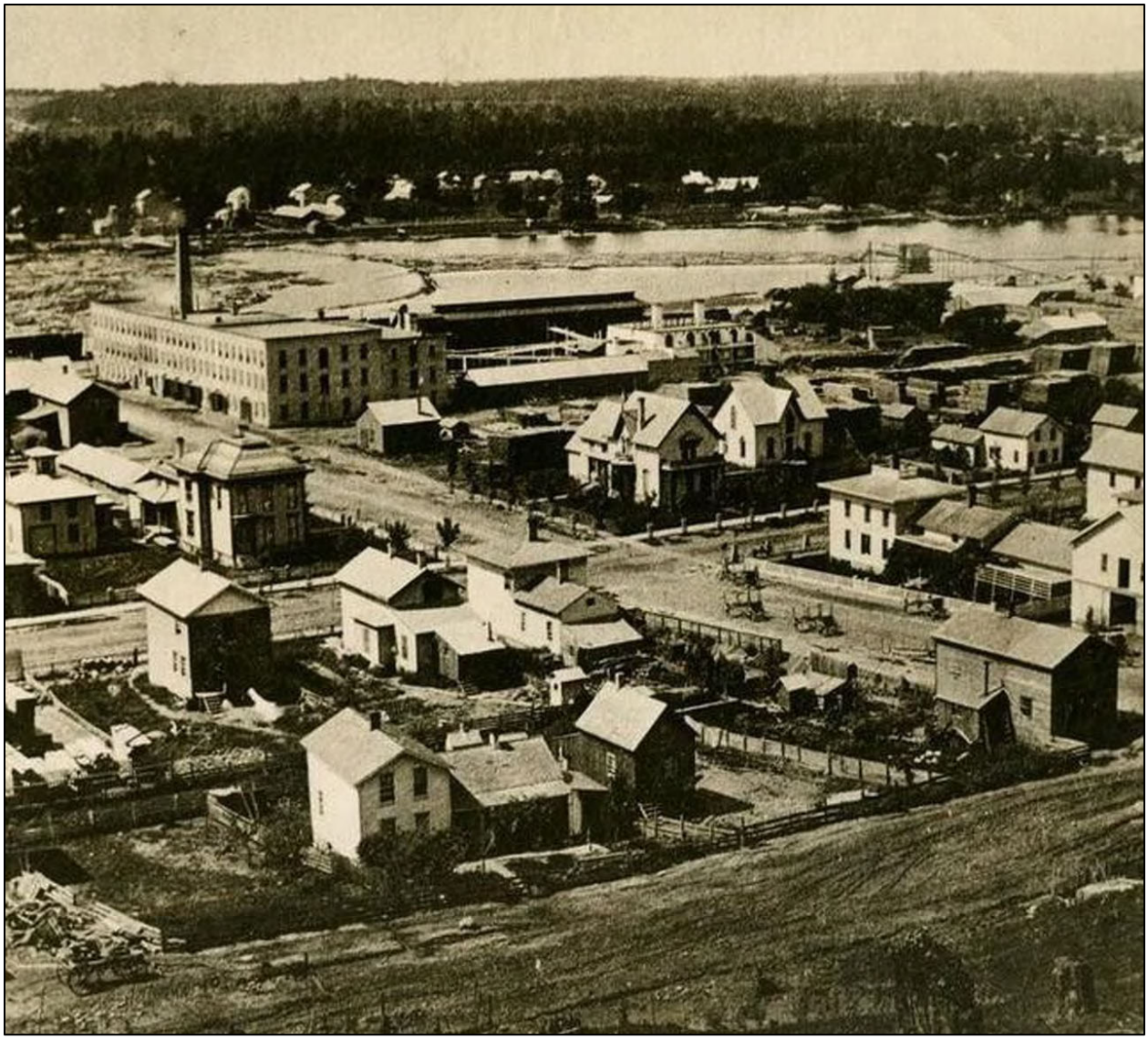

Figure 2.0-2: View of Grand Rapids in 1865 with the 1849 Horseshoe Dam in the Background (GRPL)

In 1866, the West Side Water Power Association began construction on the West Side Canal. Through an agreement with the East Side Water Power Company, the water rights would be split between the two companies, and a new, more permanent timber crib dam would be constructed across the river at Fourth Street that would serve both canals. This was known as the water power dam, or Fourth Street Dam (Figure 2.0-3). It was located a few blocks south of the earlier horseshoe dam, which remained in place until at least 1878 but was gone by 1888 (GRCARC 1873, 2019; Sanborn Map Company 1888). The Fourth Street Dam was later known as the Sixth Street Dam (Robinson et al. 2020).

In the early twentieth century, Grand Rapids experienced a series of disastrous floods. The first of these in 1904 damaged a 150-foot section of the Fourth Street Dam. At that time, it was suggested that a concrete dam replace the 1866 timber crib dam, although it appears that the dam was simply repaired (*Grand Rapids Herald* 1904). The city hired Lyman E. Cooley, an engineer from Chicago, to make recommendations regarding flood control and improving water power. Cooley proposed in 1904 that flood

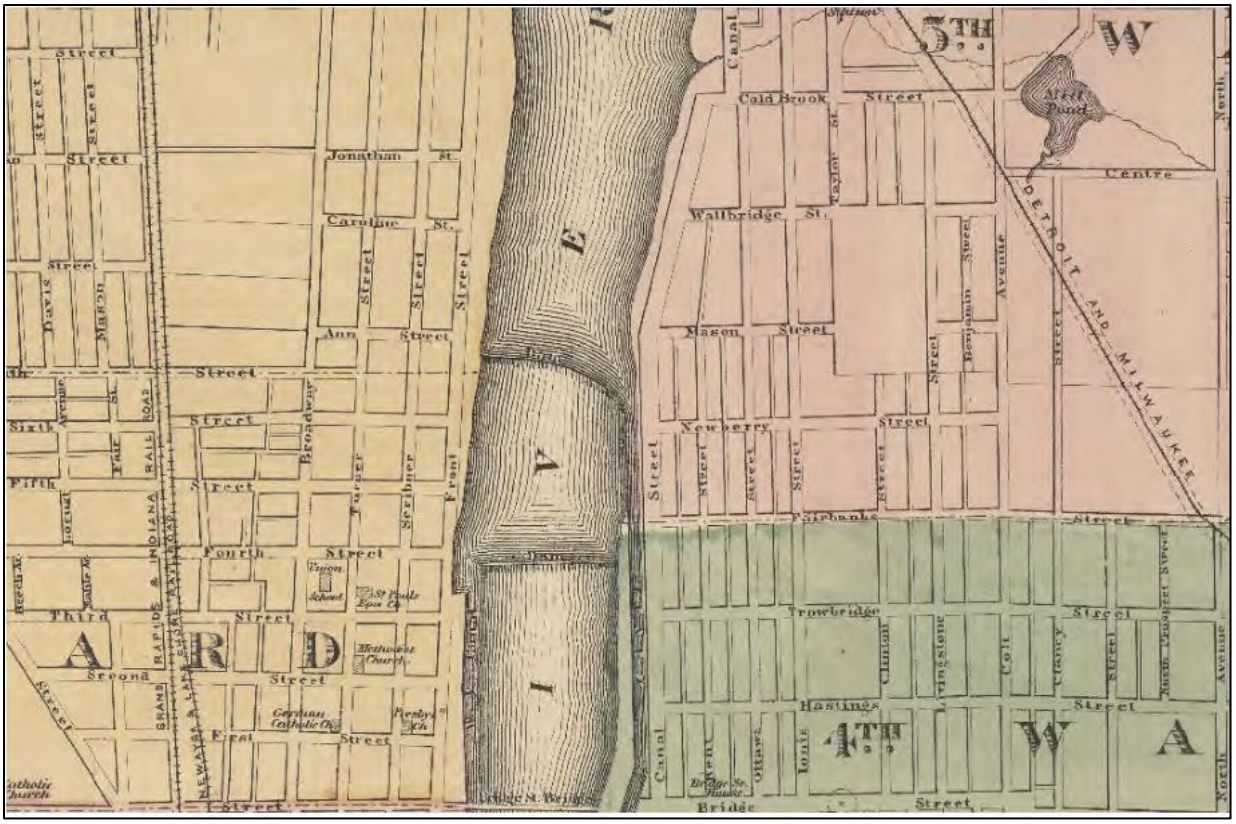

Figure 2.0-3: Map of Grand Rapids in 1873 Showing the 1866 Fourth Street Dam, the 1849 Horseshoe Dam, and the East and West Side Canals (GRCARC)

walls be constructed through the city, and work on these was begun soon after (Figure 2.0-4; Lydens 1966:122). In 1909, Cooley proposed that a new dam be constructed 300 feet north of Bridge Street. This dam was apparently not constructed (Biolchini 2019; Cooley 1909; Forist and Gleisner 2015).

In 1915, another major flood took out a 100-foot section of the western part of the Fourth Street Dam. Plans were proposed for the repair of the dam, with both a timber crib replacement and an upgrade to concrete being considered. The design of the concrete section is nearly identical to the plans later used for the Beautification Dams downstream. It appears from later plans that the damaged section was replaced with concrete, and the remaining timber crib section was replaced in 1926 when the beautification project was undertaken (GRCARC 2019).

The idea of a series of low-head dams on the Grand River in order to maintain water in the river bed and prevent the accumulation of trash and brush in the river was proposed by city planner Harland Bartholomew, whose firm was hired by the Grand Rapids Planning Department in the early 1920s to develop a master plan for the city (GRPL 2017). The diversion of water for the East and West Side Canals and city water works had resulted in the river often lacking a constant flow, resulting in the accumulation of trash and brush in the riverbed (Figure 2.0-5). The low-head dams would maintain the flow of the river and would “add greatly to the appearance and provide ample water surface for boating,” according to Bartholomew (Bartholomew 1925; Biolchini 2019; GRPM ca. 1926). An appropriation was approved for the beautification project in March 1926, but it was not until May 1927 that a bid of $24,112 was accepted from a Grand Rapids firm for the construction, with an expected completion date of

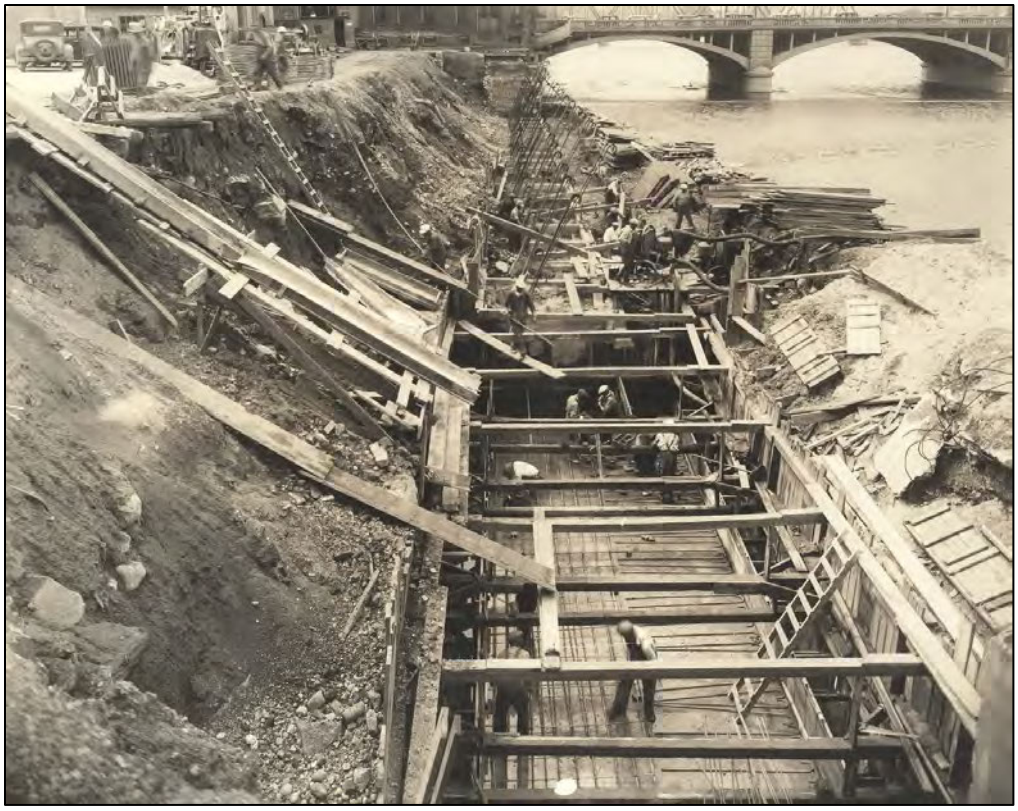

Figure 2.0-4: Construction of Flood Walls on the East Side of the River above the Pearl Street Bridge (GRCARC)



Figure 2.0-5: View of Downtown and the River Showing Brush Growing in the Riverbed Downstream of the Fourth Street Dam (GRPM)

January 1, 1928. The *Grand Rapids Press* praised the city for approving the plan, which would help the river "take on some of the beauty which existed before drought and the west side canal removed all liquid attractions" (*Grand Rapids Press* 1927a, 1927b).

The dams were constructed by diverting water using a coffer dam, leaving the riverbed dry (Figure 2.0-6) (*Grand Rapids Herald* 1927). They were completed by January 2, 1928, when a report of the Engineers' Office noted that it had overseen the placement of the dams at a cost of $37,000. In April 1928, the mayor remarked that the dams had "improved the appearance of the river 100 percent." In July 1928, the *Grand Rapids Press* remarked, "By expenditure on a series of carefully placed dams Grand Rapids has succeeded, without increasing its flood hazard in restoring some of the beauty of Grand river between the main dam at Fourth street and a point two or three hundred feet north of Pearl Street bridge" (*Grand Rapids Press* 1928a, 1928b).

The dams have remained in place to the present, with no known significant changes. The purposes of the dam construction project were well realized, as the water level was maintained, and public and private development became more focused on the river in the twentieth century. Numerous parks and public and private attractions have been established on both sides of the river, including the Gerald R. Ford Presidential Museum, Grand Rapids Public Museum, the Civic Auditorium (now part of the DeVos Place Convention Center), Ah-Nab-Awen Park, and Sixth Street Park.

Details related to the conception, design and construction of the Beautification Dams, as well as their place within the context of city planning in general and the work of Harland Bartholomew in particular, are discussed in greater detail in Section 4.



Figure 2.0-6: Dry Bed of the Grand River during Construction of Beautification Dams, View to the South from Bridge Street Bridge; Dam #2 is in the Foreground (GRCARC)

3. METHODS

3.1 Survey Methods

The current investigation was prompted by a request from the MI SHPO for additional information about the four low-head dams and their historical context to assist in a determination of eligibility. In a comment letter dated December 17, 2020, MI SHPO requested survey information about the nature and condition of the dams and a discussion of their potential NRHP eligibility within a proper historical context.

Because of accessibility issues due to the COVID-19 pandemic and the fact that the dams are currently covered by water, ERM architectural historians undertook a remote survey of the properties based on historical plans and historical and current photographs from a variety of sources including the GRCARC, GRWW, GRPL, Google Earth, and previous site visits. The photographs were used to record the structures' overall appearance and details. Topographic maps and aerial photographs were used to record the relationship of the structures to each other and the surrounding landscape features and infrastructure.

A Michigan State Architectural Properties Identification Form was completed as part of the recordation process, which is attached in Appendix A.

3.2 Documentary Research

In order to assess the significance of the dams, ERM collected information from knowledgeable experts in local history, city planning, and historical public works. ERM conducted online research to identify historic themes, events, and patterns important in the development of local, regional, and national significance. Local government records and information provided by knowledgeable local organizations also were examined to establish a context for the development of the water control systems in Grand Rapids, as well as specific details relating to the system as built and as it exists today. Documents, maps, and photographs were collected from the GRCARC, the GRPM, the GRPL, and the GRHC.

3.3 NRHP and Effects Evaluation

The four dams were evaluated with respect to their eligibility for listing on the NRHP using published guidance from the National Park Service. According to 36 CFR 60.4 (Andrus and Shrimpton 2002), cultural resources eligible for listing on the NRHP are defined as buildings, structures, objects, sites, and districts that have "integrity" and that meet one or more of the criteria outlined below. Criterion D is typically relevant to archaeological sites. Historic resources are generally evaluated in relation to Criteria A, B, and C. Criterion C is typically applicable to architectural resources but also may be relevant in the case of resources that are associated with landscape architecture (like cemeteries or battlefields) or engineering (like dams, bridges, railroads, and mines).

- Criterion A (Event). Association with one or more events that have made a significant contribution to the broad patterns of national, state, or local history
- Criterion B (Person). Association with the lives of persons significant in the past
- Criterion C (Design/Construction). Embodiment of distinctive characteristics of a type, period, or method of construction; or representation of the work of a master; or possession of high artistic values; or representation of a significant and distinguishable entity whose components may lack individual distinction
- Criterion D (Information Potential). Properties that yield, or are likely to yield, information important in prehistory or history. Criterion D is most often (but not exclusively) associated with archaeological resources. To be considered eligible under Criterion D, sites must be associated with specific or

general patterns in the development of the region. Therefore, sites become significant when they are seen within the larger framework of local or regional development.

"Integrity" is perhaps the paramount qualification of NRHP eligibility, and can be related to any or all of the following (Andrus and Shrimpton 2002):

- Location: the place where the historic property (or properties) was/were constructed or where the historic event(s) occurred
- Design: the combination of elements that create the form, plan, space, structure, and style of a property (or properties)
- Setting: the physical environment of the historic property (or properties)
- Materials: the physical elements that were combined to create the property (or properties) during the associated period of significance
- Workmanship: the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory
- Feeling: the property's (or properties') expression of the aesthetic or historic sense of the period of significance
- Association: the direct link between the important historic event(s) or person(s) and the historic property (or properties).

The four dams were evaluated in relation to these criteria and attributes, and then the criteria of adverse effect were applied for the proposed undertaking in accordance with ACHP regulations at 36 CFR 800.5. Specifically,

> An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the National Register. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative.

4. SURVEY RESULTS

This section presents the findings of the historic architectural investigation carried out for the Project. One resource, consisting of four low-head dams in the Grand River at Grand Rapids, known as Beautification Dams, was evaluated as part of the Section 106 review for the Project. The dams would be removed as part of the Project, and thus would be subject to direct effects from the Project.

4.1 Previous Investigations

A literature review of previously recorded resources determined that the Beautification Dams had not been previously recorded as historic resources. An Architectural Properties Identification Form was completed as part of the current investigations (Appendix A).

4.2 Current Survey Findings

The Beautification Dams consist of four low-head concrete dams ranging from 1.5 to 3 feet in height and approximately 425 to 440 feet in length, located in the Grand River between the Interstate 196 Bridge and the Pearl Street Bridge. The four dams together constitute the evaluated resource, and are collectively referred to as the Beautification Dams in the Grand River. They are recommended eligible for the NRHP and are summarized in Table 4.2-1. A view of each dam is shown in Figures 4.2-1 through 4.2-4.

Table 4.2-1: Summary of Beautification Dams in the Grand River

Number	Location	Length*	Height†
Dam #1	135–155 feet north of the center of the Bridge Street Bridge	437 feet	3 feet
Dam #2	148–175 feet south of the center of the Bridge Street Bridge	440 feet	1.5 feet
Dam #3	336–373 feet north of the center of the Gillette Pedestrian Bridge (Interurban Bridge)	440 feet	2 feet
Dam #4	85 feet north of the center of the Pearl Street Bridge	425 feet	1.5 feet

* Estimated length based on aerial photographs

† Based on ca. 1927 profile drawings



Figure 4.2-1: Dam #1, View to the Northeast



Figure 4.2-2: Dam #2, View to the East



Figure 4.2-3: Dam #3, View to the East



Figure 4.2-4: Dam #4, View to the West

4.2.1 Beautification Dams History

Low-head or low-stage dams typically run the width of a river or stream and allow the water flow to pass over all or most of its length. They can be as high as 15 feet, but are more commonly just a few feet in height. These types of dams are common throughout the United States and are usually constructed to raise the water level for civic, industrial, or agricultural use. They also enhance recreational opportunities. Many low-head dams were constructed across the U.S. in the eighteenth and nineteenth centuries to power gristmills and small industries (Tschantz and Wright 2011:8).

The use of low-head dams for beautification and recreation, rather than commercial and industrial uses, coincided with the emergence of city planning as a professional pursuit in the early twentieth century, and a shift in public attitudes toward the environment and the revitalization of urban areas through public improvement projects and regulatory policy (Hill 2000:153). Harland Bartholomew was a prominent city planner from the 1920s to the 1980s, known for advocating for zoning laws and creating the concept of the “City Efficient.” His firm, Harland Bartholomew & Associates (HB&A) developed more than 500 city plans and more than 300 zoning proposals for cities in the U.S. and internationally (Barone 2018:438).

Bartholomew began working on a plan for Grand Rapids as early as 1921 (GRPL 2017). His plan for Grand Rapids was based on similar principles to those he applied in other cities, both large and small. The plans were based on zoning, a concept that was being recognized by city leaders as the most efficient way to maintain property values and grow their cities in a controlled manner. Bartholomew’s zoning classes were based on variations on three factors: use, building height, and lot size. Industrial uses were zoned to the outskirts of the city, along rail lines and waterways, while the downtown area was designated for commercial use. Planning firms worked with city planning commissions to develop a plan that the commission could promote to city officials, civic groups, and business leaders. The planning commissions also worked to build public support for the plans. The goal was to get buy-in from a variety of interests in the city by highlighting the economic advantages that would accrue from a comprehensive zoning plan. In Grand Rapids, the City Planning Commission presented their early planning work at a municipal fair called “City Show” in 1920 (Moskowitz 1998:308–309).

Bartholomew produced a number of documents for the City of Grand Rapids between 1921 and 1927. His overall vision was presented to the public in 1924 through the *Grand Rapids Press* (1924a), which published a rendering of the “Future Grand Rapids” produced by Bartholomew (Figure 4.2-5). The Grand River occupied the prominent spot in the oblique aerial view and was flanked by a tree-lined esplanade on the east bank and a park with trees, open spaces, and walkways on the west bank. The bridge at the bottom of the drawing is the Bridge Street Bridge, with the next two bridges being the interurban rail bridge (Gillette Pedestrian Bridge) and the Pearl Street Bridge. No dams are evident in the view, but the river is full from bank to bank, with no obstructions. Eventually, the esplanade along the river was constructed in the form of the Riveredge Trail, and parks were established along the west side of the river, as envisioned in the plan. The changes proposed in the plan, including a “beautiful river front,” were praised by the paper as “outstanding” (Grand River Press 1924b).

Bartholomew’s City Plan for Grand Rapids included a section on riverfront improvement (Bartholomew 1925:100–103). He stated that the river was the city’s “raison d’etre,” but had fallen into insignificance in the commercial age. However, Bartholomew maintained that opportunities for development were available, and that the city should purchase as much of the riverfront property as possible. The flood walls in place along portions of the river were seen as a positive influence that would permit linear parks adjacent to the river. He recommended the construction of additional walls and the reclaiming land adjacent to the east side of the river that was occupied by the East Side Canal and constructing a road alongside the river. This would separate the buildings from the riverside docks and encourage more aesthetic architecture. The improvements would not interfere with the commercial or industrial activities of

the city, because the river no longer had value to those interests. The plan for the river was plainly laid out, including improving the appearance below the existing 6th Street dam:

> Grand Rapids must complete its flood wall as a protective measure. It would seem that this work would offer the best opportunity to carry out a more thorough riverfront improvement program. Not only should the banks be improved by the use of wall, terraces, small parks and plazas, but the appearance of the river below the dam should be improved. During the dry seasons certain stretches of the rapids have the appearance of an abandoned stone quarry overgrown with weeds and littered with tin cans, crates and rubbish. Several low-stage dams could be constructed at intervals which would maintain water constantly in the river. This would add greatly to the appearance and provide ample water surface for boating [Bartholomew 1925:102].

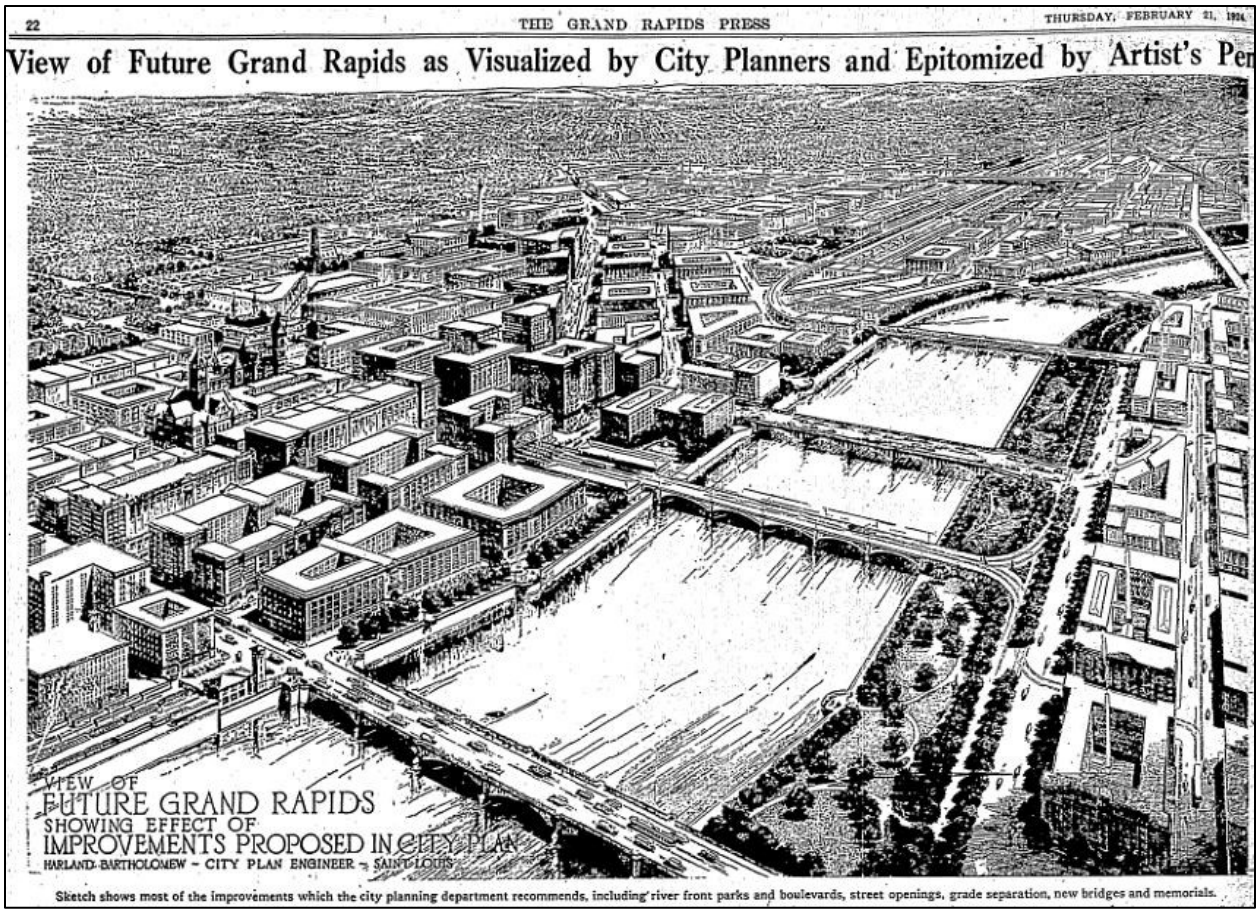

Figure 4.2-5: Artist Rendition of Harland Bartholomew's City Plan (1924)

In October 1925, the city reached an agreement with the Consumers Power Company (the former West Side Water Power Association) and the East Side Power Company to purchase the rights to the East Side Canal, which would be closed to form a sewer and a riverside park. The city had held an option on the rights to the canal for some time, and it appears that the acquisition of the property was part of the effort to carry out the plans for beautification of the river. The agreement stipulated that the city "reserved perpetual right to sufficient water for all city purposes, and that "sufficient water must be kept running over

the large dam to keep a series of smaller dams filled the year around" (*Grand Rapids Press* 1925). The story in the *Grand Rapids Press* stated that the city would keep the river clean, and "To this end it has secured the necessary options for construction of three dams, one just north of Bridge-st., one just south of Bridge-st., and third just north of Pearl-st., calculated to hold enough water to hide the ugly bottom, now strewn with all manner of debris and overgrown with weeds." According to the article, the "pretentious program of beautification, as sketched by Harland Bartholomew of St. Louis, city planning expert responsible for Grand Rapids' zoning ordinance, now approaches a step nearer realization."

The value of improving the river both economically and aesthetically was not lost on observers, even in the planning stages. The *Grand Rapids Press* noted of the plan in 1925 that, "Advantage will be taken of the open sloping west bank, which now is a mass of weeds, and a modest program of landscaping and care is expected to do wonders." The acquisition of the canal land allowed for a reorganized street plan and the availability of valuable land. "When this wilderness of rubbish, old iron and decrepit buildings has been cleared away the increased value of the property, according to the analysis of [assistant to the city's consulting engineer] Mr. Tenlloor, will have justified the trouble, and the city will be rid of perhaps its greatest fire menace" (*Grand Rapids Press* 1925).

The original plan apparently included five dams, but only four were constructed due to water rights of the last user of the West Side Canal for a water wheel (*Grand Rapids Press* 1927a, 1928b). The city appropriated $7,500 in March of 1926 for "…beautification of Grand River through the erection of dams intended to create a greater depth of water inside the city limits" (*Grand Rapids Press* 1926). However, it was not until May of 1927 that a bid was accepted for the project. The $24,000 bid of Peninsular Construction Company of Grand Rapids was over the city's estimate for the work, but was less than the only other bid received. The plans at that time were for the dams to be constructed of concrete and approximately 470 feet long. The dams were to be located 100 feet north of Bridge Street, 36 feet south of Bridge Street, at Brumrich Street, 50 feet north of Pearl Street, and 35 feet south of Pearl Street (*Grand Rapids Press* 1927a). The locations given approximate the final placements, which are detailed in Table 4.2-1.

Profile plans of the dams are shown in Figure 4.2-6 (GRCARC ca. 1927). It is not clear if the dams were built to these exact specifications, as no as-built drawings have been located. The profiles indicate that Dam #1 would have a height of 3 feet, Dam #2 and Dam #4 would be 1.5 feet high, and Dam #3 and Dam #5 would each be 2 feet high. Dam #5 was eventually dropped from the plan. A profile map of the river made in 1928 indicates that the actual dams were lower (GRCARC 1928). Current elevations taken across the dams show irregular heights across the width of the dams and only about a 1–1.5-foot drop between them. This may be due to erosion of the tops of the dam as a result of water scouring. The profiles in Figure 4.2-6 show a typical low-head concrete dam shape that has a slightly sloping upstream face with a beveled cap and a ramp-like downstream face to break the fall of the water. Each dam would have a flap or drain valve at the base. Figure 4.2-7 shows the profile of the dams after construction, which is consistent with the plans. The valve appears to have been constructed as a gated opening rather than an outlet in the base of the dam, as can be seen in Figure 4.2-8.

Work on the coffer dam to divert the river during construction began by July 1927 (*Grand Rapids Herald* 1927). As noted above, the dams were completed on schedule by January 1, 1928, although the $37,000 cost was considerably more than the $24,000 bid. Figure 4.2-9 shows Dam #1 after construction, looking north, with the Sixth Street Dam in the background.

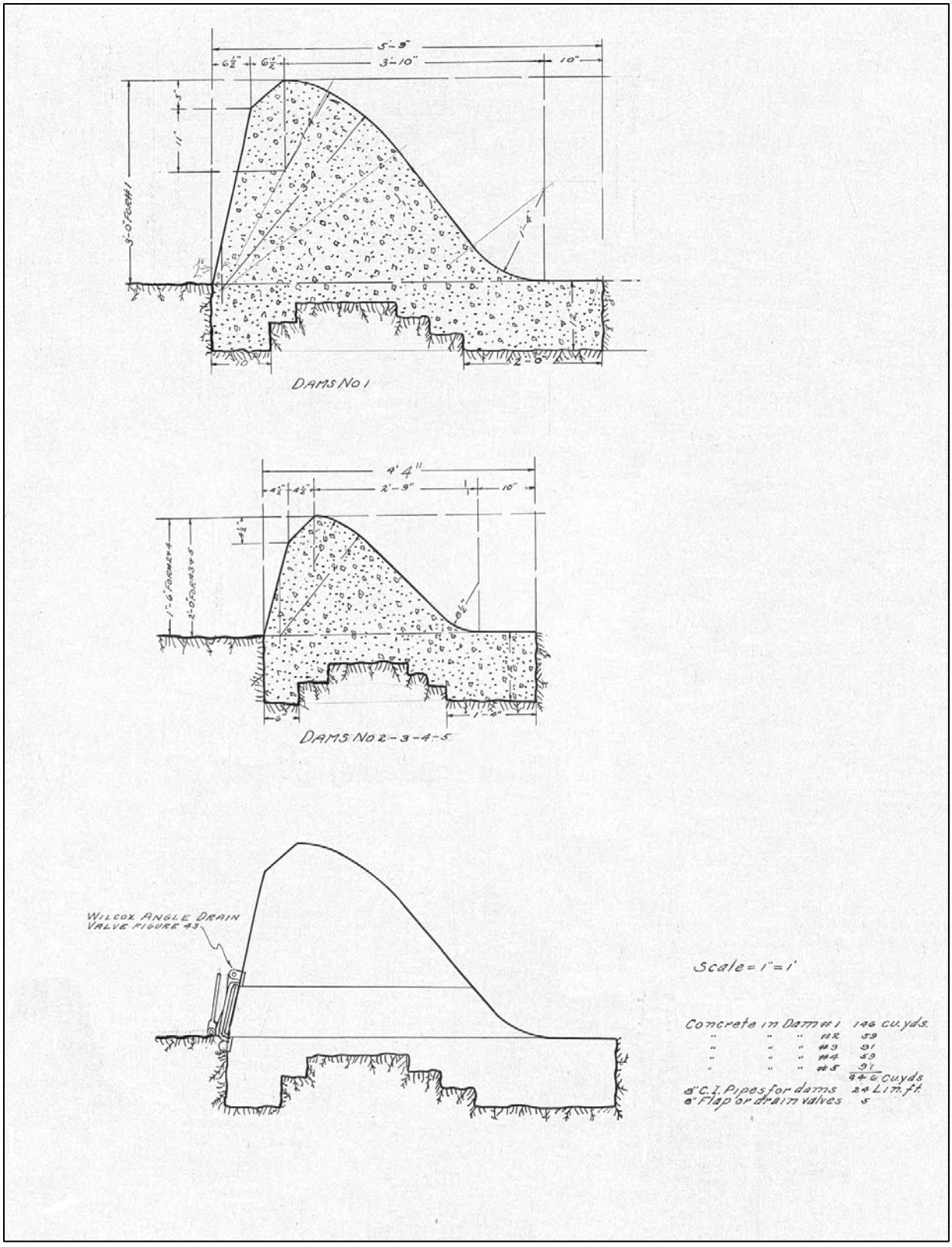

Figure 4.2-6: Engineering Drawings Showing Profile of Dams, ca. 1927 (GRCARC)



Figure 4.2-7: View of Dam #1, North of Bridge Street, 1927, Showing Dam Profile (GRCARC)



Figure 4.2-8: View of Dam #1, North of Bridge Street, 1927, Showing Opening Near Center (GRCARC)



Figure 4.2-9: Dam #1 after Construction, 1927, with Water Flowing in the River Bed (GRCARC)

4.2.2 Beautification Dams: Architectural Description and Evaluation

The Beautification Dams in the Grand River are four low-head, concrete dams that run the width of the river in downtown Grand Rapids. They vary in height from 1.5 to 3 feet, and in length from approximately 425 feet to 440 feet. They are anchored in bedrock to a depth of approximately 1 foot. Historical drawings and photographs indicate that a gated opening was located in each dam, but the nature and location of these openings in the current dams is not clear due to the dams being obscured by water. The dams have the same basic profile as shown in Figures 4.2-6 and 4.2-7. The form and construction technique is typical of low-head dams constructed throughout the United States during the period.

NRHP Evaluation: ERM recommends that the Beautification Dams in Grand River are potentially eligible for the NRHP under Criterion A for their association with events important to the history of Grand Rapids. The dams reflect efforts in the early twentieth century to improve the city through planning, zoning, and public works projects. The result was a shift in the orientation of the downtown area to embrace the river as an attraction for enjoyment and recreation. Parks and trails were established along the banks, and new buildings were constructed with an emphasis on attractive architecture that encouraged public use of the surrounding spaces. ERM recommends that the dams are also significant under Criterion B for their association with Harland Bartholomew, one of the most influential city planners of the twentieth century.

Beginning in St. Louis in 1916, Bartholomew and his firm developed plans for hundreds of cities, influencing zoning decisions and promoting urban renewal and beautification. Bartholomew's plan for Grand Rapids specifically called for the installation of the dams, which consequently influenced the development of the downtown area in the way in which he intended. Although the Beautification Dams retain sufficient architectural integrity to convey the resources' historical significance, their design is utilitarian and common to contemporary structures across the country. As a result, they do not represent exceptional design or engineering and do not constitute an outstanding example of architecture associated with historic water control features. Therefore, ERM recommends the Beautification Dams in Grand River are not potentially eligible for the NRHP under Criterion C. For similar reasons, ERM recommends that the dams are not likely to yield information important to history and are thus not potentially eligible under Criterion D.

Assessment of Effects: The function of the Beautification Dams would not be retained as a result of their removal, although the Project is intended to restore the beauty of the original rapids that once characterized the river. The placid, quiet waters created by the dams would be replaced by faster moving water that would create a different atmosphere than that which characterized the river between 1927 and the present. Although the goal of the Project, in part, is similar to that of the 1925 Bartholomew plan in making the river attractive for expanded recreation and use, the nature of the experience for those using the river space would be different from that intended by Bartholomew. Therefore, it is ERM's opinion that the proposed removal of the dams would compromise the character-defining features of the dams that make them historically significant, and the action would constitute an adverse effect.

5. CONCLUSION AND RECOMMENDATIONS

ERM conducted an evaluation of the NRHP eligibility of four low-head dams in the Grand River in Grand Rapids, which would be affected by the Grand Rapids Whitewater Project. With the support of the City of Grand Rapids and GRWW, ERM prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are potentially eligible for the NRHP, and if so, whether removal of the dams as part of the Project would result in adverse effects to these cultural resources. The findings of the current study are intended to support the Section 106 review of the proposed undertaking, which is subject to funding by the NRCS.

Based on the information gathered and presented here, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are potentially eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. Although the Beautification Dams retain sufficient architectural integrity to convey their historical significance, their design is utilitarian and common to contemporary structures across the country, and is not likely to yield information important to history. Therefore, ERM recommends that the Beautification Dams are not potentially eligible for the NRHP under Criteria C and D.

The function of the Beautification Dams to maintain water levels across the width of the Grand River would not be retained as a result of their removal. Although the goal of the Project, in part, is similar to that of the 1925 Bartholomew plan in making the river attractive for expanded recreation and use, the nature of the experience for those using the river space would be different from that intended by Bartholomew. Therefore, it is ERM's opinion that the proposed removal of the dams would compromise the character-defining features of the dams that make them historically significant, and the action constitutes an adverse effect. The Project plan as currently proposed requires removal of all of the dams and does not allow for avoidance or minimization of adverse effects. It is ERM's recommendation that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project.

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1888 Fire Insurance Maps of Grand Rapids, Michigan. Sanborn Map & Publishing Company, New York.

Tschantz, Bruce A., and Kenneth R. Wright
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APPENDIX A ARCHITECTURAL PROPERTIES IDENTIFICATION FORM

Michigan SHPO Architectural Properties Identification Form

Property Overview and Location

Street Address	Grand River, between I-196 Bridge and Pearl Street Bridge				
City/Township, State, Zip Code	Grand Rapids, Michigan, 49503				
County	Kent				
Assessor's Parcel #	N/A				
Latitude/Longitude (to the 6th decimal point)	Lat:42.968836		Long: -85.674529		
Ownership	Private ☐	Public-Local ☒	Public-State ☐	Public-Federal ☐	Multiple ☐

Property Type

Building ☐ select sub-type below Commercial ☐ Residential ☐ Industrial ☐ Other ☐	Structure ☒ Object ☐

(Insert primary photograph below.)



Architectural Information

Construction Date	1927	
Architectural Style	Dams (4)	
Building Form	Low-head dams	
Roof Form	N/A	
Roof Materials	N/A	
Exterior Wall Materials	N/A	
Foundation Materials	Bedrock anchor	
Window Materials	N/A	
Window Type	N/A	
Outbuildings	Yes ☐	No ☒
Number/Type:		

Eligibility

Individually Eligible	Criterion A ☒	Criterion B ☒	Criterion C ☐	Criterion D ☐
Criteria Considerations:		a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐		
Component of a Historic District	Contributing to a district ☐	Non-contributing to a district ☐	Historic District Name	
Not Eligible ☐				

Area(s) of Significance	Events important to history of Grand Rapids, association with Harland Bartholomew						
Period(s) of Significance	1927						
Integrity – Does the property possess integrity in all or some of the 7 aspects?							
Location ☒	Design ☒	Materials ☒	Workmanship ☒	Setting ☒	Feeling ☒	Association ☒	
General Integrity:	Intact ☒	Altered ☐	Moved ☐	Date(s):			
Historic Name	Beautification Dams						
Current/Common Name	Beautification Dams						
Historic/Original Owner	City of Grand Rapids						
Historic Building Use	Dams						
Current Building Use	Dams						
Architect/Engineer/Designer	Harland Bartholomew & Associates						
Builder/Contractor	Peninsular Construction Company						

Survey Date	7 Nov 2018	Recorded By	ERM	Agency Report #	

For SHPO Use Only	SHPO Concurrence?: Y / N	Date:

Form date: 2/28/2020

Narrative Architectural Description

Provide a detailed description of the property, including all character-defining features and any accessory resources. This is required for all properties.

The Beautification Dams in the Grand River are four low-head, concrete dams that run the width of the river in downtown Grand Rapids. They vary in height from 3 feet to 1.5 feet, and in length from approximately 425 feet to 440 feet. They are anchored in bedrock to a depth of approximately 1 foot. The only feature of the dams is an opening, presumably for flow and debris control. The dams have the same basic profile. The form and construction technique is typical of low-head dams constructed throughout the United States during the period.

History of the Resource

Provide information on previous owners, land use(s), and construction and alteration dates in a narrative format. This is required for all intensive level surveys, NRPQs, and nominations, and recommended for other identification efforts.

(see Figures at end of form)

Low-head or low-stage dams typically run the width of a river or stream and allow the water flow to pass over all or most of its length. They can be as high as 15 feet, but are more commonly just a few feet in height. These types of dams are common throughout the United States and are usually constructed to raise the water level for civic, industrial, or agricultural use. They also enhance recreational opportunities. Many low-head dams were constructed across the U.S. in the eighteenth and nineteenth centuries to power gristmills and small industries (Tschantz and Wright 2011:8).

The use of low-head dams for beautification and recreation, rather than commercial and industrial uses in the early twentieth century coincided with the emergence of city planning as a professional pursuit, and a shift in public attitudes toward the environment and the revitalization of urban areas through public improvement projects and regulatory policy (Hill 2000:153). Harland Bartholomew was a prominent city planner from the 1920s to the 1980s, known for advocating for zoning laws and creating the concept of the “City Efficient.” His firm, Harland Bartholomew & Associates (HB&A) developed more than 500 city plans and more than 300 zoning proposals for cities in the U.S. and internationally, making it likely the largest city planning firm in the country (Barone 2018:438).

Bartholomew began working on a plan for Grand Rapids as early as 1921 (GRPL 2017). His plan for Grand Rapids was based on similar principles to those he applied in other cities, both large and small. The plans were based on zoning, a concept that was being recognized by city leaders as the most efficient way to maintain property values and grow their cities in a controlled manner. Bartholomew’s zoning classes were based on variations on three factors: use, building height, and lot size. Industrial uses were zoned to the outskirts of the city, along rail lines and waterways, while the downtown area was designated for commercial use. Planning firms worked with city planning commissions to develop a plan that the commission could sell to city officials, civic groups, and business leaders. The planning commissions also worked to build public support for the plans. The goal was to get buy-in from a variety of interests in the city by highlighting the economic advantages that would accrue from a comprehensive zoning plan. In Grand Rapids, the City Planning Commission presented their early planning work at a municipal fair called “City Show” in 1920 (Moskowitz 1998:308–309).

Bartholomew produced a number of documents for the City of Grand Rapids between 1921 and 1927. His overall vision was presented to the public in 1924 through the *Grand Rapids Press* (1924a), which published a rendering of the “Future Grand Rapids” produced by Bartholomew (Figure 1). The Grand River occupied the prominent spot in the oblique aerial view and was flanked by a tree-lined esplanade on the east bank and a park with trees, open spaces, and walkways on the west bank. The bridge at the bottom of the drawing is the Bridge Street Bridge, with the next two bridges being the interurban rail bridge (Gillette Pedestrian Bridge) and the Pearl Street Bridge. No dams are evident in the view, but the river is full from bank to bank, with no obstructions. Eventually, the esplanade

along the river was constructed in the form of the Riveredge Trail, and parks were established along the west side of the river, as envisioned in the plan. The changes proposed in the plan, including a "beautiful river front," were praised by the paper as "outstanding" (Grand River Press 1924b)

Bartholomew's City Plan for Grand Rapids included a section on riverfront improvement (Bartholomew 1925:100–103). He stated that the river was the city's "raison d'etre," but had fallen into insignificance in the commercial age. However, Bartholomew maintained that opportunities for development were available, and that the city should purchase as much of the riverfront property as possible. The flood walls in place along the river were seen as a positive influence that would permit linear parks adjacent to the river. He recommended reclaiming land adjacent to the east side of the river that was occupied by the East Side Canal and constructing a road alongside the river. This would separate the buildings from the riverside docks and encourage more aesthetic architecture. The improvements would not interfere with the commercial or industrial activities of the city, because the river no longer had value to those interests. The plan for the river was plainly laid out:

> Grand Rapids must complete its flood wall as a protective measure. It would seem that this work would offer the best opportunity to carry out a more thorough riverfront improvement program. Not only should the banks be improved by the use of wall, terraces, small parks and plazas, but the appearance of the river below the dam should be improved. During the dry seasons certain stretches of the rapids have the appearance of an abandoned stone quarry overgrown with weeds and littered with tin cans, crates and rubbish. Several low-stage dams could be constructed at intervals which would maintain water constantly in the river. This would add greatly to the appearance and provide ample water surface for boating. (Bartholomew 1925:102)

In October 1925, the city reached an agreement with the Consumers Power Company (the former West Side Water Power Association) and the East Side Power Company to purchase the rights to the East Side Canal, which would be closed to form a sewer and a riverside park. The city had held an option on the rights to the canal for some time, and it appears that the acquisition of the property was part of the effort to carry out the plans for beautification of the river. The agreement stipulated that the city "reserved perpetual right to sufficient water for all city purposes,"…and that "sufficient water must be kept running over the large dam to keep a series of smaller dams filled the year around" (*Grand Rapids Press* 1925). The story in the *Grand Rapids Press* stated that the city would keep river clean, and "To this end it has secured the necessary options for construction of three dams, one just north of Bridge-st., one just south of Bridge-st., and third just north of Pearl-st., calculated to hold enough water to hide the ugly bottom, now strewn with all manner of debris and overgrown with weeds." According to the article, the "pretentious program of beautification, as sketched by Harland Bartholomew of St. Louis, city planning expert responsible for Grand Rapids' zoning ordinance, now approaches a step nearer realization."

The value of improving the river, both economically and aesthetically was not lost on observers, even in the planning stages. The *Grand Rapids Press* noted of the plan in 1925 that, "Advantage will be taken of the open sloping west bank, which now is a mass of weeds, and a modest program of landscaping and care is expected to do wonders." The acquisition of the canal land allowed for a reorganized street plan and the availability of valuable land. "When this wilderness of rubbish, old iron and decrepit buildings has been cleared away the increased value of the property, according to the analysis of [assistant to the city's consulting engineer] Mr. Tenlloor, will have justified the trouble, and the city will be rid of perhaps its greatest fire menace" (*Grand Rapids Press* 1925).

The original plan apparently included five dams, but only four were constructed due to water rights of the last user of the West Side Canal for a water wheel (*Grand Rapids Press* 1927a, 1928b). The city appropriated $7,500 in March of 1926 for "…beautification of Grand River through the erection of dams intended to create a greater depth of water inside the city limits" (Grand Rapids Press 1926). However, it was not until May of 1927 that a bid was accepted for the project. The $24,000 bid of Peninsular Construction Company of Grand Rapids was over the city's estimate for the work, but was less than the only other bid received. The plans at that time were for the dams to be constructed of concrete and approximately 470 feet long. The dams were to be located 100 feet north of Bridge Street, 36 feet south of Bridge Street, at Brumrich Street, 50 feet north of Pearl Street, and 35 feet south of Pearl Street (*Grand Rapids Press* 1927a).

Profiles plans of the dams are shown in Figure 2 (GRCARC ca. 1927). It is not clear if the dams were built to these

exact specifications, as no as-built drawings have been located. The profiles indicate that Dam #1 would have a height of 3 feet, Dam #2 and Dam #4 would be 1.5 feet high, and Dam #3 and Dam #5 would each be 2 feet high. Dam #5 was eventually dropped from the plan. A profile map of the river made in 1928 indicates that the actual dams were lower (GRCARC 1928). Current elevations taken across the dams show irregular heights across the width of the dams and only about a 1–1.5-foot drop between them. This may be due to erosion of the tops of the dam as a result of water scouring. The profiles in Figure 2 show a typical low-head concrete dam shape that has a slightly sloping upstream face with a beveled cap and a ramp-like downstream face to break the fall of the water. Each dam would have a flap or drain valve at the base. Figure 3 shows the profile of the dams after construction, which is consistent with the plans. The valve appears to have been constructed as a gated opening rather than an outlet in the base of the dam, as can be seen in Figure 4.

Work on the coffer dam to divert the river during construction began by July 1927 (*Grand Rapids Herald* 1927). As noted above, the dams were completed on schedule by January 1, 1928, although the $37,000 cost was considerably more than the $24,000 bid. Figure 5 shows Dam #1 after construction, looking north, with the Sixth Street Dam in the background.

Statement of Significance/Recommendation of Eligibility

Provide a detailed explanation of the property's eligibility for the National Register. Include an evaluation under at least one of the four National Register Criteria and one Area of Significance. Include a discussion of the seven aspects of integrity, and make a recommendation about eligibility. This is required for all properties.

The Beautification Dams retain integrity of location, as they have not moved from their original location. In addition, the associated bridges and the river have remained unchanged, and most of the buildings surrounding the dams are original to the construction of the dams, which means the dams still retain integrity of setting. The Beautification Dams do retain their design and material integrity as no alterations to the utilitarian structures are known. Furthermore, the dams retain integrity of workmanship and association as a structure that conveys the craftsmanship of a utilitarian design tied to water control and public works improvement projects. Finally, the Beautification Dams retain integrity of feeling when viewed as a whole, with the river and surrounding bridges. For these reasons, ERM recommends that the Beautification Dams in Grand River are potentially eligible for the NRHP under Criterion A for their association with events important to the history of Grand Rapids. The dams reflect efforts in the early twentieth century to improve the city through planning, zoning, and public works projects. The result was a shift in the orientation of the downtown area to embrace the river as an attraction for enjoyment and recreation. Parks and trails were established along the banks, and new buildings were constructed with an emphasis on attractive architecture that encouraged public use of the surrounding spaces. ERM recommends that the dams are also significant under Criterion B for their association with Harland Bartholomew, one of the most influential city planners of the twentieth century. Beginning in St. Louis in 1916, Bartholomew and his firm developed plans for hundreds of cities, influencing zoning decisions and promoting urban renewal and beautification. Bartholomew's plan for Grand Rapids specifically called for the installation of the dams, which consequently influenced the development of the downtown area in the way in which he intended. Although the Beautification Dams retain sufficient architectural integrity to convey the resources' historical significance, their design is utilitarian and common to contemporary structures across the country. As a result, they do not represent exceptional design or engineering and do not constitute an outstanding example of architecture associated with historic water control features. Therefore, ERM recommends the Beautification Dams in Grand River are not potentially eligible for the NRHP under Criterion C. For similar reasons, ERM recommends that the dams are not likely to yield information important to history and are thus not potentially eligible under Criterion D.

References

List references used to research and evaluate the individual property. For NRPQ's include copies of key documents.

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_____ 1924b. “The Future City.” 22 February.

_____ 1925. “Power Company and City Ready for Canal Deal.” 17 October.

_____ 1926. “Asks More Cash to Conduct City in Coming Year; Would Beautify River.” 29 March.

_____ 1927a. “Grand Rapids Firm Bids Lowest on Beauty Dams.” 26 May.

_____ 1927b. “For a Wet River.” 7 July.

_____ 1928a. “A Promising Start.” 25 April.

_____ 1928b. “Our River.” 25 July.

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Figure 1: Artist Rendition of Harland Bartholomew's City Plan (1924).

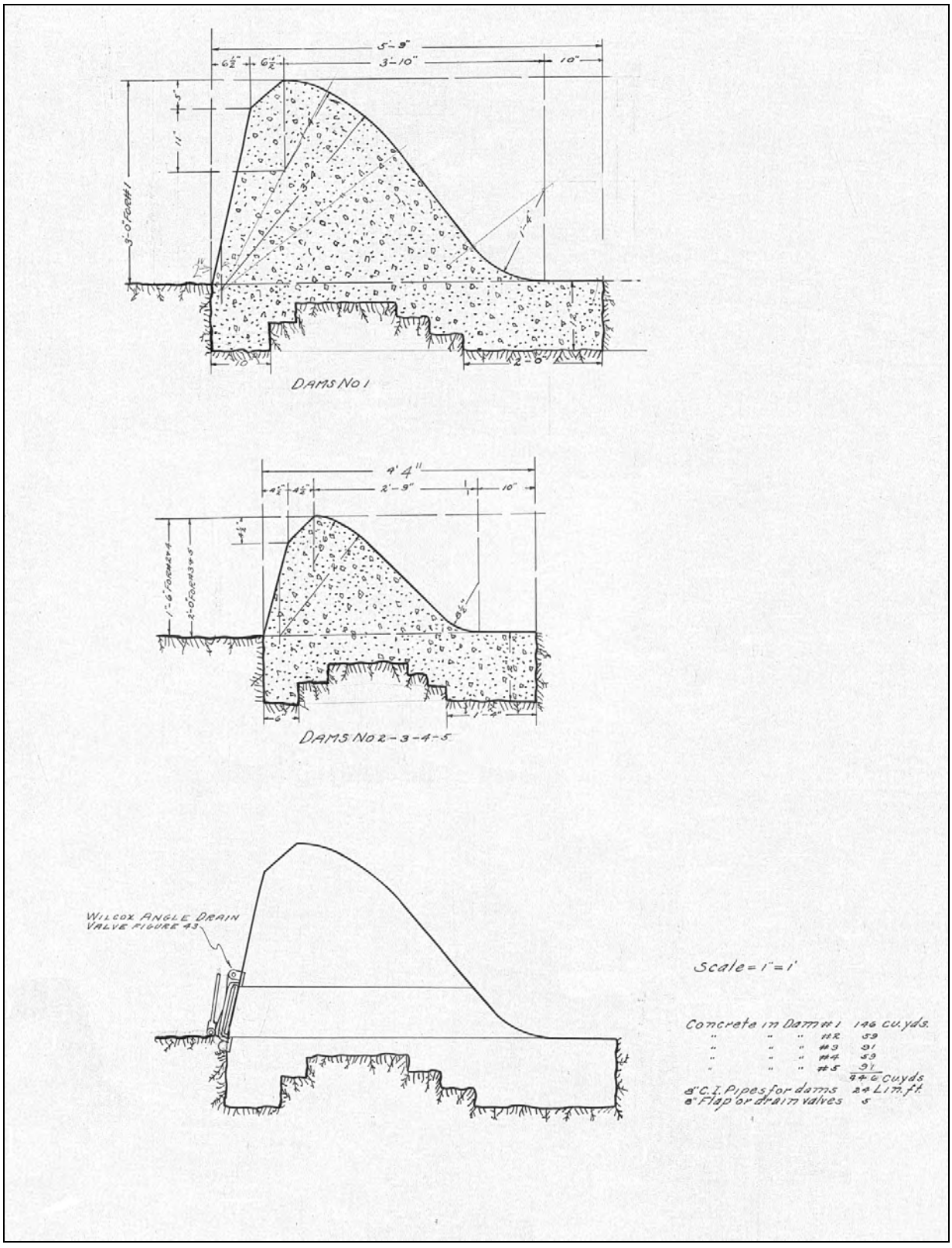


Figure 2: Engineering Drawings Showing Profile of Dams, ca. 1927 (GRCARC)



Figure 3: View of Dam #1, North of Bridge Street, 1927, Showing Dam Profile (GRCARC).



Figure 4: View of Dam #1, North of Bridge Street, 1927, Showing Opening Near Center (GRCARC).



Figure 5: Dam #1 after Construction, 1927, with Water Flowing in the River Bed (GRCARC).



Dam #2, View to the East.



Dam #3, View to the East.



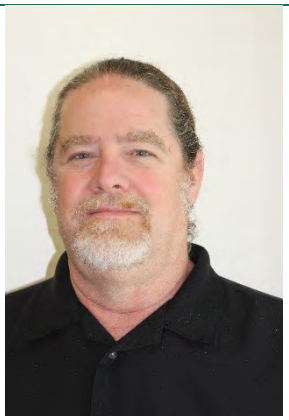
Dam #4, View to the West.

APPENDIX B RESUMES

Jeffrey L. Holland

Historian

Mr. Holland has over 30 years of experience on Cultural Resources Management projects throughout the eastern United States, the Midwest, and Texas. He has conducted historical research and documentation for National Register properties and districts, HABS/HAER recordation, Assessments of Effects reports, and cultural resources survey, testing, and data recovery projects. He has also authored popular histories for major industrial facilities and summaries of archaeological projects for public education. Mr. Holland's specialties include slavery, African American history, nineteenth century agriculture, the Civil War, and the history of military installations, utilities, and infrastructure in the twentieth century.



Experience: 30+ years' experience in Section 106, NEPA, and Historic Preservation Planning for government, energy, and industrial sectors

Email: jeffrey.holland@erm.com

LinkedIn: https://www.linkedin.com/in/jeff-holland-54993548/

Education

- M.A., History (with Historical Archaeology Apprenticeship), College of William & Mary, 1995
- B.A., History, Davidson College, 1984

Fields of Competence

- Historical research, documentation, and assessment of NRHP properties
- NEPA, Section 106
- Historic preservation planning
- Genealogical research
- Cemetery relocation
- Historical archaeology

Languages

- English, native speaker

Key Industry Sectors

- Energy
- Military
- Utilities
- Transportation

Publications

- Holland, Jeffrey. 2007. Landownership and Hardship: Interpreting the Landscape of an African-American Community in Eastern Gwinnett County, Georgia. *Early Georgia* 35(2).
- Holland, Jeffrey. 2006. *Under One Roof: The Story of Air Force Plant 6.* Aeronautical System Center, Acquisition Environmental, Safety, & Health Division, Wright-Patterson Air Force Base, Ohio.
- Garrow, Patrick H., and Jeffrey L. Holland. 2005. Camp Lincoln and the Army of Southeastern Missouri. *Missouri Archaeologist* 66 (Dec):93–118
- Pietak, Lynn Marie, and Jeffrey L. Holland. 2003. Excavations at the Colclough Farmstead: Exploring Rural Life in Nineteenth and Twentieth Century Northeastern Mississippi. *Mississippi Archaeology* 37(2):165–218.

Key Projects at ERM

Energy Client, Pipeline Project, 2015–2019
Conducted cultural resource investigations as part of the permitting of a 600-mile natural gas pipeline in three states. Prepared historical contexts, conducted research on properties, assessed effects of project on resources, prepared mitigation plans for NRHP-eligible properties. Federal Energy Regulatory Commission issued Programmatic Agreement approving implementation of mitigative measures to complete compliance with Section 106 of the National Historic Preservation Act.

Energy Client, Wind Energy Project, 2019–2020
Prepared a Cumulative Visual Effects Assessment for a proposed off-shore wind energy installation of 800-megawatts in the waters of Rhode Island and Massachusetts. The analysis incorporated 17 lease areas and 761 wind generating turbines from the proposed project and reasonable foreseeable future projects. The assessment focused on three historic properties, including a Traditional Cultural Property and a National Historic Landmark.

Energy Client, Wind Energy Project, 2017–2019
Developed context and assessed historic significance for resources in three county area of northeast Pennsylvania that might be affected by a series of proposed wind turbines sites. The context addressed thematic resource types of primary significance in the region including coal industry related sites, railroads, and agricultural properties.

Energy Client, NRHP Evaluation of LNG Terminal, 2019
Developed context and assessed historical significance of an LNG terminal in Alaska completed in 1969 that was the first to export LNG from the United States. The research addressed the process involved in liquefying natural gas and changes to the plant over time. The plant was recommended as eligible for the NRHP.

Energy Client, NRHP Evaluation of Abandoned Pipeline, 2018
Served as author of reports for four western states assessing the historical significance of a 700-mile former oil pipeline converted to natural gas that was slated for abandonment. The assessment was conducted in accordance with a Notice of Exemption issued by the Advisory Council on Historic Preservation regarding abandoned historic natural gas pipelines.

Manufacturing Client, NRHP Evaluation of Historic Orchard Property, 2018
Conducted historical research and produced historical context for historic apple orchard and other historic properties in Jefferson County, West Virginia. Assessed significance of properties and potential direct and visual effects of a fiber manufacturing facility.

Energy Client, Wind Energy Project, 2016–2017
Developed context and assessed historic significance for resources in four county area of northeast West Virginia that might be affected by a series of proposed wind turbines sites. The context addressed a number of resource types including historic coaling and lumber communities, railroads, and industrial sites. Assessed architectural resources for NRHP eligibility under Criteria A and B through local history sources, deed research, and genealogy. Prepared inventory forms for data entry.

Key Projects Prior to Joining ERM

Energy Client, NRHP Documentation, 2014
Researched the ownership history and development of the William Evans farmhouse and associated buildings using county records, historical maps, census returns, and other primary and secondary sources as part of a Memorandum of Agreement to mitigate the effects of a transmission line with a permanent archival record of the property

Government Agency, Nuclear Power Program History, 2013
Conducted historical research using documents from the agency's corporate libraries, records in the National Archives, contemporary newspaper articles, and secondary sources on the nuclear power industry to produce a fully-referenced, illustrated history of what was for many years the nation's largest nuclear power program. The agency commissioned this historical overview of its nuclear power program to provide a concise reference for the agency.

Government Agency, HABS Documentation, 2012
Examined project records and historic photographs, along with other primary and secondary sources to establish the history of the former project offices of the Falcon Dam Project on the Rio Grande, constructed in 1951.

Government Agency, NRHP Assessment, Levees and Water Control Features, 2010–2011
Researched the records of the U.S. Boundary and Waters Commission and the Bureau of Reclamation to assess the significance of two levees constructed on the Rio Grande to control flooding. The levees interfaced with irrigation systems constructed prior to the levees, which also had historic features.

Government Agency, Oral History Documentation of Federal Housing Project, 2009
Conducted historical research on two housing projects slated for demolition using records at the local historical societies and libraries. Current residents of the developments were interviewed about their experiences in public housing. The documentation was part of a recordation of the two facilities intended to produce a comprehensive history of the public housing prior to the sale of the properties by the city.

Energy Client, Pipeline Project, 2008
Produced statewide contexts for five states, as well as more specific histories for dozens of counties and parishes along a 507-mile natural gas transmission pipeline in the southeast U.S. Historical research was also conducted on identified architectural resources to aid the assessment of their NRHP significance. The project was conducted on a short time schedule.

Military Agency, Air Force Facility History, 2006
Served as Historian and Author for the production of a pictorial history of Air Force Plant 6, an aircraft assembly plant operated by Bell Aircraft Company during World War II and later by Lockheed Aeronautics Company and its successors. The book is a fully-illustrated, perfect-bound history of the plant intended for a general audience and was distributed to libraries, government agencies, and other interested organizations.

Government Agency, Cultural Resources Survey of Redevelopment Property, 2006
Researched agency records and photographs on site and at the National Archives Southeast Region Branch in Atlanta, as well as local facilities to document the history and historic significance of a portion of the agency's reservation. The site included numerous industrial properties related to weapons manufacture in World War I, New Deal agricultural programs, and hydroelectric power. The assessment of the facilities was later used to develop an adaptive reuse plan for the property.

Government Agency, Archaeological Data Recovery in Historic District, 2006
Served as a Historian for this investigation of two blocks of a commercial and residential street in a historically black neighborhood of Savannah, Georgia. Using Sanborn Fire Insurance maps, city directories, and a variety of historical sources, documented neighborhood development, racial and social composition, and landscape characteristics over a period of approximately 100 years. The information was applied to the archaeological evidence from the excavation of features related to domestic and business activities on the street during the early twentieth century. A popular pamphlet on the results of the investigation was also produced.

Government Agency, Historical Research for NRHP Historic District Nomination, 2005
Conducted background research on the history of town in West Georgia, the evolution of the built environment within the district, and the construction date of the buildings, as part of a survey of 60+ properties for this historic downtown historic district. The information was used for an NRHP nomination submitted to the Georgia SHPO, and the district was listed in 2007.

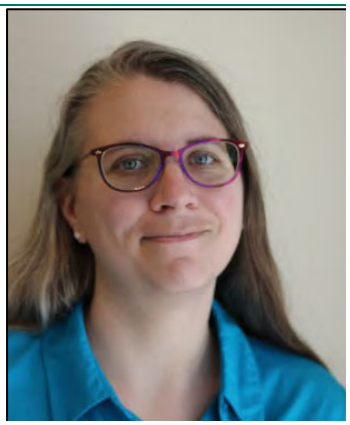
Energy Client, NRHP Assessment of Hydroelectric Power System, 2004
This project involved a review of historical documents related to the design and construction of 11 dams and powerhouses along two major rivers in North and South Carolina. Published histories, company documents, contemporary accounts were consulted, and similar large-scale power and flood-control projects in the Southeast and in the United States were studied to assess the significance of a series pf projects that spanned two states and included multiple facilities along an entire river system.

Military Agency, Context and NRHP Assessment of Korean War and Cold War Structures, 2003
Conducted background research to develop historic contexts to aid in the interpretation and assessment of BASOPS structures from the Korean War and Cold War periods at Fort Bliss and Briggs Army Airfield, Texas. The assessment of the facilities required the application of NRHP guidelines for properties of exceptional significance but less than 50 years old.

Emily Tucker-Laird

Senior Architectural Historian and Archaeologist

Ms. Tucker-Laird is Secretary of the Interior Qualified as an architectural historian and archaeologist. Emily is based in ERM's Duluth Georgia office, and attached to the cultural resources field services group. Emily has extensive experience working as a Principal Investigator. Her projects have included intra and interstate pipelines, electrical transmission lines, wind projects, solar projects, microwave towers, and treatment plans. In addition to fieldwork, Emily has experience supervising and coordinating for complex projects, and developing treatment plans for historic property concerns. Emily's has consulted with a wide range of state and federal agencies, as well as local stakeholders and interested parties.



Experience: 15 years of experience in the field of Cultural Resource Management

LinkedIn: https://www.linkedin.com/in/emily-tucker-laird-9224b4132/

Email: emily.laird@erm.com

Professional Affiliations & Registrations

- Society of Architectural Historians
- Register of Professional Archaeologists
- The Vernacular Architecture Forum

Fields of Competence

- Architectural surveys and evaluations
- Development of research and fieldwork designs for cultural resources
- National Register of Historic Places eligibility evaluation and assessments for historic resources
- Compliance with state, and federal cultural resource regulations, including guidelines set forth by various State Historic Preservation Offices, the National Historic Preservation Act and the National Environmental Policy Act
- Phase I, II, and III Archaeological Field Investigations and report preparation
- Project management and coordination

Education

- M.A., Anthropology, Ball State University, 2013
- M.S., Historic Preservation, Ball State University, 2003
- B.S., Social Sciences, University of Pittsburgh, 1999

Languages

- English, native speaker

Key Industry Sectors

- Power generation and transmission
- Oil and gas
- Public and private land development
- Telecommunications

Key Projects

Energy Client, Wind Project, 2016
Architectural historian 2016 for a 72-turbine wind project in Grant and Tucker County West Virginia. Key tasks included field survey and reporting, and analysis of visual simulations. Project met the requirements of the West Virginia Public Service Commission, and Section 106.

Energy Client, Pipeline Project, 2015-present
600-mile-long natural gas pipeline extending from West Virginia to North Carolina. Architectural Historian and Principal Investigator for historic architecture survey and assessment of effects and Historic Architecture Task Manager responsible for overseeing treatment plans to mitigate project effects. Task Manager for FCC tasks. Responsibilities also include consultations with the FERC, SHPO, and consulting parties.

Energy Client, Transmission Line Project, 2017
Six transmission line alternatives in Fairfax County, Virginia. Cultural resource specialist who prepared sections of the routing study, SCC application, and pre-application analysis, and conducted the technical review for the cultural resource investigations conducted for a proposed line to be sited in northern Virginia.

Energy Client, Pipeline Project, 2016
Architectural Historian for a 96-mile natural gas pipeline in Calcasieu, Jefferson Davis, Acadia, and Evangeline parishes. Completed architectural survey to meet the requirements of the FERC and LASHPO.

Telecommunications Client – Nationwide 2014-2015
Architectural Historian and Archaeologist for a nationwide NEPA Program Management Team serving a major national telecommunications carrier. Provide QA/QC oversight on cultural resources submittals and client deliverables. Tasks include assuring that all compliance submittals conform to regulatory requirements as well as meeting client standards, and assuring that required documentation of compliance is included in all client deliverables.

Key Projects before Joining ERM

Energy Projects, 2012
Muscle Shoals Reservation, Alabama: Architectural Historian for the HABS Level II documentation of selected resources of the Tennessee Valley Authority Muscle Shoals Reservation. The architectural survey included a detailed survey of both the interior and exterior of 20 resources. Final products included a photographic record, historical context of each resource, and architectural descriptions.

City Planning Project, 2010
Georgetown, SC Historic District Survey: One of a team of Architectural Historians recording 900 resources within the National Register-listed historic district. Final products included a comprehensive historic district inventory, maps which identified building by period of construction and contributing status, South Carolina Department of Archives and History Intensive-level historic structure forms and photographs, and a report.

Macon Cemetery Preservation Corporation, 2007
Cemetery Preservation Plan in Georgia: Architectural Historian for a conditions assessment of the 13-acre Linwood Cemetery. Containing over 4,000 burials. Identified the extent of interments, overall conditions across the cemetery, and specific graves and markers requiring repair and stabilization. The product of the work was an assessment of the cemetery's condition and a preservation plan.

Energy Client, Lateral Pipeline Project, 2013-2015
75-mile crude oil pipeline in Illinois and Indiana: Principal Investigator for historic structures, Field Director and Crew Coordinator for the project. Managed several crews, and subcontractors, met with the land office to determine what was available for survey, and acted as the health and safety officer.

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Appendix C – *SHPO Documentation Standards*
(68-page document)

MICHIGAN ABOVE-GROUND SURVEY MANUAL

UPDATED BY
KATIE KOLOKITHAS AND DIANE TUINSTRA

2018



STATE HISTORIC PRESERVATION OFFICE

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THE MICHIGAN ABOVE-GROUND SURVEY PROGRAM

INTRODUCTION

This manual provides standards and guidelines for conducting surveys of above-ground historic resources in Michigan. The State Historic Preservation Office (SHPO) recommends that this manual guide those individuals planning and carrying out surveys and requires compliance with the requirements identified in this manual for projects funded by SHPO grant funding or requiring review or approval from SHPO. This manual provides information regarding approaches to identification, documentation, and evaluation of historic above-ground sites, buildings, and features in accordance with the *Secretary of the Interior's Standards for Identification, Evaluation, and Preservation Planning*. This manual is designed to provide guidance for all types of above-ground surveys, including:

- Surveys funded by the federal Historic Preservation Fund and administered by the State of Michigan;
- Surveys required by the State Historic Preservation Office (SHPO) under Section 106 of the National Historic Preservation Act; and
- Surveys intended to provide an informational database for the establishment of local historic districts under Michigan's local historic districts enabling act, Public Act 169 of 1970, as amended, or for other preservation planning purposes, including preparation of National Register of Historic Places nominations.

This manual does not provide instruction for archaeological surveys. For information about archaeological surveys, please contact SHPO's archaeologists at 517-373-1618.

SURVEY IN MICHIGAN

The Michigan statewide survey program was started in the late 1960s under the direction of SHPO, but with the participation of numerous partners including local communities, regional planning agencies, and citizens around the state. In the 1980s, SHPO created *Surveying Michigan's Historic and Architectural Resources: A How-To Guide*, which directed the survey program for a number of years. In the 1990s, a series of eight survey manuals were used as the guide for the program. In 2001 a new survey manual was written by Robert Christensen and Barbara Wyatt called *Manual for Historic and Architectural Surveys in Michigan*. This 2018 manual replaces the 2001 manual.

In 2016 the Michigan SHPO initiated a project to make the survey data collected over the past fifty years more accessible to the public by creating a GIS-based program to collect, store, and map data. The project, called MiSHPO, will allow for online submission of survey reports and data as well as Section 106 applications, National Register nominations, and more. When MiSHPO is complete and ready to accept online submission of surveys, this manual will be updated with the necessary information to guide the electronic submission of surveys through that portal.

RECONNAISSANCE-LEVEL AND INTENSIVE-LEVEL SURVEYS

Survey refers to the process of identifying and gathering data on a community's historic resources. There are two main types of survey for above-ground resources: Reconnaissance-level and Intensive-level Survey. Survey can include field survey, the physical search for and recordation of historic properties; background research to establish historic context for the properties within the project area; and historical research on surveyed properties. The final products of a survey should include the following:

- Survey Report
- Color-photographs of the historic properties
- Inventory or data information on each property

Reconnaissance-level survey identifies properties of architectural significance and updates existing information in SHPO files. The reconnaissance survey documents properties using photographs, brief descriptions, condition, and location information. Limited research on the history of the buildings, sites, and features is undertaken. Reconnaissance-level surveys look primarily at the architectural integrity of the properties or National Register criteria C. This type of survey is the first step in the preservation planning process and can be undertaken in a limited or broad geographic area. The products of a reconnaissance-level survey include information entered into the survey report, survey forms, and the MiSHPO system. Reconnaissance-level surveys should be used as a means to determine where to focus intensive-level survey efforts.

Intensive-level survey seeks to identify and thoroughly document significant properties and districts through research and evaluation of the National Register of Historic Places criteria within the broader historic context. Intensive-level surveys are more complex, time-consuming, and represent a larger financial commitment for a community. These surveys also provide the most detailed information about an area's history and historic properties. Intensive-level survey begins with a reconnaissance survey or an update of an older survey. The survey then continues with research on potentially significant properties using primary sources, researching the community history, evaluating the properties for National Register significance, identifying historic districts, and completing MiSHPO submission information. Finally, many intensive-level surveys provide recommendations for future preservation activities.

PURPOSE OF SURVEY

The National Historic Preservation Act of 1966, as amended, requires all SHPOs to direct and conduct survey. The act states, "It shall be the responsibility of the State Historic Preservation Officer to administer the State Historic Preservation Program and to—in cooperation with Federal and State agencies, local governments, and private organizations and individuals—direct and conduct a comprehensive statewide survey of historic properties and maintain inventories of such properties."

Survey can serve many purposes including but not limited to the following:

- To provide a basis for local planning
- To provide data to support locally designated historic districts, National Register of Historic Places districts, or individual property designations
- To comply with environmental review requirements under Section 106 of the National Historic Preservation Act
- To achieve or maintain Certified Local Government (CLG) status
- To develop heritage tourism initiatives
- To provide information for thematic studies
- To provide a permanent record for the future

FREQUENTLY ASKED QUESTIONS ABOUT SURVEY

WHAT IS THE DIFFERENCE BETWEEN A RECONNAISSANCE-LEVEL SURVEY AND AN INTENSIVE-LEVEL SURVEY?

A reconnaissance-level survey identifies properties based on their architectural significance and provides basic property information for SHPO files. Reconnaissance surveys include limited historical research on the individual buildings and are used as a tool to determine where to concentrate more intensive research. Intensive-level survey seeks to identify and thoroughly document properties and districts through research and evaluation of the National Register criteria. These surveys provide a more extensive context for the area and research on each individual building.

SHOULD WE DO A RECONNAISSANCE-LEVEL SURVEY OR AN INTENSIVE-LEVEL SURVEY?

The purpose of the survey helps to determine the appropriate level of research. Reconnaissance-level surveys are a good first step and preservation planning tool while intensive-level surveys provide a more complete picture of the surveyed area. Determination of the level of review required for your project can be made through consultation with SHPO.

THERE ARE TREES/BRUSH/UTILITY LINES BLOCKING MY PHOTOGRAPH, WHAT SHOULD I DO?

We ask surveyors to do their best to take photographs without obstructions such as vegetation and utility lines, but we understand that in certain conditions obtaining a good photograph of a building may be difficult. Surveys should be conducted in the spring or fall when the leaves are not on the trees. If the surveyor is not able to obtain a clear photograph of the building they should be sure to describe the architectural characteristics in detail.

IS IT OKAY TO TRESPASS IN ORDER TO SURVEY A PROPERTY AND TAKE PHOTOGRAPHS?

No. Surveyors are required to stay in the public right of way while conducting their fieldwork. Permission from the property owner must be obtained in order to access the property.

WHY CAN'T I USE MY PHONE TO TAKE PHOTOGRAPHS?

While there have been many advances in the technology of smart phone cameras, SHPO is asking surveyors to continue to use a high quality digital camera to take their official photographs. Many phones do not allow users to change the resolution while taking photographs.

WHAT IS MISHPO? HOW DO I GET ACCESS TO THE SYSTEM?

MiSHPO is SHPO's new database and online submission system that will eventually allow consultants, federal agencies, and members of the public to submit their surveys, Section 106 applications, National Register nominations, Tax Credit applications, and other items directly to SHPO online. Any individual will be able to obtain a log-in through the website for the online submission portal. In order to get access to the database to conduct research on known sites, individuals and agencies or companies must purchase a license to gain access to SHPO's data. This manual will be updated once the system is fully operational.

WHAT DOES ELIGIBILITY MEAN? WHO DETERMINES THIS?

Eligibility is the assessment of whether a historic property meets the criteria for listing in the National Register of Historic Places. Persons meeting the professional qualifications as identified in the Code of Federal Regulations 36 CFR Part 61 can make recommendations based on their research of the eligibility of a property or district and SHPO will review the research and agree or disagree with the recommendations.

HOW DO I FUND A SURVEY IN MY COMMUNITY?

Surveys are funded by a variety of sources including private funding, grant funding, and municipal funding. Grant funding is occasionally offered through SHPO's Certified Local Government (CLG) grant program to eligible communities. SHPO uses its federal allocations to fund surveys as well and these are presented as RFPs for consultants. Sometimes a local municipality will utilize their general funds to conduct a survey, usually under the direction of a qualified consultant. Survey is a fundable activity for federal projects in which a survey is required under Section 106 of the National Historic Preservation Act of 1966. At this time SHPO does not offer grant funding to individuals to conduct survey work.



SURVEY PLANNING AND FIELDWORK

Survey is often initiated by a few people and undertaken to address a specific need in a community, but the survey planning process needs to include a much larger group of interested participants. Planning should be a community effort with qualified architectural historians and historians listening and being actively involved with community members to determine what areas are significant to them. Many surveys involve a planning committee that includes any or all of the following:

- Community organizations
- Local historians or representatives of local historical societies, historical commissions, or historic district commissions
- Faculty of local educational institutions with relevant expertise
- Representatives of executive and legislative branches of local government
- A member of the community's planning staff
- Members of the local board of realtors

Surveys should be publicized to the community through different avenues. The surveyor should also notify local law enforcement to explain the nature of the survey activity and make them aware of their presence. Surveyors should also carry identification at all times.

QUALIFICATIONS

Reconnaissance-level surveys must be undertaken by a lead investigator who meets the Secretary of Interior's Professional Qualifications Standards in the Code of Federal Regulations, 36 CRF Part 61. Lead investigators should be trained architectural historians and have experience with research and photography. The investigator should also be well versed in the National Register criteria. For Intensive-level surveys, the researcher or research team should be qualified as architectural historians and historians. An individual may qualify as both.

SHPO maintains a list of qualified consultants and while this list is not exhaustive of the consultants in the state of Michigan, it does provide a list of individuals who have submitted their credentials to the office for review. **Inclusion in this list does not constitute endorsement by SHPO or guarantee that any work product carried out by persons on the list will necessarily meet federal and state requirements.** Before engaging the services of any consultant, it is always advisable to contact references named by the consultant— especially those people for whom a consultant has worked. Inquiring about the nature of the project and the quality and timeliness of the work performed may provide an indication of a consultant's ability to successfully complete your project.

WHAT TO SURVEY

One of the fundamental issues in planning a survey is determining what to include in the project. This determination should be guided by the purpose for which the survey is being carried out, yet tempered by the need to complete the project within a defined budget. Surveys typically fall into two categories:

- Survey everything within the set boundaries, regardless of age, and
- Survey everything more than forty years old within the set boundaries

Surveying everything within the boundaries regardless of age is the most thorough documentation method, but it is also the most expensive and time consuming. This type of survey is appropriate for smaller municipalities or neighborhoods with several hundred properties or fewer. Surveying only what is known to be over forty years old is appropriate for cities and larger municipalities. The forty-year date range is to allow for the National Register's fifty-year age criterion and additional time so the survey is not outdated as soon as it is complete.

The goal of every survey should be to document a full range of types of historically significant properties in the survey area. Historic resources come in many forms—some are not as obvious. The National

Register property types are to be used for surveys in the State of Michigan. For full definitions of these terms according to National Register Bulletins 16A and 24, please see Appendix A, the Architectural History Survey Glossary of Terms.

- Buildings
- Site
- Structure
- Object
- District

Many historic resources such as parks, cemeteries, farms, mill and factory complexes, and residential properties can be complex properties that contain a variety of individual historic features. In an intensive-level survey, the property as a whole and each of its historic features should be surveyed. In a reconnaissance-level survey, it may be appropriate to survey only the entire property and key historic features rather than each and every historic element. Examples of this would include houses and grounds, farms, government complexes, churches, cemeteries, parks, factory and mill complexes, and utilities.

Churches in particular rarely stand alone, and the complexes often include cemeteries, educational buildings such as schools, teachers' residences, parsonages, or rectories, along with additions to the main building. The whole complex may be fronted by ornamental fencing or a gate. All of the various components of such church complexes should be surveyed. Farmstead Survey is discussed further in Appendix B Farmstead Survey Standards.

Questions often arise on whether features such as roadways and walkways; bridges; trees, boulders and other natural features; and mobile home parks or manufactured home developments should be included in the survey.

- For roadways and walkways, only intact, well-preserved examples surfaced with paving brick or other materials not commonly used today, should be included in the survey. Historic examples of public stairways should also be included in the survey.
- Many bridges in Michigan have been previously surveyed in the statewide highway bridge surveys, but some local highway bridges, particularly those no longer in highway use may have been missed. SHPO can provide you with a list of the bridges that have been previously surveyed. Historic culverts, pedestrian bridges, and railroad bridges should be included in the survey.
- Natural features are normally not included in the survey. If they are directly associated with historic events—not merely planted or placed at the site to commemorate them—they should be surveyed. Examples would be witness trees the original surveyors of Michigan used to describe corners of sections or quarter-sections, and trees associated with important persons or events.
- Mobile home and manufactured communities should be included in the survey if they are more than forty years old as they may possess significance in terms of landscape design, social history, and architecture.

CONTRACTING SURVEYS

A few communities will find themselves in the fortunate position of having persons with the requisite background, experience and skills to take on their surveys as volunteer projects, but most will need to contract for some or all of the work. SHPO maintains a list of consultants interested in survey work who meet the basic federal qualifications for historian and/or architectural historian. The list is updated frequently and is available on SHPO's website. This list should not be considered all-inclusive; there may be other consultants in your area who are not listed. It must also be emphasized that inclusion on the list is not a guarantee of high-quality work, and credentials and experience should be reviewed and references consulted. For additional detail regarding the hiring of a consultant and the RFP process please see Appendix C Contracting Surveys.

USING VOLUNTEERS

Some survey projects have been carried out entirely as volunteer projects, and volunteers can certainly assist in specific tasks such as the field survey work and property-specific research. Using volunteers in contracted survey projects, however, should be done with caution and a clear knowledge of the level of commitment of each volunteer. SHPO's experience has been that volunteers are sometimes not sufficiently motivated to carry out assigned tasks without defined deadlines.

ADVISORY BOARD

An advisory board comprising local historians, planners, members of a local historic district commission, and interested citizens can be an asset in a survey. The board may suggest resources for research, people to interview, and collections of information. A valuable role of the board is to be an emissary of good will during the project and an advocate for the survey's use after it is complete.

FIELD WORK

Field work is one of the most important steps in the survey process. Field work should:

- Record locational and descriptive data on each property
- Photograph properties and context views
- Map the property locations

One of the important steps before beginning fieldwork is the preparation of maps. Maps should be obtained from the local community to create base maps that will be used in the field and then in the preparation of the final map. The more detailed the maps, the more useful they will be in precisely locating the surveyed resources and in assisting users of the survey materials in their comprehension of the survey area's historic resources. Maps should show all streets and current property lines and/or building outlines.

More information on mapping in the MiSHPO system will be provided later in this manual.

RECORDING DATA IN THE FIELD

The collection of field survey data is one of the most important steps in the survey process. Field survey will provide locational and descriptive information—and perhaps some historical background information obtained by informants—about each property, which will ultimately form part of the record for the property. Prior to beginning field work, surveyors should review the list of required fields or data categories and instructions for the MiSHPO system. Surveyors should also include as much information as possible in each of the fields. Some examples of required fields include:

- Address (number, street direction and street name)
- City/village or township
- County
- Survey date and surveyor
- Historic name and current name
- Current building materials
- Additions, removals, and condition of the property

Many surveyors use paper survey forms and enter the data into the system at a later date. Many surveyors also create their own paper forms for use in the field. The SHPO Survey and Information Coordinator or the National Register Coordinator are available to review survey forms prior to the

commencement of field work. See Appendix D for a sample field form that can be customized and reproduced.

At this time, the use of survey applications for smart phones is not available for use with the MiSHPO program, but SHPO hopes to develop one in the coming years so surveyors will be able to utilize the technology in the field.

PHOTOGRAPHIC DOCUMENTATION

Every property included in the survey, including each building and other surveyed feature in a complex property or district, requires a minimum of one high quality photograph to show as much of the property as possible. Each surveyor is required to use a digital Single Lens Reflex (SLR) camera with a minimum capture size of eight mega-pixels. Images must be shot at the highest photo resolution possible.

Images must be delivered as an unaltered JPEG image on disk or thumb drive. Each image must be a minimum of 2000 pixels and 3000 pixels. Please consult with SHPO staff regarding file naming conventions for survey photos.

Survey photography is documentary. Good photographs can be taken if the photographer keeps several things in mind beyond the normal photographic considerations. These include composition, clarity, lighting quality and direction, and perspective distortion. Prior to beginning photography, a plan should be made based on the direction the building faces relative to sunlight, timing of possible obstructions (holiday decorations, leaves, vehicles, etc.), daylight, and weather.



CLARITY

The major cause of unclear photographs is camera movement. The best way to avoid this is to place the camera on a firm support or tripod when the photograph is being taken. If a tripod is unavailable, using a faster shutter speed and gently squeezing the shutter button can enhance image clarity.

COMPOSITION

Generally, a ¾-view of a building is preferred, to show as much building detail as possible in a single view. Since a record is produced for each property, do not include the adjacent buildings in the inventory photographs. If necessary, more than one photograph should be taken to document large or complicated buildings.

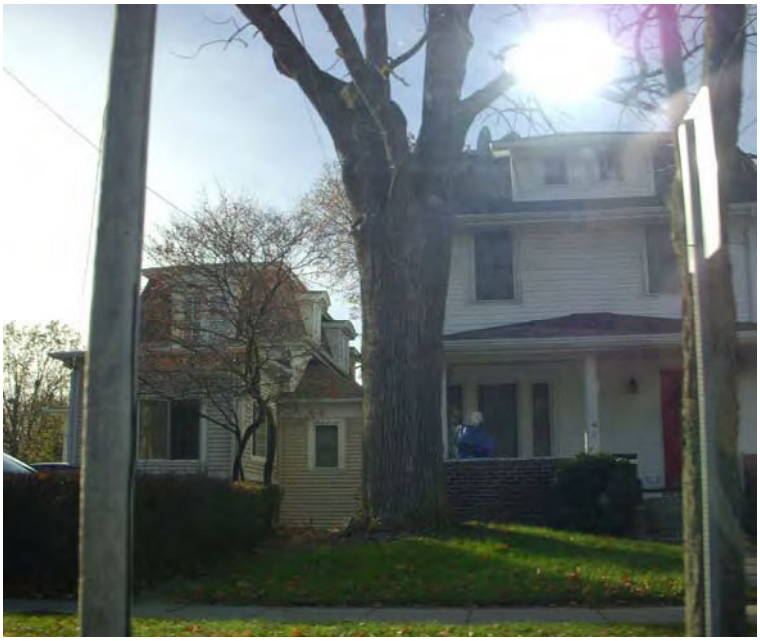




LIGHTING QUALITY AND DIRECTION

A building is modeled and described by the sunlight, and the relationship of the sun to the property varies from case to case. A photo of a rusticated building, for example might be enhanced by sun using direct light to bring out the texture. A building with a broad overhang is sometimes best photographed in hazy sun because deep shadows can obliterate details. It is difficult, therefore, to generalize, except to say that the photographer should study the subject and make a determination based on a building's inherent characteristics.





Be careful about backlighting, or placing the sun directly behind the camera, because such flat lighting can obscure the shadow lines that give a building character and depth.



PERSPECTIVE DISTORTION

An otherwise well-thought-out photograph can be ruined by perspective distortion. The only way to get rid of this distortion completely is to have the film plane of the camera exactly vertical when taking the photograph. Tipping the camera up to capture the top of the building is the most common perspective distortion, this makes the building appear to be falling over backwards. The best way to limit the impact of this distortion is by using a perspective-control (PC) lens. Those without access to such equipment, however, should follow a few simple tips. The easiest solution is to back up far enough from the subject to include the entire building without tilting the camera upward. This can be accomplished by either moving away from the subject or by changing the camera to a wide-angle setting. Surveyors should use caution when using a wide-angle lens as this can exaggerate any tilting of the camera.

A telephoto lens that tends to flatten buildings can be used to reduce the impact of the perspective distortion. Users of a telephoto lens should be aware that the lens can also exaggerate camera motion, so a tripod is recommended.

Surveyors can also stand on a rise, truck, ladder or other equipment to elevate themselves and reduce the perspective distortion.

More information on photography is available in National Register Bulletin 23 *How to Improve the Quality of Photos for National Register Nominations*.

Other photography tips include the following:

- Avoid signs, cars, people, trees, and poles in the foreground as much as possible
- Lens filters and shields should be used to minimize glare
- Use imagination in finding the position that will allow the best view of the property







DESCRIBING HISTORIC PROPERTIES

Architecture should be described using appropriate terminology for architectural styles, building forms, and other characteristics. Surveyors should make use of architectural style guides, studies of specific building types, and other source material that provide background information about the architecture they are surveying. The following resources should prove useful for nearly every survey:

- Architectural Dictionaries and Terminology Guides:
  - Phillips, Steven J. *Old-House Dictionary*. NY: John Wiley & Sons, Inc., 1994.
  - Burden, Ernest. *Illustrated Dictionary of Architecture*. Third Edition. NY: McGraw-Hill, 2012.
  - Roth, Leland M. *American Architecture: A History*. Second Edition. CO: Westview Press, 2016.
- Houses:
  - McLennan, Marshall. "Common House Types in Southern Michigan." In Michigan Folklife Reader, edited by C. Kurt Dewhurst and Yvonne R. Lockwood, 15-45. East Lansing: Michigan State University Press, 1987.
  - McAlester, Virginia and Lee McAlester. *A Field Guide to American Houses (Revised).* NY: Alfred Knopf, 2015.
- Farms and Agricultural Buildings:
  - Michigan Agricultural Experiment Station bulletins and Michigan Cooperative Extension

Service bulletins, found at the Michigan State University Library, contain useful background information on farm and building layouts and design.

- *The Agricultural Landscape of Michigan: An Historic Context for the Theme of Agriculture*. Lansing, MI: Michigan State University for Michigan Department of Transportation, 2004. On file at SHPO and MDOT.
- Dandekar, Hemalata C. *Michigan Family Farms & Farm Buildings: Landscapes of the Heart & Mind*. Ann Arbor: The University of Michigan Press, 2010.
- Noble, Allen G. *Wood, Brick & Stone: The North American Settlement Landscape.* 2 vols. Amherst, Ma: University of Massachusetts Press, 1984. Volume 2 deals with barns and farm structures.
- Noble, Allen G., and Hubert G. H. Wilhelm, eds. *Barns of the Midwest*. Athens, OH: Ohio University Press, 1995.
- Visser, Thomas Durant. *Field Guide to New England Barns and Farm Buildings*. Hanover, NH: University Press of New England, 1997.

- Mid-Century Modern Resources
  - APT Building Technology Heritage Library. https://archive.org/details/buildingtechnologyheritagelibrary. Includes house plan books for postwar housing companies.
  - *Historic Residential Suburbs. Guidelines for Evaluation and Documentation for the National Register of Historic Places.* U.S. Department of the Interior. National Park Service. Washington, DC. 2012.
  - Jester, Thomas C. *Twentieth-Century Building Materials: History and Conservation*. Los Angeles: Getty Conservation Institute. 2014.
  - *A Model for Identifying and Evaluating the Historic Significance of Post-World War II Housing*. National Cooperative Highway Research Program Report 723. Transportation Research Board Washington, DC. 2012.
  - *The Ranch House in Georgia. Guidelines for Evaluation.* Stone Mountain, Georgia: New South Associates.
  - Statewide Search for Subdivision Plats. www.dleg.mi.us/platmaps/sr_subs.asp. Michigan Department of Licensing and Regulatory Affairs (LARA).
- Schools
  - Michigan State Historic Preservation Office. *An Honor and an Ornament: Public School Buildings in Michigan*. Lansing, Michigan: Department of History, Arts and Libraries, 2003.
  - Michigan Superintendent of Public Instruction. Superintendent of Public Instruction Annual Reports. Lansing, MI: State of Michigan Superintendent of Public Instruction. The annual reports of 1859, 1864, 1869, 1893, 1913-1914, 1915-1916, and 1916-1917 contain illustrated material on school building design and furnishings, including standard plans.
- Commercial Architecture
  - Longstreth, Richard. *The Buildings of Main Street: A Guide to American Commercial Architecture.* Walnut Creek, CA: AltaMira Press, 2000.
- Industrial Architecture
  - Bradley, Betsy Hunter. *The Works: The Industrial Architecture of the United States.* NY: Oxford University Press, 1999.

For specific questions concerning architectural terminology, contact the Survey and Designation staff at SHPO.



HISTORICAL RESEARCH

All surveys should include a historical research component. Historical research in survey provides the framework for evaluating the historic significance of the surveyed properties and their eligibility for inclusion in the National Register of Historic Places.

The primary difference between reconnaissance-level survey and intensive-level survey is that intensive-level survey includes in-depth historical research on each of the surveyed properties. Reconnaissance-level survey only records property-specific information from readily available sources. Both levels of survey should include research in two areas: 1) the general history of the survey area or community and 2) study of historical themes applicable to the survey area. Intensive-level survey will include the individual property history information as well.

The survey report must include a summary history of the area that introduces the important historic themes and places them in a broader context. The history should be written as a narrative rather than in timeline format. It should include key dates in the area's chronology and introduce the area's early settlement history, driving forces behind its growth and economy (including significant people or ethnic groups) and other developmental factors. An example for Port Hope (see below), taken from the Port Hope multiple property nomination for the National Register, introduces each of the significant historic themes represented by properties included in the nomination: lumbering, forest fires of 1881 and relief efforts, agriculture, transportation, ethnic history, and architecture.

Thematic narratives should be identified through consultation with National Register Bulletin 15, "How to Apply the National Register Criteria for Evaluation" (page 8), which defines a theme as "a means of organizing properties into coherent patterns based on elements such as environment, social/ ethnic groups, transportation networks, technology, or political developments that have influenced the development of an area during one or more periods of prehistory or history."

ARCHITECTURAL NARRATIVE

For most survey projects, architecture will prove a relevant theme, and an architectural narrative will be necessary. Architectural narratives too often tend to be generic discussions focusing on style that provide little detail about the specific survey area. This should be avoided! It may be worthwhile for the person preparing the architectural narrative to begin with a fresh review of architecture while in the field. Working from only the survey photos months after the completion of the field survey may hinder insightful analysis of the architecture.

The purpose of the architectural narrative is to place the survey area's architecture in the broader context of the community and region in which it is located. The architectural narrative should discuss the architecture in terms of property types. Property types should be defined using the list in Appendix E.

The architectural narrative should discuss all property types within the broad categories (residential, commercial, or agricultural) for which a substantial number of properties are present. For example, for rural survey areas containing numerous farms, the broad range of agricultural building and structure types present should be discussed and analyzed. For older, in-town neighborhoods containing many old stable/carriage house buildings, the architectural narrative should include some discussion of this building type. Conversely, property types represented in the survey area by only one or a very small number of properties—typically churches, schools, and other institutional resources—need not be included in the architectural narrative. For the few institutional properties present in most survey areas, any needed architectural analysis can be presented within the narratives for the themes with which the properties are associated, such as religion or education.

Just as for the entire survey report, an important purpose of the architectural narrative is to educate public officials, planners, property owners, and the general public about what is interesting and significant from an architectural standpoint about the survey area's properties. A relatively small number of high-style properties in the survey area certainly merit discussion and analysis, but the narrative should focus on

the common property types and forms generally represented by the vast majority of surveyed properties whose significance will not be obvious to the report's readers.

The narrative should be organized by broad property type, such as residential and commercial. The discussions of property types should be arranged in the overview in the approximate order of their predominance. In most survey areas, residential properties will form by far the greatest proportion of the surveyed resources; in such cases, the residential section should come first in the architectural narrative.

In the discussion of each property type, discussion and analysis of the issues of form and massing should almost always precede any discussion of style. For example, in a section of an architectural narrative that discusses single-family houses within a broad category of domestic (i.e. residential) architecture, the houses should be discussed in terms of the specific house forms present, such as bungalow or upright-and-wing, before they are discussed in terms of their architectural style. Building forms characteristic of the survey area and broader community, such as a certain house form prevalent in a survey area, but less common elsewhere, should be identified. Any locally distinct varieties of standard architectural styles and the common use of distinctive decorative elements in the local architecture, such as a polychromatic brickwork found in many houses in the Dutch settlement area of West Michigan, should be noted and discussed.

Examples of pattern-book, pre-cut, and manufactured architecture should be discussed, if possible, as part of the architectural narrative. While originals of old pattern and plan books and catalogs are hard to come by, many of these books have been reprinted by a variety of publishers, and more are being done every year. Dover Publications, Inc., the publisher of by far the greatest number of reprints, is the architectural historian's friend, having reprinted dozens of old plan and pattern books since the 1960s, with most of them still in print in inexpensive paper editions. These pattern books—especially those by the Aladdin Company and Sears, Roebuck and Company—will be useful for survey in Michigan.

The narrative should provide information about architects, engineers, artisans, craftspeople, and contractors who worked in the survey area. Biographical data, such as birthplace and birth and death dates, educational background, firm affiliations and dates, and important commissions are important pieces of information that should be sought and included in the narrative. Newspaper obituary notices are an important source of information. In addition, the following can be useful sources of information on architects and engineers:

- *American Institute of Architects Historical Directory of AmericanArchitects*
- *Avery Obituary Index of Architects.* Microform/Columbia University. Boston, MA: G.K. Hall, 1984.
- Downs, Winfield Scott, ed. *Who's Who in Engineering. A Biographical Dictionary of the Engineering Profession.* New York: Lewis Historical Publishing Co., Inc. (Editor, title and publisher vary between editions). Eight editions were published between 1922 and 1959.
- Koyl, George S., ed. *American Architects Directory*. New York: R. R. Bowker Co. Editions were issued in 1956 and 1962.
- Withey, Henry F., and Elsie Rathburn Withey. Biographical Dictionary of American Architects (Deceased). Los Angeles: New Age Publishing Co., 1956.

RECONNAISSANCE-LEVEL SURVEY

The level of research for a reconnaissance-level survey will be limited to those documents and resources that are easily accessible including old county and fire insurance maps and published histories, as well as information such as historic name and date, gleaned from inspections of the property. The recording of specific information from directories, tax assessors' records, and other more detailed sources is generally not a part of a reconnaissance survey. For some of the properties, no historical information will be located.

INTENSIVE-LEVEL PROPERTIES

For properties surveyed at the intensive-level at least a basic level of information should be gathered for each of the properties forty-or-more-years-old, with more in-depth research performed on those that appear to possess more than typical historical or architectural significance. The surveyor must provide a basic, standard level of historical documentation for all of the surveyed properties and help determine which of them possess significance according to the National Register criteria.

The amount of time spent on research for a given property in an intensive-level survey should correspond to the property's apparent historic significance. Property-specific research can be the most time-consuming aspect of a survey project, but it is the most important. Surveyors should have realistic expectations about what information is available, so that research efforts can be appropriately directed. Sometimes finding basic information for a property, such as the precise date of construction and an architect or builder, will be impossible.

SOURCES OF INFORMATION FOR HISTORICAL RESEARCH

The sources of information that will be used for general history, thematic, and property-specific research will vary with the nature and location of resources, but the following will generally be useful tools.

- Published and unpublished histories
- County maps and atlases, plat books, and fire insurance maps
- City and county directories
- State gazetteers and business directories
- Tax assessors' records
- Tax records
- Building permit records
- Local historians and knowledgeable informants, including long-term property owners
- Federal census records
- State census records
- Rural property inventories
- Vertical and newspaper clippings files
- Photograph collections
- Birdseye views
- Biographical albums and records
- Newspapers
- Property abstracts
- Public land records
- Federal land patent records

While secondary sources can be useful to begin your research and uncover potential primary sources, they should be used with caution and primary sources should be used as the main documentation whenever possible.



SUMMARY HISTORY FOR PORT HOPE

EXAMPLE

Port Hope began in 1858 with a sawmill and dock constructed by William R. Stafford, a partner in a firm established to log the area and market its products to Cleveland. Lumber continued to be the area's chief industry until forest fires in 1871 and 1881 destroyed most of the remaining timber. The 1881 fires, coming after decades of logging had left mountains of timber debris in their wake, not only destroyed most of the remaining forests in the area, but also cleared much of the debris left from logging activities, opening the Port Hope area and much of the Thumb to farming far more than the lumber industry itself. The land was fertile. As a result, in the 1880s and 1890s agriculture became the major livelihood of Port Hope's residents. Many early settlers in Port Hope in the 1860s and 1870s were Germans and in the late nineteenth century the Germans became Port Hope's largest ethnic group. Cheap water transportation on the lakes made possible the community's economic growth in the nineteenth century. Lumber and, later, agricultural products were shipped to market exclusively by boat prior to the construction of a railroad line to the town. The opening of a rail link to the existing line at Harbor Beach in 1903 took place at the same time that commerce on the lakes was in decline because of competition from the ever-growing railroad network. The railroad line gave Port Hope a greater market for its agricultural products and encouraged further development of agriculture in the area. Port Hope's architecture in the nineteenth and early twentieth centuries reflected the development of the town and the contemporary architectural tastes of the nation at large and of Michigan's Thumb region.



LUMBER INDUSTRY THEMATIC NARRATIVE FOR PORT HOPE

EXAMPLE

Commercial logging in Michigan began in the 1830s, 40s, and 50s with the development of improved sawmilling technology and the introduction of steam-powered sawmills. Extensive logging began along the east shore of Lake Michigan and the west shore of Lake Huron in the Lower Peninsula and gradually worked its way inland along the major waterways. The sawmills were located at the mouths of the streams and the logs driven downstream to them during the spring high waters. Chicago was the first the principal destination of timber cut along Michigan's west shore, while the mills on the Lake Huron side of the state served Detroit, Toledo, Cleveland, and Buffalo for the most part. In 1860 there were nearly one thousand sawmills operating in Michigan producing in that year about 800 million board feet of lumber, principally white pine. The fine quality of the wood and the phenomenal growth of Michigan's and the Midwest's population in the years after 1860 led to rapidly expanding lumber production in Michigan. Production statewide reached a maximum of 4,292,000,000 board feet in 1888. Production began to decline thereafter because of the depletion of timber lands; however, Michigan continued to be the leading producer of lumber in the nation in 1900.

Commercial logging along the west shore of Lake Huron began in the 1830s and was well underway at Port Huron, Saginaw, Bay City, and other places by the late 1840s. Port Huron reached its high point of lumber production—56 million board feet—in 1873. The Saginaw Valley reached its high point of production of more than one billion board feet in 1882. More northerly points such as Alpena and Cheboygan reached their peak production in the late 1880s and early 1890s. Much of the production from the east shore mill towns was sent to market in ships and barges, and Bay City and Saginaw in particular became large shipbuilding centers in the late nineteenth century.

Eastern investors, a number from Maine and New Hampshire, played an important role in the Michigan lumber boom beginning as early as the 1840s, if not before. These investors witnessed the gradual depletion of the northern New England pine woods in the mid-nineteenth century and the consequent rise in value of the remaining timber lands. They recognized the opportunities for profit from Michigan timber lands, which could still often be bought at bargain prices from Uncle Sam and the lumber inexpensively shipped by water to an ever-growing market. Single investors often bought thousands of acres of land, logged them off over many years, and then resold as much land as possible while developing some themselves for agricultural purposes.

Huron County, at the tip of the Thumb between Lake Huron and Saginaw Bay, was established as a county in 1859. The first sawmills—small, water-powered affairs—were established in 1838 and 1839. John Hopson put up the first steam sawmill in 1850 at Rock Falls south of Harbor Beach. Lumber and shingle manufacturing quickly became the county's chief industries. The principal woods were pine, hemlock, cedar, basswood, beech, maple, birch, and ash. A series of forest fires burned over much of the county in October 1871, at the same time that the Chicago Fire raged. Nevertheless, in 1874 the county produced 36 million board feet of lumber. In 1876 several planks cut at Verona Mills in the county were displayed at the Centennial Exposition in Philadelphia. The planks were sixteen feet long, five feet two inches wide, four inches thick, and without knots or other flaws. In September 1881, however, another series of disastrous fires burned over the bulk of Huron and much of several other counties and put an end to large scale logging in the county. Small scale operations continued for a few more years here and there.

In Port Hope William R. Stafford was a pioneer lumberman. Stafford (1829-1916) came to Michigan from Bath, New Hampshire, in 1849 and settled in Lexington, on the Lake Huron shore between Port Huron and Huron County. In 1852, Stafford became a partner in a mercantile business that apparently involved lumber. The business was reorganized in 1854 with Clark Haywood, another New Hampshire native and a former employee of Stafford's, as his partner.

In 1851, Stafford, Reuben B. Dimond, William Southard, and Josiah F. Wilson, all (with probably the exception of Dimond) New Hampshire natives who were personal friends and business associates, made a purchase of timber lands in the area near what became Port Hope. In 1857 or 1858, Stafford, Haywood, and a third New Hampshire native, former U.S. senator B. W. Jenness, then a resident of Cleveland, formed a partnership to exploit the timber resources of the Port Hope area. Stafford had charge of the sawmill the partners built in 1858 at what became the settlement of Port Hope. The mill produced lumber,

lath, and shingles. Jenness ran a lumberyard in Cleveland that the Port Hope mill supplied. During some years prior to the 1871 fires the mill produced 7 million board feet of lumber. The 1871 fire destroyed the mill, dock, and lumber on hand, a loss of $100,000 to Stafford & Haywood (Jenness had withdrawn in 1868). Stafford & Haywood rebuilt the mill and dock in 1872. As of 1874 they produced 1.4 million board feet out of the 36 million produced in the county. At least four operations in the county were larger. The 1881 fire burned the mill and dock again, a $40,000 loss, and, in 1884, Haywood also withdrew from the firm, leaving Stafford as sole owner. Stafford built a third, smaller sawmill and planing mill and sash and door factory to supply primarily local needs.

In 1880, R. C. Ogilvie built a second sawmill and dock at a cost of eight-thousand dollars. The mill and dock also burned in 1881. Ogilvie rebuilt in 1993, but the mill apparently closed for the lack of timber by about 1889. Stafford's sawmill is listed in the Michigan State Gazetteer and Business Directory as late as the 1893 edition, and probably closed in the early 1890s. Perhaps some lumber and other wood building products were shipped to Cleveland until the very end of local sawmilling operations. Mrs. C. J. Bisbee in her 1915 historical sketch of Port Hope states that "The mill operated until every bit of virgin timber was nailed into Ohio houses."

A by-product of logging in Michigan was salt manufacturing. What is known to geologists as the Michigan Basin, which includes the Lower Peninsula, is one of the greatest areas of halite concentration in the world. Subsurface deposits of rock salt and brine occur in many places. In 1859 the Michigan legislature, hoping to encourage salt production, authorized a bounty of ten cents per bushel produced. This bounty was soon repealed, but not before it had done its work in generating real interest in salt manufacturing. Michigan soon became the nation's leading salt producer, and by 1884 was producing half of the nation's salt.

Salt production in Huron County and elsewhere in Michigan was encouraged by the plentiful supply of wood. Wood fueled the engines that pumped the brine from which salt was obtained up to the surface and powered the furnaces that evaporated water from the great pans or vats of brine. Cheap fuel made Michigan salt the most inexpensive in the nation. In Huron County salt manufacturing began in 1863 in Port Austin and continued until about 1890. In 1884 the county had eleven salt-manufacturing operations, several of them using more than one well. The decline coincided not with the depletion of the brine deposits, but with the destruction of the forests that provided the cheap fuel.

In Port Hope the first salt-manufacturing enterprise, the Port Hope Salt Company (in which W. R. Stafford was the principal owner) was established in 1874. Its plant appears to have been typical of the Huron County salt "blocks." The first year the company produced 16,000 barrels of salt at 280 pounds per barrel. In 1884 the company used 10,000 cords of wood to produce 60,000 barrels. It had a well 800 feet deep (Huron County wells ranged from 600 to nearly 2,000 feet in depth) and four and one half inches in diameter. The brine was pumped to the surface into five evaporating "pans" and the brine settled to the bottom. So-called "bitter water" at the top was drained off. Furnaces provided the chief means of evaporation. A force of twenty coopers produced the needed barrels. Much of the salt produced went for dairy purposes, but the company also shipped much of its product to the mining regions of Montana. The Port Hope Salt Company closed in 1890.

Robert G. Ogilvie established a second salt-manufacturing concern in Port Hope in 1883. His operation had its own sawmill and barrel factory and produced 150 barrels of salt daily in 1884. Ogilvie's operation apparently closed by 1890.

The remains of the Port Hope Salt Company plant were dismantled in 1913-14, but the site has not been developed and some remains are still present. At the site of the Ogilvie salt block, some development has taken place and no remains are visible. No archaeological testing of either site has been done.



EVALUATION AND MAKING ELIGIBILITY RECOMMENDATIONS

Evaluation of the historic significance of the surveyed properties is the very heart of the survey project since the properties evaluated as historically significant are the ones to which future historic preservation planning efforts will be geared and the rest of the properties will likely be excluded from future preservation planning. Evaluation criteria for surveys of any kind should use the National Register of Historic Places Criteria for Evaluation.

CRITERIA: The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

A. That are associated with events that have made a significant contribution to the broad patterns of our history; or
B. That are associated with the lives of persons significant to our past; or
C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
D. That have yielded, or may be likely to yield, information important in history or prehistory.

CRITERIA CONSIDERATIONS: Ordinarily cemeteries, birthplaces, or graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties will qualify if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

A. A religious property deriving primary significance from architectural or artistic distinction or historical importance; or
B. A building or structure removed from its original location but which is significant primarily or architectural value, or which is the surviving structure most importantly associated with a historic person or event; or
C. A birthplace or grave of a historical figure of outstanding importance if there is no appropriate site or building directly associated with his productive life; or
D. A cemetery which derives its primary significance from graves of persons or transcendent importance, from age, from distinctive design features, or from associations with historic events; or
E. A reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or
F. A property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own exceptional significance; or
G. A property achieving significance within the past 50 years if it has exceptional importance.

EVALUATION PROCESS

Evaluating historic resources should involve assessing historic properties from three perspectives:

- Historic context
- Historic significance
- Historic integrity

HISTORIC CONTEXT

Historic resources must be understood within the framework of the historic themes with which they are associated and the place and time in which they occurred. The theme, geographic parameters, and temporal definition provide the context for understanding a property, for example, popular music (theme) in Detroit (place) from 1920 to 1975 (time frame). Evaluations need to include:

- Comparison with properties that are similar in terms of function, form or style
- Relationship to a historic event
- Comparison with other properties associated with the same historic theme(s) and in the same geographic area and time frame

The geographic area that forms one of the bases for evaluation may need to be larger than the survey area to provide an adequate context for evaluation. In general, evaluations should be made, at a minimum, within the context of the entire community.

The historical significance of an above-ground property refers to its importance in the history, architecture, or culture of the local area, state, or nation. Significance is defined in terms of the four National Register criteria: historic events, important people, distinctive physical characteristics, and information potential.

Historical integrity of a property refers to the extent that the physical components have survived from the historic period—in other words, how much the property reflects its historic appearance. The National Register criteria defines seven qualities of integrity that properties must meet: location, design, setting, materials, workmanship, feeling, and association.

If the history of a property is deemed important within one or more historic themes and if the property possesses a high degree of integrity, it is generally considered eligible for listing in the National Register of Historic Places. The surveyor makes recommendations on the eligibility of resources, which are then reviewed by SHPO staff, who make the final determination.

In addition to these instructions, survey personnel should review the *Secretary of the Interior's Standards for Evaluation*; *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*; and other National Register bulletins, as appropriate to the surveyed resources.

Evaluations should be done through the identification of the applicable themes and the related properties in the surveyed area through the creation of lists for inclusion in the survey report. The list for each theme should include not just properties that clearly possess historic significance but also a more representative sampling of all of the types of properties that reflect the theme. When placing these lists in the report, the properties should be organized by a broad property type category (such as Commercial or Domestic). Districts identified in the survey and properties such as farms, industrial complexes, parks, and cemeteries should each be listed and evaluated as whole complexes. Components should not be listed and evaluated separately unless the entire district or complex property turns out not to meet the criteria. Some properties will relate to more than one theme; these should be listed under all appropriate themes. The property list for architecture should be organized by styles, building forms, and other aspects of the survey area's architecture defined in the narrative as significant.

Using the National Register criteria, standards should be developed for evaluating properties associated with the survey area's defined historic themes. For each theme, define the following:

- Property types that are important in illustrating the theme
- How the National Register criteria apply to each property type on the basis of the important events, people, and patterns, etc., developed in the narratives (In some cases several property types may be grouped together.)
- The level of physical integrity a property must possess to be eligible for listing as an example of the property type

The following are examples of specific criteria established for individual property types or groupings of property types within a theme:

- The criteria under the theme of commerce might define a commercial building as eligible for the National Register if it housed a leading commercial enterprise by virtue of its size and role in the community (a department store in a large community or a general store in a small community, for example) or if it housed a specific business or business use for a long period of time (a hardware or clothing store, or a succession of shoe stores or ice cream parlors, that remained in business at the same location, for example).
- The criteria under the commerce theme might define a house as eligible for the National Register if it is associated with a pioneer merchant or businessperson who owned an important business or a business that remained in operation for a long time.

Criteria should be tailored to the survey area's historic themes and to the surveyed properties and property types. Avoid using a standard, "canned" criteria that applies to all themes.

EVALUATION AND RECONNAISSANCE-LEVEL SURVEY

Every reconnaissance-level survey should include at least a measure of evaluation based on the criteria and a recommendation of eligibility for the properties in the survey area. In order for a reconnaissance-level survey to be useful in future planning efforts, the surveyor should use available information, including basic historic information and the level of architectural integrity. For those resources with widely available histories, the surveyor should undertake the evaluation process in the manner described above utilizing all four National Register criteria. For those without a well-documented history, the survey report should include an eligibility recommendation for National Register criterion C: architecture. Reconnaissance-level surveys should be considered locally as the first step in a two-step process; however, funding often limits the ability of a community to complete the second step— intensive-level survey—in a timely manner.

EVALUATION AND INTENSIVE-LEVEL SURVEY

Evaluation of resources for an intensive-level survey should be undertaken utilizing all four National Register Criteria.

IDENTIFYING AND DOCUMENTING POTENTIAL HISTORIC DISTRICTS

One purpose of survey is to identify and document any potential historic districts located within a survey area. According to National Register Bulletin 15, "A district possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development. . . . A district derives its importance from being a unified entity even though it is often composed of a wide variety of resources. The identity of a district results from the interrelationship of its resources, which can convey a visual sense of the overall historic environment or be an arrangement of historically or functionally related properties."

Historic districts can encompass business districts, residential neighborhoods, rural villages or agricultural districts. These areas must possess significance under one or more of the National Register criteria and retain an adequate degree of architectural integrity. The boundaries of the potential historic district must include the full extent of the historic resources related to the applicable historic themes and time frames while excluding adjacent areas whose properties bear no strong relationship to them.

APPLYING THE CRITERIA

A CASE STUDY ON THE HOME OF A SETTLER FROM NEW YORK STATE

Robert O. Christensen

A building that was the Michigan home of a pioneer settler from New York State should be reviewed in terms of the broad pattern of migration to the area from upstate New York and the settler's importance as a reflection of that migration and as a member of the community, and conceivably, the importance of the building itself in reflecting the architectural tastes of the date in that area.

In reviewing eligibility, the history of the area should be considered. For the settler's house, it is important to know whether or not the migration from upstate New York to this area was a common pattern. If it was, the house can be viewed as possessing some significance through the connection with this broad pattern of local history. It is also important to know whether the settler played a significant role in local history. Was he or she a businessperson who established a general store that served the community for a long period of time, for example, or a farmer who played a key role in introducing a new and ultimately important crop? In other words, was the subject someone who made a definable contribution to local history?

Architectural significance also may be a factor in the evaluation. Does this upstate New York settler's house fall into a broad architectural pattern in illustrating the use of building forms or materials characteristic of upstate New York that were used by other early settlers who came from that area? Does the building exemplify commonly used traditional house forms or high-style design of its period, or is it an important example of its designer's work—whether the designer was a fashionable architect of national reputation or a local carpenter-builder?

Once some conclusions concerning how the building fits into the patterns of local history have been reached, an attempt should then be made to determine whether the house is of sufficient importance within these historical patterns to merit designation. For example, perhaps the settler was but one of a great number of such people who settled in the same general area and many of the houses these settlers built have survived. The evaluation of this particular building's importance in representing the theme of the eastern migration to the area might be much less than it would be if only a few of the early settlers' homes had survived, say in an urban area.

Here, the issue of physical integrity becomes important. If fifty houses that relate to the settlement of the area of New Yorkers survive, certainly some of them—all other things being equal—illustrate better than others what it was like for these New Yorkers to establish their lives in Michigan in the early days. Those that retain enough of their historic appearance and character to provide a clear illustration are of greater importance than those that have lost this ability.

Synthetic siding, major renovations that result in the loss of original materials such as trim, and moving from the original site reduce the ability of a building to convey its significant history. Most buildings do not remain in pristine form, and many have been moved. How much the alterations have reduced the overall ability of the building to illustrate the history must be evaluated. In effect, the standards for physical integrity for properties possessing historical significance only mildly related to the architecture differ somewhat from those of properties whose significance is primarily architectural.

The New York settler's house loses a strong measure of significance if it is moved off the property on which the pioneers actually settled. The house loses some measure of significance if synthetic siding is installed or other changes are made, but may retain sufficient integrity to be eligible if the changes made are reversible ones that do not change the fundamental character of the property.

On the other hand, a building that is viewed as eligible primarily because of its architectural value in illustrating high style or vernacular tastes of its time period may not be viewed as losing integrity by being moved (as long as the new setting is appropriate), but may be viewed as losing a substantial amount of integrity by being sided or changed in other ways that reduce the building's ability to illustrate the historic architectural finishes and materials.



SURVEY PRODUCTS AND REPORT

A final survey report is required for all survey projects. This report must be uploaded to the MiSHPO "My Applications" tab. The survey report should provide information on the purpose, parameters, methodology, limitations, findings, background, historical context, and descriptions on the findings. SHPO requires that report authors adhere to the most recent edition of the *Chicago Manual of Style and the* *Michigan State Historic Preservation Office Style Guide*.

SURVEY REPORT COMPONENTS: SECTION ONE

- COVER OR TITLE PAGE: Include the name of the survey, municipal unit(s) and counties, sponsoring agency, completion date of the final report, names and location of the person or firm responsible for carrying out the survey, and names of the report author and primary project personnel, if different.
- ACKNOWLEDGMENTS/FUNDING CREDIT: Most projects are funded by federal, state, or local funding and the source of funding should be acknowledged in the report. For project funded through the Historic Preservation Fund, the following acknowledgment of federal assistance is required behind the title page and before the executive summary:

The activity that is the subject of this project has been financed in part with Federal funds from the National Park Service, U.S. Department of the Interior, through the Michigan State Housing Development Authority. However, the contents and opinions herein do not necessarily reflect the views or policies of the Department of the Interior or the Michigan State Housing Development Authority, nor does the mention of trade names or commercial products herein constitute endorsement or recommendation by the Department of the Interior or the Michigan State Housing Development Authority.

This program receives Federal financial assistance for identification and protection of historic properties. Under Title VI of the Civil Rights Acts of 1964, Section 504 of the Rehabilitation Act of 1973, and the Age Discrimination Act of 1975, as amended, the U.S. Department of the Interior prohibits discrimination on the basis of race, color, national origin, disability, or age in its federally assisted programs. Michigan law prohibits discrimination on the basis of religion, race, color, national origin, age, sex, marital status, or disability. If you believe you have been discriminated against in any program, activity, or facility as described above, or if you desire further information, please write to:

Chief, Office of Equal Opportunity Programs
United States Department of the Interior
National Park Service
1849 C Street, NW
Washington, DC 20240

- EXECUTIVE SUMMARY: Briefly describe the scope of the survey project, its purpose and goals, and the results in terms of the survey products, evaluations of eligibility for the National Register of Historic Places, and recommendations for local districting and other actions. Provide a summary of National Register eligibility recommendations and any other recommendations for action from the Evaluation Results and the Planning Needs and Recommendations sections. The executive summary should direct the reader to the appropriate sections of the report (include page numbers) where more detailed information can be found. This information will be copied into the MiSHPO survey submission as the abstract. **As part of the executive summary, the following information is required for all surveys submitted to SHPO.**
    - Number of properties surveyed at the reconnaissance level and at the intensive level: break this down by municipal unit if survey work took place in more than one and break it down by area if survey activities took place in more than one survey area.
    - Number of acres and hectares surveyed (SHPO requires this information as it must be reported to the National Park Service).

- TABLE OF CONTENTS
- CREDITS AND CREDENTIALS: Indicate who worked on each part of the project, their areas of expertise, and how they qualify as historians or architectural historians according to the federal qualifications set forth in 36 CFR 61. This part of the report can also be used to acknowledge funding or other assistance rendered the surveyor or team.
- PROJECT OBJECTIVES AND METHODOLOGY: Explain why the survey was undertaken and the goals and objectives that the survey project was intended to fulfill. What situations, conditions, planning needs, or other circumstances led to the survey and how and by whom were the objectives developed. List any previous surveys or studies relating to the survey area and define any data gaps or outdated information in these studies that warranted new study. Describe in reasonable detail the work program that was developed to carry out the goals and objectives. Provide a verbal description of the survey area boundaries and set forth the various tasks and components of the project and the order in which they were undertaken. Identify sources—such as the local libraries, university archives, county register of deeds, or interviews and personal records of residents—of historical information to be used in the project.
- DATA LOCATION: List repositories for survey material, such as libraries, archives, planning departments, and SHPO. Indicate where copies of the full set of survey materials, photographs, and copies of the report have been deposited for future access.
- EVALUATION RESULTS SUMMARY:
    - RECONNAISSANCE-LEVEL SURVEY: The evaluation results section will contain recommendations concerning individual properties and areas deemed worthy of further study because of some potential for National Register of Historic Places eligibility. For each individual property, complex property, and district recommended for intensive level survey, provide at a minimum a single paragraph statement that contains a summary description of the resource and rationale for why it is viewed as worthy of intensive level study followed, in the case of resources consisting of multiple properties, by a specific boundary description. Provide a map illustrating the boundaries of areas recommended for intensive level survey (See Maps section of this chapter).
    - INTENSIVE-LEVEL SURVEY: The Evaluation Results section should contain specific recommendations concerning individual and complex properties and districts that appear to meet the National Register criteria along with clearly defined boundaries. For each individual or complex property evaluated as National Register eligible, list the property and its street address (or latitude/longitude to six digits) and municipal unit (if the survey included more than one municipal unit). For a district, provide a detailed boundary description and a rationale for the boundaries selected. For each individual and complex property and districts evaluated as National Register eligible, include a short summary description and significance statement that is similar to the summary paragraphs in National Register nominations. For each proposed district, provide a map that shows the boundaries for the district for inclusion in the Evaluation Results section of the report. The map should be no larger than an 8 ½'' x 11'' format or must be able to be folded to that size in a hard copy of the report.
- PLANNING NEEDS AND RECOMMENDATIONS: If appropriate, include recommendations for other measures that should be undertaken to encourage the future preservation of the survey area's historic resources. These can include recommendations for local historic district designation, for educational programs to increase public awareness (books, videos, websites, programming, etc.), for establishing financial incentive programs to encourage historically sensitive rehabilitations of downtown commercial buildings or

homes in historic districts, for zoning changes, etc. This may be more appropriate for surveys conducted during the Section 106 process. Information should also be included regarding Section 106 recommendations and information on avoiding Adverse Effects on the historic properties.

- PRESERVATION ISSUES AND THREATS: In considering the local preservation environment, the surveyors should note any known threats to buildings in the area and the nature of those threats. The surveyor will also be expected to provide information regarding threats to individual buildings.
- SURVEY MAPS: Provide a complete, final set of survey maps. These maps should be reproducible without color copying capabilities.

SURVEY REPORT COMPONENTS: SECTION TWO

Section Two of the report contains a descriptive overview of the survey area, the historical overview and context narratives, plus evaluation sections relating to the historic themes. This section should be arranged in the following order:

- DESCRIPTIVE OVERVIEW: Provide a summary description of the survey area that defines its physical character, including features such as location and setting, topography, land uses, and general character of the historic resources present. For survey areas that comprise several sections, provide a descriptive overview for each section. The description should begin with general information, including a description of the boundaries (if the survey doesn't encompass an entire community) and a discussion of the area's general character, including the setting and topography. More detailed information about the survey area's physical form and layout and its architectural character should follow. The length of the overviews will vary depending on the size and character of the survey areas. Paradoxically, it seems that for a large survey area, such as an entire community, a relatively short overview will generally make sense, while for a relatively small area, such as a neighborhood, a lengthier overview will often be warranted.
- HISTORICAL CONTEXT: See historical overview section above. This section should include a historical sketch of the development of the community that focuses on settlement patterns, immigrant groups, important industries, and dominant architectural traditions. This section should also include information on themes.
    - o THEMATIC NARRATIVES: The thematic narratives should be prepared as described in the Thematic Narratives section of Chapter 4 and should follow the historical overview for the survey area. Each historical narrative should be followed by evaluation standards for the theme and a list of properties associated with it.
- BIBLIOGRAPHY: The required citation style of Michigan SHPO is the most recent edition of the Chicago Manual of Style. The bibliography should contain a list of all references consulted during the course of the survey.

SURVEY REPORT COMPONENTS: SECTION THREE

Section Three of the report comprises the survey data itself, as well as the following components:

- INDEX LIST OF SURVEYED PROPERTIES: This should be organized by street and number in alphabetical and numerical order. The entry in each surveyed property should

reference the map on which the surveyed property is found (if there is more than one survey map). Individual properties and complex properties at single addresses (generally houses or estates, farms, industrial or institutional complexes, or parks or cemeteries) should be listed alphabetically by street and then numerically by address number. Historic districts should be listed alphabetically by historic name at the beginning of the index list.

- INVENTORY FORMS: Provide a complete set of printed Historic Resource Inventory Forms and a Historic District Inventory Form for all surveyed properties. The forms should be arranged in the same order as the index list. The Michigan SHPO has created a template that includes the mandatory terms for survey in the state (See Appendix D).
- SURVEY PHOTOS: Photographs should be taken in accordance with the above standards.

A survey report is an official document summarizing the results of an important planning activity that will hopefully promote and influence the course of historic preservation activities in the survey area for years to come. The credibility of the report and its conclusions and recommendations can be enhanced by a professional appearance or reduced by an appearance that is less than professional. The final version of the report should be free of typographical and grammatical errors. Reports prepared for SHPO will not be accepted if they contain typographical errors and other unprofessional characteristics. The overall layout and graphics, including mapping, should have a polished, professional appearance.

The survey report is not an academic exercise that will never see the light of day, but rather a public document that will likely be scrutinized for years to come not only by preservationists but also by those seeking to demolish historic properties. The report should be written in an objective tone that clearly demonstrates the significance of the historic resources. Avoid damning historic properties with faint praise. For example, the same building was described in earlier and later versions of the same report as follows:

“In contrast to the Ottawa Street Power Station is the extremely modest Art Deco store at 1136 S. Washington Avenue.”

“In contrast to the grandeur of the Ottawa Street Power Station is the modestly sized Art Deco store front at 1136 S. Washington Avenue. Although the building itself is very small, almost tiny, the unique octagonal windows and pencil-line concrete detailing above the twin entries make this building a distinguished and elegant part of the lively South Washington streetscape.”

The first of these statements says nothing to indicate that this building is significant; in fact, the implication is that it is unimportant, and thus expendable. The second statement, especially when read in combination with another statement about the building on a different page in the report makes unmistakeably clear the importance of the building as evaluated by the report’s authors: “One of the city’s unique structures is the diminutive but jewel-like Art Deco building at 1136 S. Washington.”

DISTRIBUTING SURVEY REPORTS

Every survey should be viewed as an opportunity to help preserve Michigan’s significant cultural resources. The survey products provide an explanation of a community’s development and constitute documentation regarding the location and significance of above-ground resources associated with various themes in a community’s history and architecture. These materials can be a tool for a variety of groups besides SHPO, including:

- Planners, to develop strategies to minimize the impact of development projects on significant resources; to facilitate their responsibilities, under federal law, regarding the protection of cultural resources; and to provide a basis for establishing priorities for the rehabilitation or conservation of neighborhoods
- Historic interest groups that promote local history and the preservation of significant properties or areas, that serve an educational role in the community, and that may be a repository for local historic collections

- Property owners desiring information about their houses or businesses
- Teachers, who use local history and the built environment in classes ranging from social studies to history to art
- The media, which needs background information for news coverage and special reports and programming
- Neighborhood organizations that work to enhance the quality of life in specific areas, and
- Youth groups that may sponsor projects that enhance the environment, including historic resources

Thus, survey reports should be widely available to both governmental and planning agencies and members of the general public. A sufficient number of survey reports should be produced to allow for distribution. The following agencies or organizations should receive a copy of the report:

- Local planning department
- County or regional planning agency
- SHPO (One digital copy and one paper copy)
- Local libraries
- Library of Michigan, Lansing
- Local or regional archives and repositories nearest the survey area, such as
    - Burton Historical Collection, Detroit Public Library
    - Michigan Historical Collections, Bentley Library, University of Michigan
    - Clark Historical Library, Central Michigan University
    - The university archives at Michigan Technological University, Oakland University, and Western Michigan University

We also encourage discussing with the local planning department the possibility of incorporating the survey data into a local Geographic Information System (GIS). These discussions should include SHPO staff.

RECOMMENDATION FOR INTENSIVE LEVEL SURVEY FOR AN AREA RESULTING FROM RECONNAISSANCE LEVEL SURVEY

EXAMPLE: "Island" Survey Area, Sault Ste. Marie

This primarily residential area located on the island formed by the St. Mary's River and the power canal contains a potential National Register-eligible historic district for which precise boundaries should be established as a result of intensive level survey work. The potential district extends east from the county courthouse along portions of Maple, Cedar, Spruce, Carrie, Dawson, Kimball, and Brady Streets and St. James Place in the general area bounded on the west by Bingham, north by Portage, east by Johnston, and south by the power canal and Lyon Street. The area contains a rich concentration of large and often high-style late nineteenth- and early twentieth-century houses, including most of the city's most architecturally distinguished Queen Anne houses plus notable examples of "Free Classic," Tudor, Arts-and-Crafts-influenced, and other styles of houses. It contains two substantial houses built with walls of local pinkish-brown sandstone. A row of very fine Arts-and-Crafts houses lines the south side of Carrie west from Johnston. The area also contains the Neoclassical former Carnegie Library building on Cedar Street plus the Gothic Revival (Catholic) St. Mary's Pro-Cathedral complex, which includes the Art Deco St. Mary's School directly behind the church between Maple and Cedar and the large schoolyard that extends west to Spruce.

The area that appears to merit intensive-level survey is bounded by Portage on the north, Bingham on the west, the power canal on the south, and Johnston on the east, and the two brick bungalows on the east side of Johnston south of Carrie.

RECOMMENDATION FOR NATIONAL REGISTER-ELIGIBLE DISTRICT RESULTING FROM INTENSIVE LEVEL SURVEY

EXAMPLE: Schoolcraft Historic District, Schoolcraft

DESCRIPTION: The recommended Schoolcraft Historic District comprises portions of nine blocks on the village's west side and is centered in the area bounded by Haywood on the east, Eliza on the south, West on the west, and Vienna on the north. It contains many of the community's oldest houses, dating from the 1830s and 40s, and some of its most architecturally distinguished houses, including Greek and Gothic Revival, Italianate, Eastlake, and "Free Classic" buildings. Many of the finest of these houses are located along the two blocks of West Cass Street.

SIGNIFICANCE: The proposed Schoolcraft Historic District occupies much of the original plat of Schoolcraft, laid out in 1831 for owner Lucius Lyons and named by him in honor of his friend, Henry R. Schoolcraft, explorer and Indian agent for the Michigan Territory. The commons Lyons set aside for church and school sites survives, having been made into a park in the 1890s after the only building ever constructed there, a church, was removed. The district, comprising almost the entire village before additional areas were platted beginning in 1835, contains the homes of many of the village's earliest white settlers. These include the person who platted the area for Lucius Lyons; the village's and county's first physician (and later the local Underground Railroad conductor); an owner and a proprietor of the village's first hotel, which stood in this area before Grand Street (US-131) was laid out and became the main street; a part owner of the village's first store; the village's first postmaster; and a participant in Michigan's constitutional convention (and later mayor of Kalamazoo). Anumber of these houses date from the early 1830s and are among the oldest buildings in the southwestern part of Michigan. The district's early

building stock contains examples of a broad range of house forms characteristic of the southern part of Michigan and of the New England and New York State origins of the earliest settlers. They include the I-house, gable-front, upright-and-wing, upright-and-double-wing, and gabled-ell forms. Examples of Greek Revival, Italianate, Gothic, Eastlake, and "Free Classic" houses are present, and some of them, especially along West Cass Street, are unusually distinguished examples of their styles within the overall context of the region's building stock.

BOUNDARY DESCRIPTION: the district boundary begins at the NW corner of lot 57; thence S to NW corner of lot 69; th W along N line of lot 68 to center of West St.; th S to center of Clay St.; th W to rear (W) line of lot 78; th S along rear (W) lines of lots from 78 to 139 and to center of Eliza St.; th E to center of West St.; th S along W line of lot associated with 322 W. Eliza to SW corner of property; th E to SE corner of property; th N to center of Eliza St.; th W to E line of lot 140; th N along E linesof lots 140, 137, 128, and 125 to SE corner of lot 116; th E along S line of lots 117 and 118 to SE corner of lot 118; th N along E line of lot 118 to SE corner of lot 111; th E along S line of lot 110 to center of Hayward St.; th N in center of Hayward to a point in line with N line of lot 62; th W along N line of lots 62 and 63 to center of Center St.; th N to a point in line with N line of lot 57; th W to Point of Beginning. All in Original Plat of the Village of Schoolcraft.

BOUNDARY RATIONALE: This boundary was drawn to include the areas within the original plat containing a concentration of houses relating to the village's earliest days as well as other historically and architecturally significant houses while avoiding those areas in which concentrations of historically and architecturally significant properties are not present.

SURVEY AREA DESCRIPTION FOR A COMMUNITY

EXAMPLE

Port Hope is a small village (population of 360 as of 1980) located on the shore of Lake Huron in the Thumb region of Michigan's Lower Peninsula. The Thumb, bounded on the east by Lake Huron north of Port Huron and on the northwest by Saginaw Bay, is a rural, agricultural area generally of low, slightly rolling topography. The principal part of Port Hope from approximately Main Street west lies on a nearly level plain that extends inland in all directions. East of Main Street the land drops off a short distance to a lower terrace along the lakeshore itself. The village is surrounded on the land side by farm country with scattered stretches of forest. A modern county park and several campgrounds and trailer parks occupy much of the lake frontage in the village, but to the north and south the shoreline is wooded and in some cases swampy. US-25 is the principal commercial street, passing through the small central business district, with its handful of clapboards and brick Late Victorian buildings, in the two blocks between School Street and Portland Avenue. US-25 southeast of the point where Main Street cuts off from it follows a modern alignment that cuts diagonally across the historic platted patterns of streets. Main Street on either side of the business district and the streets to the west—First, Second, Third, State, and School—is the residential portion of town and contains a mixture of mostly modest late nineteenth- and twentieth-century houses plus two older churches. The lakeshore terrace to the east historically was the site of mills and elevators, and presently contains several elevator complexes and other commercial enterprises, plus free-standing chimney stacks from long-ago-destroyed saw and planing mills. It appears that many of the streets in the north and southeast parts of town shown in the 1890 map as platted were never opened.

SURVEY AREA DESCRIPTION FOR A NEIGHBORHOOD

EXAMPLE

River Point is bounded on the north and west by the Grand River, east by the Red Cedar River, and south by the railroad line south of South Street, which forms the southern edge of the original part of Lansing platted in 1847. The neighborhood comprises two components, the commercial corridor along South Washington, which spills over slightly onto the side streets, and the larger residential area along Hazel, Elm, South, Grand, and Platt to the east. River Point's distinct edges define the neighborhood's character and make it a place apart from the rest of the city.

The South Washington corridor between the river and the railroad tracks possesses much visual interest because of the variety of older buildings present—from one of the city's largest early twentieth-century apartment buildings to a Spanish Mission-style former gas station to a Moderne enameled metal panel bowling alley to a Neoclassical bank building to one of Lansing's Art Deco jewels to a turn-of-the-century railroad station. The station is located just outside of the survey area; it is listed in the National Register of Historic Places.

The corridor's buildings have survived reasonably intact and restorable despite years of neglect and underutilization. Much of the commercial building stock consists of early twentieth-century two-story Commercial Brick blocks in which the facades rely for their decorative interest not on historical styling but on the brickwork itself. The most commonly seen trademarks of Commercial Brick are panels of brickwork and corbelled brickwork below the upper cornices or roofline. The range of buildings at 1131-1149 S. Washington, although as simply detailed as any Commercial Brick block in the city, are unusual for the uniform façade design with slightly recessed brickwork panels in the friezes carried throughout. The four-store front building at 1000-1006 displays the most intricate brickwork paneling of any of the area's numerous examples. Alternating panels of horizontal stretcher bricks and diagonal stretchers flanking central lozenge ornaments—the panels outlined by bands of headers with square blocks at the corners—stretch across the façade at frieze level. The three-storefront building at 1202-1206 S. Washington (each section of the building today is treated differently, with the central third clad in 1960s-looking metal sheathing that should come off one day) displays a robust Commercial Brick corbelled cornice in which projecting stretchers alternate with recessed headers. The Popoff Meat Co.'s northerly building employs an even more eye-catching corbelling technique in its cornice. In the alternating tiers of projecting and recessed corbelled brickwork, the recessed tiers begin one course above the projecting ones. This results, when sunlight falls on the façade, in a checkerboard-like appearance. Like Commercial Brick buildings elsewhere in Lansing, the South Washington ones exhibit considerable variety in brick hues and textures.

One of the city's unique structures is the diminutive but jewel-like Art Deco building at 1136 S. Washington. This symmetrical two-storefront limestone-clad building displays octagonal shop windows, fluted horizontal banding, chevrons, and dramatic striping on the façade. The façade is completely intact, including the doors with their streamlined push bars.

Another landmark, although not a commercial building, along South Washington is the Washington Arms Apartments located just south of the Grand River. Along with the Porter, located on Townsend at Lenawee, the massive red brick Washington Arms is probably the largest early twentieth-century apartment building in a city which until well into the twentieth-century century was almost exclusively a community of single-family houses, with only a relatively small number of two-family and townhouse buildings.

The streets east of Washington comprise the bulk of the River Point residential neighborhood (a few residential buildings are also found west of Washington, and notice will be taken of one of them in a few paragraphs). The River Point neighborhood is characterized by narrow streets and, except north of Hazel, small lot sizes. Houses stand close by one another and close to the street. Far from being drawback,

these factors along with the abundant shade from large trees give the neighborhood an intimate scale that is one of its most appealing features.

The houses in River Point appear to date primarily from the 1890s to the 1920s. There are none of the larger and more elaborately detailed houses found in some other Lansing neighborhoods. The houses are generally simple and of modest scale. Some of the larger of the oldest houses are narrow-fronted and deep two story, cross-gable houses such as 1135 S. Grand and a brick example at 1145 S. Grand. A number, such as 215 Hazel and 1134 Platt, are gable-front buildings where the entrance stands at the back of a shed-roof side porch. Among the neighborhood's early twentieth-century homes, the two-story square-plan "foursquares" found in other Lansing neighborhoods are present along with a small number of bungalows. The bungalows tend to display simple Arts-and-Crafts-inspired detailing including exposed rafter ends below the broadly projecting roofs and, in the case of 1140 S. Grand, door and window trim with elongated lintels and slanting sides. A small number of Colonials, including narrow and deep Dutch Colonials with their gables to the street such as the one at the southeast corner of Hazel and Grand, are also present. A gable-front turn-of-the century-looking Colonial house at 222 Elm stands out among the neighborhood's dwellings because of its tripartite, with arched center, Palladian-inspired window in the front gable.

Most houses in River Point occupy narrow-fronted and deep lots and thus embody similarly narrow and deep forms. Elm Street presents virtually the only exceptions to this general pattern. A stuccoed, hip-roof, two-family house of Arts-and-Crafts inspiration—the only building constructed as a two family house noted in the neighborhood, at the southwest corner of S. Grand—and a broad-fronted gambrel-roof Dutch Colonial with shed dormer, located on Elm's north side between Grand and Platt, are highly visible buildings because of this broad-fronted orientation.

The neighborhood's only church building stands at the south end of the area on South Street between Grand and Platt. It is a cross-gable, early twentieth-century, auditorium-type church building with a square-plan tower near the façade's midpoint. Simple bargeboards mark the eaves.

The short east-west streets west of Washington retain few buildings. The most notable of them—really one of the outstanding buildings of the neighborhood—stands at 117 S. South. This two-story, symmetrical-front building, presumably once an apartment house, sports an Arts-and-Crafts façade of brick of various hues from red orange to brown that is divided into three vertical bays by boldly projecting piers, the central ones rising well above the tiled pent roofs that top the bays. The central bay's entry and broad windows in either side bay, set within segmental arches and panels of header brick outlined by stretcher brick (itself a reversal of the typical panel treatment), separates the first-floor openings from those above. Another pent-roof building, a smaller one-story commercial building with an arched central entry, stands next door to the west at 121.

River Point today all but turns its back to the river. Although some streets and houses stand close to the Grand and Red Cedar, steep, thickly wooded banks conceal the water from view. The city has developed the small River Point Park at the actual confluence of the Grand and Red Cedar, but, it seems, more could be done to make the rivers' proximity a community asset.



UPDATING PREVIOUS SURVEYS

Areas may require re-surveying because the existing data has become outdated, a higher level of survey is required (an intensive-level survey will replace an old reconnaissance-level one), or the quality of the old survey is unreliable. Whatever the reason, past survey activity may provide information useful for the present project, including:

- Existing site-specific records (inventory cards, forms, or database records);
- Research that can contribute to the current research effort;
- Recommendations regarding eligibility;
- Districting proposals.

The new survey should build upon the old one. The old thematic narratives should not be used as is, but the new survey should be seen as an opportunity to revise and expand them. The aim of a new survey should be to provide survey materials meeting current standards for all properties in the survey area that have previously been surveyed and that meet the survey criteria developed for the re-survey project. A re-survey project should generally be performed at the intensive level; it usually makes little sense to re-survey previously surveyed properties unless the survey will generate additional information. Old surveys often omitted features of complex properties such as carriage house/stable buildings and agricultural outbuildings that would be included in current intensive-level surveys. The new survey provides an opportunity to obtain complete survey data that should not be missed.

The new survey report should include all of the standard products as well as any newly surveyed properties within the re-survey area.



THEMATIC SURVEYS AND CONTEXT STUDIES

Thematic survey is the survey of properties relating to a specific property type or historic theme. Thematic surveys of industrial and engineering sites, highway bridges, post offices, and state parks have been carried out at the statewide level, and myriad other property types or themes such as vernacular log buildings, outdoor sculpture, designed historic landscapes, and the automobile industry could be the subjects of statewide thematic surveys. Thematic surveys within single counties or larger cities are equally feasible.

A survey project in Grand Rapids included thematic surveys of city parks, public school buildings, and cemeteries. Surveys of public schools, apartment buildings, and banks in the city of Detroit have been completed. The Michigan SHPO has undertaken these context studies as a way to better assist planning efforts in these regions. Thematic surveys could involve important aspects of local history, such as the struggle for Civil Rights in Detroit or Detroit's rich twentieth-century heritage as a center for jazz and other forms of popular music. A survey of sites associated with the history of popular music in Detroit, for example, might seek to identify birthplaces and homes of musicians, recording studios, and clubs, ballrooms, and other places where locally and nationally important performers and groups played. The possibilities for thematic surveys and context studies are endless.

Thematic surveys differ from other survey types by requiring an initial property-specific research phase to identify the specific properties to be surveyed or to locate the areas likely to produce resources that merit survey. Standard sources of information such as published histories, typically used for surveys, may not be as useful in thematic surveys, and research in specialized sources of information appropriate to the project will be needed. A statewide survey of historic railroad bridges might require a search for railroad company records, engineering and railroad journals and bridge company records and catalogs that might provide information on specific structures, and a review of maps to locate likely points for major bridges. Surveys of Civil Rights struggle-related sites or popular music-related sites in Detroit would probably require numerous oral history interviews. A survey of the Finnish farmsteads in the Upper Peninsula would likely require research in old maps and census records to determine where the concentrations of Finnish settlements were located.

Surveyors will need to devise research strategies appropriate for identifying and documenting the resources to be surveyed. Persons with specialized knowledge of the survey's subject matter should be involved in the project at the earliest planning stage. In carrying out a thematic survey, the general instructions for intensive-level survey provided here should be followed. However, a thematic survey must begin with a research phase both to document the theme itself and to identify and document the associated properties. The thematic research will lead to the preparation of a single thematic narrative that includes discussion of associated property types.

Many thematic surveys are done under contract with SHPO. These projects often involve the preparation of inventory forms and a Multiple Resource Documentation Form for the National Park Service. In addition to this form, these surveys must include a separate survey report following the guidelines outlined in this document. Consultants should utilize site forms following the example in Appendix D for the creation of their inventory forms. These items must also be entered in the MiSHPO system as outlined in this document.



SURVEY AND SECTION 106

As a part of their compliance with Section 106 of the National Historic Preservation Act, federal agencies and their designees have the responsibility to identify historic properties that may be affected by an undertaking. An undertaking is a federally assisted or licensed project, such as housing rehabilitation and demolition, streetscape improvements, new road construction and road reconstruction or realignment, airport expansions and renovations, water and sewer projects, new bank branches, railroad line abandonments, and communication towers. Under Section 106, federal funding or licensing agencies (or their designees when permitted under federal regulations) must provide SHPO with data on historic properties that might be affected by their proposed projects along with substantive comments on the eligibility of those properties. The submission of this information is a prerequisite to obtaining comments from SHPO on the effects of the projects on historic above-ground resources. Projects that involve both above-ground and below-ground disturbances should also contact the State Archaeologist to conduct appropriate file reviews of below-ground sites in the project area.

The APE for a project should be defined in consultation with SHPO. **Please note that the area of potential effects (APE) is not simply the project's physical boundaries or right of way.** It is important to understand this. The APE is defined as the geographic area or areas within which an undertaking may directly, or indirectly, cause changes in the character or use of historic properties. The area of potential effects is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by an undertaking. In defining the APE, you must consider not only physical effects but also visual, auditory, and sociocultural (i.e. land use, traffic patterns, public access) effects.

The potential National Register of Historic Places eligibility of properties that may be affected by a federally assisted or licensed project must be reviewed in the context of the neighborhood or area in which they are located. The agency requesting SHPO's review must provide sufficient information to answer the question, "What are the historic properties either listed in or eligible for listing in the National Register of Historic Places within the area of potential effect (APE) for the project?" This includes determining not only whether affected properties may be individually eligible for the National Register, but also whether they may contribute to the historic character of a larger area or district that as a whole meets the National Register criteria. Competent professionals meeting the federal professional qualifications for historian and architectural historian should perform the work.

WORK PROGRAM

Federal agencies or their federally delegated designees ("Responsible entities" for HUD-funded projects) must perform the following in order to provide the basic information SHPO requires. This information will be used to make informed determinations of eligibility and effect for properties in the APE:

1. A visual inspection of the exterior of each property in the APE and of the surrounding neighborhood to
    a. Evaluate the architectural character and integrity
    b. Determine if properties in the APE may be part of a National Register-eligible district and if so, to define the district's boundaries.
2. Contact SHPO to
    a. Review National Register listings for the community
    b. Determine whether SHPO has previously established firm boundaries for a National Register-eligible district in the area.
3. Research the properties in the APE and document their histories, using standard sources such as
    a. Historic atlases and plat books
    b. Directories and published sources such as county and local histories
    c. Tax records
    d. Interviews with current and past property owners, local historians, and long-term residents



APPENDIX A

HISTORIC ARCHITECTURE SURVEY GLOSSARY OF TERMS

These definitions were obtained from the National Park Service National Register Bulletins 15, 24, and 16a.

ARCHITECTURE CLASSIFICATION – Item on the National Register form calling for the entry of an architectural style or other term by which the property can be identified.

BUILDINGS – A building, such as a house, barn, church, hotel or similar construction is created to shelter any form of human activity. Building may also refer to a historically and functionally related unit, such as a courthouse and jail or a house and barn. Examples include stables, sheds, garages, courthouses, city halls, social halls, commercial buildings, libraries, factories, mills, train depots, stationary mobile homes, theaters, schools, and stores.

DISTRICT – A district possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development. Examples include college campuses, central business districts or other commercial areas, residential areas, industrial complexes, civic centers, rural villages, large farms, ranches or estates, and large landscaped parks.

FORM CLASSIFICATION – the item on the National Register form calling for the architectural form or other term by which the property can be identified.

HISTORIC CONTEXT – An organizing structure for interpreting history that groups information about historic properties that share a common theme, common geographical area, and a common time period. The development of historic context is a foundation for decisions about the planning, identification, evaluation, registration, and treatment of historic properties, based upon comparative historic significance.

HISTORIC INTEGRITY – the unimpaired ability of a property to convey its historical significance.

HISTORIC RESOURCE – a building, site, district, object, or structure evaluated as historically significant.

IDENTIFICATION – the process through which information is gathered about historic properties.

LANDSCAPE – A landscape is a collection of organized features that can range from something as small as a birdbath to large fields or orchards. The U.S. Secretary of the Interior has defined the following six components of a landscape that must be identified and documented if the character of the landscape property is to be understood: spatial organization and land patterns; topography; vegetation; circulation; water features; and structures, site furnishings, and objects.

OBJECT – The term object is used to distinguish from buildings and structures those constructions that are primarily artistic in nature or are relatively small in scale and similarly constructed. Although it may be, by nature or design, movable, an object is associated with a specific setting or environment, such as statuary in a designed landscape. Examples include sculpture and statuary, monuments, fountains, fences and streetlights.

PROPERTY TYPE – a grouping of individual properties characterized by common physical and/or associated attributes.

RESOURCE – any building, structure, site or object that is part of or constitutes a historic property.

RESOURCE TYPE – the general category of property – building, structure, site, district, or object – that may be listed in the National Register.

SETTING – quality of integrity applying to the physical environment of a historic property.

SIGNIFICANCE – Importance of a historic property as defined by the National Register criteria in one or more areas of significance.

SITE – A site is the location of a significant event, a prehistoric or historic occupation or activity, or a building or structure, whether standing, ruined, or vanished, where the location itself possesses historic, cultural, or archaeological value regardless of the value of an existing structure. Examples commonly encountered in above-ground surveys include estate and other grounds, gardens, ruins of historic buildings and structures, cemeteries, parks, and designed landscapes.

STRUCTURE – The term structure is used to distinguish from buildings those functional constructions made usually for purposes other than creating shelter. Examples include bridges, tunnels, dredges, fire towers, canals, dams, power plants, water purification and sewage treatment plants, water towers, corncribs, silos, roadways, windmills, grain elevators, kilns, railroad grades, systems of roadways and paths, boats and ships, railroad locomotives and cars, carousels, bandstands, gazebos, and aircraft.

STYLE – in this case, it is the architectural style that is not on the list of the pre-defined NPS-acceptable terms for the National Register Form. If “other” is selected for the Architectural Classification field, then Style should indicate what the “other” is.

SURVEY – A survey is a systematic search for properties that possess or appear to possess significance to national, state, or local history. Survey is the process of identifying and gathering data on properties that may be historic. It includes field survey, the physical search for and recordation of basic information about historic and potentially historic properties; background research to establish the historic context for the properties within the project area; and historical research on surveyed properties.

THEME – a trend or pattern in history or prehistory relating to a particular aspect of cultural development, such as dairy farming or silver mining.



APPENDIX B

FARMSTEAD AND HISTORIC LANDSCAPE SURVEY STANDARDS

Urban, suburban, and rural survey areas may contain properties and areas that possess significance as historic landscapes. The U.S. Secretary of the Interior has defined the following six components of a landscape that must be identified and documented if the character of the landscape property is to be understood: spatial organization and land patterns; topography; vegetation; circulation; water features; structures; site furnishings; and objects. The degree of importance of any of these features depends on the landscape and its use.

The most likely types of historic landscapes encountered in the field are the Historic Designed Landscape and the Rural Historic Landscape. Before beginning work, surveyors should review *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes*; National Register Bulletin 18, *How to Evaluate and Nominate Designed Historic Landscapes;* and National Register Bulletin 30, *Guidelines for Evaluating and Documenting Rural Historic Landscapes*, for insights into identifying and documenting these important historic resources.

A Historic Designed Landscape is defined in Bulletin 18 as a landscape:

- Significant as a design or work of art
- Consciously designed and laid out either by a master gardener, landscape architect, architect, or horticulturalist to a design principle, or by an owner or other amateur according to a recognized style or tradition, or
- That has a historical association with a significant person, trend, or movement in landscape gardening or architecture, or a significant relationship to the theory or practice of landscape architecture

Historic designed landscapes may include parks, squares and other public spaces, cemeteries, parkway or boulevard systems, small residential grounds, estates, campus or institutional grounds, gardens, golf courses, and planned subdivisions and communities, including mobile-home parks/manufactured housing developments.

A Rural Historic Landscape is defined in Bulletin 30 as:

- A geographic area that historically has been used by people, or shaped or modified by human activity, occupancy, or intervention, and that possesses a significant concentration, linkage, or continuity of areas of land use, vegetation, buildings and structures, roads and waterways, and natural features. Rural landscapes often reflect the day-to-day occupational activities of people engaged in traditional work activities such as mining, fishing, and various types of agriculture. Often, they have developed and evolved in response to both the forces of nature and the pragmatic need to make a living.

Rural historic landscapes often contain large acreage and proportionally small numbers of buildings and structures compared to other types of historic properties. Examples of rural historic landscapes in Michigan include: agricultural districts, industrial districts of a series of mine complexes or remnants, a fishing village or complex, and a district of recreational camps.

SURVEYING HISTORIC LANDSCAPES

Survey forms should be customized in consultation with SHPO for a historic landscape depending on whether the landscape forms a single complex property, such as a park, cemetery, residential grounds, an estate, or a number of complex properties. For single complex property surveys, any feature that appears several times on the landscape such as a fence or wall system, should be recorded on a single form with the quantity included. For cemeteries, records should be created for all public monuments and memorials, such as veteran memorials. Private monuments and memorials should be surveyed when they mark the resting place of historically significant individuals, when they possess special artistic

merit or unique design, or when they are rare examples of a type (e.g. iron cross markers from old Catholic cemeteries).

For multiple complex properties forming a historic landscape, each property should have its own site form. Examples include the following:

- A Rural Historic Landscape that is a rural agricultural district consisting of a group of farms, each of which contains historic features that require survey;
- A Designed Historic Landscape that is a planned residential district in which each individual property contains historic features that require survey.

Survey data for a Rural Historic Landscape should be captured on both a survey form and in the description field as appropriate. Some of the items collected could include:

- Land uses and activities
- Patterns of spatial organization
- Response to the natural environment
- Cultural traditions
- Circulation networks
- Boundary demarcations
- Vegetation related to land use
- Buildings, structures, and objects
- Clusters
- Archaeological sites
- Small-scale elements

Survey data for Designed Historic Landscapes should be captured on both a survey form and in the description field as appropriate. Some of the items collected could include:

- Overall form and plan of the landscape.
- Approximate size of the landscape—Convey the scale of the landscape in terms of acres or square miles, as appropriate.
- Topography—Describe whether the land is flat, rolling, hilly, or varied in relief.
- Natural features—Describe natural features, such as rivers, lakes, hills, or bluffs that help define the landscape.
- Circulation systems of roads, paths, trails, etc.
- Spatial relationships and orientation, such as symmetry, asymmetry, and axial alignment.
- Views and vistas in to and out of the landscape.
- Vegetation—Ideally, describe the common name with caliper for trees and heights for shrubs (and put this information onto maps). At the least, describe the primary types and locations of vegetation. Mention the extent of tree cover, using appropriate terms such as grove, scattered trees, forest, wooded area, and specimen tree. If possible, name the species of trees or describe whether trees are coniferous (evergreen) or deciduous. Include the general maturity of trees. Use a similar approach to describing shrubs and their arrangement on the landscape. Flowers and other low-growing plants should be described in terms of their placement on the landscape: in beds, naturalistic plantings, planters, or specialty gardens.
- Bodies of water such as pools, fountains, lakes, streams, and cascades.

- Number and general character and location of buildings, structures, and objects present.

Photography should include an appropriate number of images to thoroughly document the entire district and individual complexes or features. The views should be taken from different directions and include one or more that illustrate the street frontage.

A single survey map should be prepared for each surveyed complex in accordance with the general survey mapping instructions. The map should include the entire district, not just areas containing the buildings. All surveyed resources should be plotted and labeled. The survey map should also illustrate those important features not surveyed but included on the survey form for the entire property.

SURVEYING FARM PROPERTIES

Farm properties commonly consist of farmstead areas containing houses, barns and other outbuildings plus the remainder of the farm properties, which may include a combination of features such as crop and pasture areas, woodlots, orchards and gardens, lanes, windbreaks, and ponds. Additional buildings such as hay barns and migrant housing clusters may stand outside of the main farmstead area. Small-scale features such as fencing, windmills, wells, and bridges may also be present. These human-built and natural elements plus the overall features of land use and circulation patterns define the character of farm properties.

A survey of farm properties should provide information on the entire property, including a comparison of the current historic patterns of land use and the physical layout as far as it can be determined. It should provide information on all buildings, structures, and other component features.

The surveyor must complete survey forms for the entire property and also individual survey forms for each of the buildings, structures, and objects regardless of age. Survey forms must also be made to cover all examples of any features that appear several times on the landscape such as fencing or wall systems. Historic vegetation associated with human occupation and use—such as windbreaks, tree lines along roads or drives, specimen trees, garden beds, and sugarbushes—should be included on survey forms, when historic information on the origins and uses of these features can be obtained. If information on the origin and use of the features is not found then they should be described and mentioned in the survey form for the larger farmstead.

Photography will include an appropriate number of images to thoroughly document the entire farm and individual features. The views should be taken from different directions and include one or more that illustrate the street frontage.

A single survey map must be prepared for each surveyed farm in accordance with the general survey mapping instructions. The map must include the entire property, not just the area containing the buildings. All surveyed resources must be plotted and labeled. The survey map should also illustrate those important features not surveyed but included on the survey form for the entire farm.



APPENDIX C

CONTRACTING SURVEYS

Survey Sponsors seeking consultants for survey work should develop a Request for Proposal (RFP) for the project. A clear RFP, with work and work products explicitly stated, helps consultants prepare more accurate budgets. If the work program is vague, consultants may have to compensate by pricing for unknown or unclear aspects of the work, and disagreement over the expected products may result at the end of the project. It is a good idea to request that the SHPO Survey Coordinator review the RFP before it is sent out to consultants.

The RFP should define the work program and products as fully as possible. It should clearly and thoroughly define:

- The work the consultant is expected to perform;
- The products—including the number of copies—to provide at the end of the project;
- The boundaries of the survey area, clearly defined in writing and illustrated by a map or series of maps;
- The expectations for the level of property-specific research, including what sources of information the consultant will be expected to use for all properties, and what additional research will be required for a specific number of apparently more significant properties, if that information is available;
- The total number of properties to be surveyed and a breakdown of the numbers by level of research, if possible;
- The time frame within which the project must be completed;
- Services or materials that may be provided to the consultant at the consultant's request; and
- Expectations for meetings the consultant will be expected to attend or presentations the consultant will be expected to make.

The RFP should clearly define the information that consultants must submit in their proposals, including:

- A thorough description of the work to be performed and the final products to indicate whether or not consultants have a clear understanding of what will be required;
- A plan of action for accomplishing the work. This should include a breakdown of the work by components and personnel and a schedule with time frames for each component;
- Educational background and related work experience of the personnel working on the project;
- Writing samples for personnel involved in preparing the report;
- Professional References.

Finally, the RFP should specifically list the criteria against which proposals will be evaluated. The criteria should award points to proposals that demonstrate:

- A solid understanding of the work and products required;
- An adequate program and realistic time frames for successful completion of the project; and
- Personnel with the necessary educational background, work experience, and proven track record of successfully completed projects.

Cost is obviously an important consideration, but no proposal should be considered unless it fully meets the evaluation criteria set forth above.



APPENDIX D

MICHIGAN HISTORY/ARCHITECTURAL SURVEY SITE FORM

NAME
Historic Name

STREET ADDRESS
Street Address

MUNICIPAL UNIT, COUNTY
City/Township, County

DISTRICT NAMES
District Name (if applicable)

Photo

YEAR BUILT
Date of Construction

PROPERTY TYPE
Resource Type

ARCHITECTURAL CLASSIFICATION
Architectural Classification
Architectural Classification Other

PLAN FOUNDATION WALLS
Plan

Foundation Materials

Wall Materials

ROOF FORM ROOF OTHER MATERIALS
Roof Form

Roof Materials

Other Materials

CONDITION INTEGRITY ARCHITECT
Condition

Integrity

Architect

HISTORIC USE CURRENT USE BUILDER
Historic Use

Current Use

Builder

OUTBUILDINGS Outbuildings

AREAS OF SIGNIFICANCE Areas of Significance

NARRATIVE DESCRIPTION
Narrative Description

STATEMENT OF SIGNIFICANCE
Statement of Significance

ELIGIBILITY RECOMMENDATION NR CRITERIA NR EXCEPTIONS
Eligibility Recommendation

NR Criteria

NR Exceptions

DISTRICT NAME
Related District Name

SOURCES
Sources

Surveyor Date Surveyed
Surveyor

Date Surveyed

Historic Name	Address	SHPO Survey Number
Common Name	Township/City	Surveyor
District Name (if applicable)	County	Date Surveyed

MICHIGAN HISTORY/ARCHITECTURAL SURVEY SITE FORM **Michigan State Historic Preservation Office**

Ownership: □ Private □ Public Local □ Public State □ Public Federal

Visible from ROW: □ Yes □ No

Endangered: □ Yes □ No Explain:

Category

□ Building
□ District
□ Site
□ Structure
□ Object
□ Landscape Feature

Condition

□ Excellent
□ Good
□ Fair
□ Deteriorated
□ Demolished
□ Ruins

Integrity

□ Unaltered
□ Slightly Altered
□ Moderately Altered
□ Severely Altered
□ Moved → → → →

Removals

Date Moved

Replacement

□ Roof
□ Porch
□ Windows - Some
□ Windows - All
□ Door
□ Other:

Additions

□ Siding
□ Wings
□ Other:

Plan

□ Rectangular
□ L
□ T
□ X
□ U
□ Irregular
□ Polygonal
□ Other:

Roof Form

□ Side-gable
□ Front-gable
□ Cross-gable
□ Hip
□ Pyramidal
□ Mansard
□ Flat
□ Other:

Roof Features

Porches
□ Front
□ Side
□ Rear

Retains Integrity of:

□ Association
□ Design
□ Feeling
□ Location
□ Material
□ Setting
□ Workmanship

Historic Use

Current Use

Foundation Materials	Wall Materials	Roof Materials	Other Materials

Architectural Classification	Builder/Architect	Significant Person(s)

Outbuildings

□ Barn
□ Carriage House
□ Chicken Coop
□ Corncrib
□ Garage
□ Granary
□ Hog House
□ Livestock Barn
□ Machine Shed
□ Milk House
□ Privy/Outhouse
□ Pumphouse
□ Shed
□ Silo
□ Smokehouse
□ Spring House
□ Stable
□ Summer Kitchen
□ Tool Shed
□ Wash House
□ Windmill
□ Wood Shed
□ Workshop
□ Other:

Descriptions:

Date Built

Areas of Significance

□ Agriculture
□ Archaeology
□ Architecture
□ Art
□ Commerce
□ Communications
□ Community Planning and Development
□ Conservation
□ Contact Period
□ Economics
□ Education
□ Engineering
□ Entertainment/ Recreation
□ Ethnic Heritage
□ Exploration/ Settlement
□ Health/Medicine
□ Industry
□ Invention
□ Landscape Architecture
□ Law
□ Literature
□ Maritime History
□ Military
□ Performing Arts
□ Philosophy
□ Politics
□ Religion
□ Science
□ Social History
□ Transportation
□ Other:

Historic Context(s)/Statement of Significance/Additional Description:

Site Plan

↑

N

Information Sources:

Photo Numbers

Eligibility Recommendation

□ Previously listed □ Individually eligible □ Contributing to district □ Non-contributing to district □ Not eligible
□ More research needed

If Eligible, Criteria Met: □ A □ B □ C □ D **Criteria Considerations:** □ a □ b □ c □ d □ e □ f □ g

Parcel Number:

Lat/Long:



APPENDIX E

MISHPO TERMS LIST

Below is a list of some of the acceptable MiSHPO terms.

OWNER TYPE:

- Private
- Public-Local
- Public-State
- Public-Federal

PROPERTY TYPE:

- Apartment building
- Bridge
- Commercial district
- Duplex
- Farm
- Lighthouse
- Railroad depot
- Residential district
- Rowhouse
- Service station
- Ship

FORMS

BUILDING FORMS

- A-frame Building
- Octagon Building
- Polygon Building
- Quonset Building – use for Quonset or other arch-rafter structure with semi-cylindrical roof and non-existent side walls
- Round Building

HOUSE FORMS

- American Foursquare
- Basilica Plan House – use in place of Hen and Chicks
- Bungalow
- Cruciform House
- Cup and Saucer House
- Front-gabled House
- Gabled Ell
- Half Basilica House
- Hall and Parlor House
- Hen and Chicks – use Basilica Plan

- I-House
- New England Large House
- New England 1½ Cottage
- Pyramidal Cottage
- Ranch House
- Upright and Double Wing House
- Upright and Wing
- Basement Barn
- English Barn
- Pennsylvania Barn
- Pole Barn
- Southwestern Michigan Dutch Barn

COMMERCIAL BUILDING FORMS: Use the following terms as appropriate. See Richard Longstreth's *The Buildings of Main Street* (Walnut Creek, CA: AltaMira Press, 2000).

- Arcaded Block
- Enframed Block
- Enframed Window Wall
- One-part Commercial Block
- Stacked Vertical Block
- Temple Front
- Three-part Vertical Block
- Two-part Vertical Block
- Vault (Architecture)

INDUSTRIAL BUILDING FORMS: Use the following terms as appropriate. See Betsy Hunter Bradley's *The Works: The Industrial Architecture of the United States* (NY: Oxford University Press, 1999)

- Industrial Loft
- Production Shed

MATERIALS

Foundation

- Brick
- Concrete
- Stone
- Stone: Granite
- Stone: Limestone
- Stone: Marble
- Stone: Sandstone
- Other

Walls

- Asbestos
- Asphalt
- Brick
- Ceramic Tile
- Cloth/Canvas
- Concrete
- Earth
- Glass
- Metal
- Metal: Aluminum
- Metal: Bronze
- Metal: Cast Iron
- Metal: Copper
- Metal: Iron
- Metal: Lead
- Metal: Nickel
- Metal: Steel
- Metal: Tin
- Stone
- Stone: Granite
- Stone: Limestone
- Stone: Marble
- Stone: Sandstone
- Stone: Slate
- Stucco
- Synthetics: Fiberglass
- Synthetics: Rubber
- Synthetics: Vinyl
- Terra Cotta
- Wood
- Wood: Log
- Wood: Plywood/Particle Board
- Wood: Shingle
- Wood: Weatherboard
- Other

Roof

- Asbestos
- Asphalt
- Metal: Copper
- Meta: Iron
- Metal: Steel
- Metal: Tin
- Stone: Slate
- Vitrified Clay Tile
- Wood: Shingle
- Wood: Shake
- Other

NATIONAL REGISTER ELIGIBILITY

- NR Eligible
- Not NR Eligible
- More information needed

STATUS IN A CURRENT OR POTENTIAL DISTRICT

- Contributing Site
- Non-Contributing Site
- More information needed


INTERNATIONAL TRANSPORTATION CENTER
SWEET SOO
OF THE NORTH
LAKE SUPERIOR
STATE COLLEGE
NO
LEFT
TURN

APPENDIX F

REPORT TEMPLATE

SECTION ONE

- Cover or Title Page
- Acknowledgment/Funding Credit
- Executive Summary
- Table of Contents
- Credits and Credentials
- Project Objectives and Methodology
- Data Location
- Evaluation Results
- Planning Needs and Recommendations
- Preservation Issues and Threats
- Survey Maps

SECTION TWO

- Descriptive Overview of Survey Area
- Historical Context
- Bibliography

SECTION THREE

- Index of Surveyed Properties
- Inventory Forms
- Survey Photos



APPENDIX G

PROPERTY INDEX TEMPLATE

SHPO will provide a copy of the excel document upon request but below are the headers that are required.

Name			**Street Address**	
Municipal Unit	**County**	**District Name**	**Year Built**	**Property Type**
Architectural Classification			**Architectural Classification - Other**	
Plan	**Foundation**		**Walls**	**Roof Form**
Roof	**Other Materials**			
Condition	**Integrity**	**Architect**	**Historic Use**	
Builder	**Outbuilding**		**Areas of Significance**	
Narrative Description		**Statement of Significance**		
Eligibility Recommendation				
NR Criteria	**NR Exceptions**		**Sources**	
Surveyor	**Date Surveyed**		**Parcel Number**	
Ownership	**Geographical Coordinates**			



VISIT US AT WWW.MICHIGAN.GOV/SHPO

MSHDA
MICHIGAN STATE HOUSING DEVELOPMENT AUTHORITY

MICHIGAN
SHPO
STATE HISTORIC PRESERVATION OFFICE

Appendix D – *Federal Curation Regulations (36 CFR 79)*

while it is in the possession of the Commission or its staff. After completing its review of the supplemental information, the Commission or its staff will return or destroy it, if the Registrant complies with the procedures outlined in Rule 418 under the Securities Act [17 CFR 230.418].

7. Each exhibit identified in the exhibit index (other than an exhibit filed in eXtensible Business Reporting Language) must include an active link to an exhibit that is filed with the registration statement or, if the exhibit is incorporated by reference, an active hyperlink to the exhibit separately filed on EDGAR. If the registration statement is amended, each amendment must include active hyperlinks to the exhibits required with the amendment."

* * * * *

Note: The text of Form N–3 does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 13. Amend Form N–3 (referenced in §§ 239.17a and 274.11b), Cover Page, by adding a new paragraph immediately after the sentence ["t]he Commission also may use the information provided on Form N–3 in its regulatory, disclosure review, inspection, and policy making roles" To read as follows:

* * * * *

A Registrant is required to disclose the information specified by Form N–3, and the Commission will make this information public. A Registrant is not required to respond to the collection of information contained in Form N–3 unless the Form displays a currently valid Office of Management and Budget ("OMB") control number. Please direct comments concerning the accuracy of the information collection burden estimate and any suggestions for reducing the burden to Secretary, Securities and Exchange Commission, 100 F Street NE, Washington, DC 20549. The OMB has reviewed this collection of information under the clearance requirements of 44 U.S.C. 3507.

* * * * *

Note: The text of Form N–CEN does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 14. Amend Form N–CEN (referenced in § 274.101) by replacing the Instruction following Item F.3 and replacing Item F.18 to read as follows:

* * * * *

Part F: Additional Questions for Unit Investment Trusts

* * * * *

Item F.3. * * *

Instruction. If the answer to Item F.3 is yes, respond to Item F.12 through Item F.19. If the answer to Item F.3 is no, respond to Item F.4 through Item F.11, and Item F.17 through Item F.19.

* * * * *

Item F. 18. Reliance on rule 12d1–4. Did the Registrant rely on rule 12d1–4 under the Act (17 CFR 270.12d1–4) during the reporting period? [Y/N]

* * * * *

Note: The text of Form N–PX does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 15. Amend Form N–PX (referenced in § 274.129), Cover Page by removing "§§ 239.24 and 274.5 of this chapter" and adding, in its place, "17 CFR 239.24 and 274.5".

Note: The text of Form N–MFP does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 16. Amend Form N–MFP (referenced in § 274.201), in Item A.14.c. by removing the term "A.14.a–c." and adding, in its place, the term "A.14.a–b."

PART 275—RULES AND REGULATIONS, INVESTMENT ADVISERS ACT OF 1940

■ 17. The authority for part 275 continues to read, in part, as follows:

Authority: 15 U.S.C. 80b–2(a)(11)(G), 80b–2(a)(11)(H), 80b–2(a)(17), 80b–3, 80b–4, 80b–4a, 80b–6(4), 80b–6a, and 80b–11, unless otherwise noted.

* * * * *

Section 275.204–2 is also issued under 15 U.S.C. 80b–6.

* * * * *

Section 275.204–5 is also issued under sec. 913, Public Law 111–203, sec. 124 Stat. 1827–28 (2010).

* * * * *

§ 275.204–2 [Amended]

■ 18. In § 275.204–2 amend paragraph (a)(15)(ii) by removing "." and adding, in its place, "; and".

§ 275.204–3 [Amended]

■ 19. In § 275.204–3 amend paragraph (b) by removing "Subject to paragraph (g), you" and adding, in its place, "You".

§ 275.204–5 [Amended]

■ 20. In § 275.204–5 amend paragraph (e)(1) by removing "§ 275.204–1(b)(3)" and adding, in its place "§ 275.204–1(b)".

§ 275.206(4)–1 [Amended]

■ 21. In § 275.206(4)–1 amend paragraph (b)(2)(i) by removing "," and adding in its place ";".

PART 279—FORMS PRESCRIBED UNDER THE INVESTMENT ADVISERS ACT OF 1940

■ 22. The authority for part 279 continues to read, in part, as follows:

Authority: The Investment Advisers Act of 1940, 15 U.S.C. 80b–1, *et seq.*, Public Law 111–203, 124 Stat. 1376.

Note: The text of Form ADV does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 23. Amend Form ADV (referenced in § 279.1) by:

■ a. In General Instruction 4 to Form ADV removing "Section 10 of Schedule R" and adding, in its place, "Section 4 of Schedule R"; and

■ b. In the Instruction to Section 4.B.7 of Schedule R removing "pre-fill Schedule B with the same indirect owners you have provided in Schedule B" and adding, in its place, "pre-fill the chart below with the same indirect owners you have provided in Schedule B for your *filing adviser*".

* * * * *

Dated: March 29, 2022.

Vanessa A. Countryman,

Secretary.

[FR Doc. 2022–06972 Filed 4–14–22; 8:45 am]

BILLING CODE 8011–01–P

DEPARTMENT OF THE INTERIOR

National Park Service

36 CFR Part 79

Office of the Secretary of the Interior

43 CFR Part 3

[NPS–WASO–CR–33054; PPWOCRADI0, PCU00RP14R50000]

RIN 1024–AE58

Curation of Federally Owned or Administered Archeological Collections

AGENCY: National Park Service, Interior.

ACTION: Final rule.

SUMMARY: The National Park Service amends regulations governing the curation of federally owned or administered archeological collections to establish definitions, standards, and procedures to dispose of material remains that have insufficient archeological interest. This rule promotes more efficient and effective curation of archeological collections.

DATES: This rule is effective May 16, 2022.

FOR FURTHER INFORMATION CONTACT: Karen Mudar, Archeology Program, National Park Service, 1849 C Street NW, Washington, DC 20005, 202–354–2103, email: *karen_mudar@nps.gov.* Individuals in the United States who are deaf, deafblind, hard of hearing, or have a speech disability may dial 711 (TTY, TDD, or TeleBraille) to access telecommunications relay services. Individuals outside the United States should use the relay services offered within their country to make international calls to the point-of-contact in the United States.

SUPPLEMENTARY INFORMATION:

Background

Authority To Promulgate Regulations

The Archaeological Resources Protection Act (ARPA; 16 U.S.C. 470aa–mm) authorizes the Secretary of the Interior (the Secretary) to promulgate regulations for the disposition of archeological and other resources recovered under the authority of ARPA, the Reservoir Salvage Act (RSA; 54 U.S.C. 312501–312508), and the Antiquities Act (54 U.S.C. 320301–320303). 36 CFR part 79's disposition process for resources recovered under ARPA, RSA, and the Antiquities Act is authorized thereunder. In addition, the National Historic Preservation Act (NHPA; 54 U.S.C. 302107 and 306131) authorizes the Secretary to promulgate regulations for the proper curation of archeological collections created under ARPA, RSA, and NHPA. 36 CFR part 79's curation requirements for resources recovered under ARPA, RSA, and NHPA are authorized thereunder. The Department of the Interior's Departmental Manual entitled ''Protection of the Cultural Environment'' (519 DM 2.3D) requires the Departmental Consulting Archeologist (DCA), located within the National Park Service (NPS), to develop regulations concerning the preservation of prehistoric and historic material remains of archeological interest under ARPA.

Regulatory History

The regulations at 36 CFR part 79 establish definitions, standards, procedures, and guidelines to be followed by Federal agencies to preserve collections of prehistoric and historic material remains and associated records that generally include those resulting from a prehistoric or historic resource survey, excavation, or other study conducted in connection with a Federal action, assistance, license, or permit.

As currently written, 36 CFR part 79 does not discuss processes for Federal agencies to dispose of particular material remains from archeological collections. It is important for Federal agencies to establish appropriate methods of disposal because prehistoric or historic material remains improperly disposed of could later be rediscovered and misinterpreted by archeologists or others as evidence of activity in the distant past. A proposed rule to establish procedures for discarding particular material remains from Federal collections was published in the **Federal Register** in 1990 (55 FR 37670, September 12, 1990). A final rule was never published. Instead, the DCA focused on the proper curation of federally owned or administered collections and left the subject of disposal of material remains for a future rulemaking.

In recent years, renewed interest from Federal agencies to address the issue of deaccessioning certain material remains has led to the promulgation of this rule. Specifically, Federal agencies such as the Department of Defense asked the DCA to help them find solutions to the growing costs of managing archeological collections. The NPS published a proposed rule in the **Federal Register** on November 18, 2014 (79 FR 68640).

Final Rule

This rule establishes procedures for the disposal of particular material remains of insufficient archeological interest that are held in federally owned or administered archeological collections. The procedures are not intended to apply to entire collections. Material remains refers to artifacts, objects, specimens, and other physical evidence, including human remains, of a historic or prehistoric resource. Federal agencies are responsible for ensuring that disposition of material remains is conducted in accordance with this rule and 36 CFR 79.7 ''Methods to fund curatorial services.'' This rule does not affect any material remains defined as ''cultural items'' by the Native American Graves Protection and Repatriation Act (NAGPRA; 25 U.S.C. 3001 *et seq.*) and subject to that statute. NAGPRA cultural items include Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony.

In addition to providing a mechanism for appropriate and carefully considered disposition, this rule will improve the curation of federally owned or administered archeological collections, such as by promoting more effective space and cost management. This rule addresses many of the comments submitted in 1990 by incorporating independent advice and opinions supplied by numerous experts that were consulted between 2005 and 2013. The NPS stresses that the disposition process laid out in this rule must be employed as part of a comprehensive collection management program that emphasizes collection stewardship and responsible accessioning practices. The best deaccession policy is a good accession policy. This rule provides measures to allow for deaccessioning only as a last resort. The NPS recommends that, in addition to proposing deaccession, agencies implement carefully designed field collection policies and create and implement clear and thoughtful scope of collections statements. Consistent with the Secretary's authority to promulgate regulations for ultimate disposition of certain material remains, this rule uses the term disposition throughout. The NPS acknowledges the museum practice of deaccessioning will be an integral and parallel part of the disposition process described in this rule.

In addition to adding a new Subpart E—Disposition of Particular Material Remains (Sections 79.12–79.18), this rule organizes existing sections 79.1–79.11 into Subparts A (Administrative Provisions), B (Archeological Collections Management), C (Public Access to and Use of Collections), and D (Inspections and Inventories of Collections). This rule also revises sections 79.1–79.4 to update legal citations, removes paragraph designations for defined terms in section 79.4 as recommended by the Office of the Federal Register's Document Drafting Handbook, and adds two defined terms that are used in Subpart E. A section-by-section analysis of the rule can be found in the Background section of the proposed rule.

Summary of Public Comments

The NPS published a proposed rule in the **Federal Register** on November 18, 2014 (79 FR 68640). The NPS accepted comments on the proposed rule through the mail, hand delivery, and through the Federal eRulemaking Portal at *http://www.regulations.gov.* Comments were accepted through February 17, 2015. The NPS received comments from individuals, federally recognized tribes, state and local government agencies, public institutions, and professional organizations. Summaries of the issues raised in the comments and responses from the NPS are provided below.

Disposition Process

1. Comment: Several commenters addressed the notification and consultation requirements in the

proposed rule. Commenters requested more time be given to interested parties to comment on a proposed disposition, and that additional direct notice be given to interested parties during the disposition process. Commenters asked that the Federal Agency Official (FAO) take additional steps to engage with public stakeholders during the disposition process.

NPS Response: The NPS made several changes in the final rule to ensure there is sufficient notice provided to interested parties during the disposition process. The NPS added a requirement that the FAO provide at least 60 days for notified entities to comment on a proposed disposition. The NPS increased the time allowed for objecting to a final determination of disposition from 30 to 60 days. The NPS added to the list of parties who must receive notice of proposed dispositions by including state archeologists, certain private landowners, broader categories of Indian tribes with cultural relationships to material remains in the collections, and organizations and institutions for which the agency has an existing relationship for research, excavation, curation, education, or other partnership in the state and region from which the material remains to be disposed were recovered. The NPS believes these notice requirements will sufficiently involve the relevant stakeholders in the disposition process prior to any determination of disposition published in the **Federal Register**.

2. Comment: Two commenters recommended that the rule limit the amount of time given to the FAO to choose a method of disposition.

NPS Response: The NPS declines to adopt this recommendation because it is important to preserve flexibility in this part of the disposition process, so that the most appropriate method is chosen. Time limits are required in other phases of the process such as during the periods for commenting on and objecting to determinations of disposition. A time limit at this stage would not further the purpose of the rule because agencies could be motivated to forego considered deliberation in order to select a method of disposition merely to meet a time limit.

3. Comment: One commenter argued that judgements other than those of the Indian Claims Court, as well as other types of documentation, should be allowed to determine aboriginal occupancy of land for purposes of whether an Indian tribe may receive deaccessioned materials excavated from lands other than Indian lands. Another commenter argued that culturally affiliated tribes that request deaccessioned material remains should be allowed to receive them.

NPS Response: The NPS has added two methods of disposition in paragraph 79.13(b) to accommodate these requests. Aboriginal occupation of lands where material remains were removed can now be documented by any type of evidence. The final rule allows material remains to be conveyed to federally recognized Indian tribes for the purposes of traditional, cultural, educational, or religious practices.

4. Comment: One commenter asked whether deaccessioned materials could be reused for educational or interpretive purposes (*i.e.,* adaptive reuse).

NPS Response: Deaccessioned materials may be used for educational or interpretive purposes. The methods of disposition in section 79.13 allow for such reuse. The rule is therefore sufficiently flexible to allow adaptive reuse after material remains have been deaccessioned.

5. Comment: One commenter argued that all methods of disposition are unacceptable because disposition is not a preservation activity.

NPS Response: ARPA section 5 (16 U.S.C. 470dd) specifically authorizes the Secretary of the Interior to promulgate regulations providing for the ultimate disposition of archeological resources. A requirement for specific disposition methods to constitute a preservation activity has no basis in the statutory authority.

6. Comment: Two commenters requested that the NPS list the methods of disposition in priority order for material remains excavated from public lands. One commenter requested that the rule provide a clear step-by-step process.

NPS Response: The NPS declines to impose a priority order on the methods of disposition because this would unduly restrict the discretion given to FAOs to dispose of deaccessioned material remains in the manner most appropriate to the situation. With the goal of making the disposition process as clear as possible, the NPS has provided a step-by-step process for an FAO to follow.

Federal Agency Official (FAO)

7. Comment: One commenter asked the NPS to identify the level of government where the FAO is located.

NPS Response: The FAO is defined in section 79.4 to mean ''any officer, employee or agent officially representing the secretary of the department or the head of any other agency or instrumentality of the United States having primary management authority over a collection that is subject to this part.'' In practice, the FAO is typically situated at the departmental, national, headquarters, or equivalent level of the agency, unless the agency has a different policy.

Collections Advisory Committee

8. Comment: Several commenters asked that individuals from outside of the Federal government be invited to participate on the collections advisory committee. One commenter proposed that any disposition should be contingent on a consensus recommendation from the collections advisory committee. Another commenter suggested that the DCA should not be eligible to serve on a collections advisory committee. Several commenters recommended that qualified experts be given more influence on the committee, while one commenter argued that the collections advisory committee should be made up of individuals who are professionally disinterested or distanced from the material remains being considered for disposition.

NPS Response: The NPS has revised the rule to clarify the qualifications necessary to serve on a collections advisory committee. The NPS added a requirement that the committee make consensus recommendations to the FAO about proposed dispositions. The NPS also added a provision stating that the DCA may not participate on the committee, because the DCA may be called upon to make recommendations in the case of a dispute. With the exception of certain Tribal officials specified in paragraph 79.15(e)(3), the NPS declines to delegate the responsibilities of Federal agencies for federally owned or administered property to non-Federal employees through an expansion of the composition of the committee. In order to increase the transparency of the committee, the final rule requires the collections advisory committee to prepare a written report for the FAO that contains, at a minimum, the following:

- The information required for the **Federal Register** notice of determination of disposition identified in paragraphs (i)(1)(i) through (iii) of section 79.15;
- The membership of the committee and their role and expertise pertinent to the deliberations;
- The committee's recommendations, including any conditions of transfer or conveyance; and
- An explanation of why the committee determined other methods of disposition were of lesser public benefit.

9. Comment: Several commenters asked the NPS to include specific procedures in the rule that collections advisory committee members must follow in order to make recommendations to the FAO about proposed dispositions, rather than allowing the committee to determine their own rules. One commenter recommended that the committee have clearly written procedures, including timelines and opportunities for public consultation and input. Another argued that the rule should identify the specific tasks and procedures of the collections advisory committee. One commenter proposed that the regulations establish a single committee to review every proposed disposition.

NPS Response: The rule supports the need for flexibility in the disposition process, including in the formation and operation of collection advisory committees. The NPS believes these committees must address the unique circumstances of each proposed disposition, as well as reflect the unique needs, capacities, and operating environments of the responsible Federal agencies, which a single central committee could not do. However, the rule also establishes some basic requirements about the composition and operation of the committees to enable appropriate recommendations. In order to strike a balance between fostering flexibility and imposing standard requirements, the rule establishes qualifications for committee membership and requires written procedures to be approved by the FAO. The NPS believes this is sufficient to ensure all recommendations are fair, open, timely, and in the best interest of the public. Mandating specific rules of procedure for each committee would be unduly rigid and make the work of the committees more difficult because they would be forced to apply strict rules to the unique situations and capacities of each committee. Although the regulations require that the composition of the committees be tailored to the characteristics of each disposition, nothing in the regulations prevents the same committee from reviewing more than one disposition of a similar nature. Under these circumstances, the Federal agency would not need to form a new committee for each proposed disposition provided the members of the committee meet the requirements in the regulations with respect to the particular collection under review.

Insufficient Archeological Interest

10. Comment: One commenter argued that a determination of insufficient archeological interest should be made on the basis of independent peer review that includes experts outside of the Federal government.

NPS Response: The NPS added a requirement in the final rule that the FAO must consult with qualified museum professionals at non-Federal repositories about the appropriateness of a proposed disposal. The NPS acknowledges that the perspective of qualified museum professionals responsible for the care and curation of the subject materials is necessary for the FAO to make an informed determination. FAOs must use appropriate judgment and base determinations of disposition on appropriate supporting information. Because the rule regulates federally owned or administered collections, however, it remains appropriate that Federal agency staff and officials, with verifiable knowledge of the materials, make decisions regarding the disposition of material remains in those collections.

11. Comment: One commenter argued that a lack of original records should not be sufficient to presume a determination of insufficient archeological interest if provenience can be reconstructed through other means.

NPS Response: The loss or destruction of associated records is one factor in determining whether there is a lack of provenience information. Under section 79.12, a qualified archeological or museum professional must determine that a disposition will not negatively impact the overall value of the collection in order to make a finding of insufficient archeological interest. In doing so, the professional must make a concerted effort to research all records, including museum records, associated with a collection. In addition, the FAO must determine that disposition of the material remains will not negatively impact the overall integrity of the original collection.

12. Comment: One commenter stated that it is unclear who makes the determination of insufficient archeological interest and what that individual's qualifications should be.

NPS Response: At least one qualified archeological or museum professional with verifiable knowledge of and experience in the type of material remains being evaluated makes a determination of insufficient archeological interest. The FAO determines whether the professional is qualified, using the Professional Qualification Standards set by the Secretary of the Interior as a benchmark, and considering the professional's verifiable knowledge of the material remains. The FAO then determines, under section 79.15, whether the material remains are eligible for disposition under this subpart.

13. Comment: Two commenters requested that the rule define the following terms related to insufficient archeological interest: Material remains, physical integrity, irreparable damage, overly abundant, and representative sample.

NPS Response: Existing regulations define material remains as ''artifacts, objects, specimens and other physical evidence that are excavated or removed in connection with efforts to locate, evaluate, document, study, preserve or recover a prehistoric or historic resource.'' This definition goes on to provide illustrative examples of different classes of material remains. The NPS declines to define the other terms requested by the commenters. These terms are commonly used by the archeological community and must be applied in context using the professional judgement of qualified personnel. For example, the amount sampled and sampling method for a representative sample must be determined on a case-by-case basis, using the professional discretion of subject matter experts and best available information. The rule requires subject matter experts to have verifiable knowledge of the material remains to be examined.

14. Comment: One commenter questioned whether material remains could possess increasing archeological interest over time.

NPS Response: For material remains that are overly redundant and not useful for research, the rule requires that a sampling strategy be developed and implemented in order that the retained samples may be subjected to new or improved analytical technologies in the future that could demonstrate those materials remains have greater archeological interest than previously known. The NPS has revised the rule to clarify that samples of material remains determined to be overly redundant and not useful for research must be representative of the population as a whole from which the sample was taken. This will help ensure the integrity and potential future worth of samples that are retained.

15. Comment: One commenter suggested that the criterion ''overly redundant and not useful for research'' be split into two separate criteria, each of which could support a determination of insufficient archeological interest.

NPS Response: The NPS declines to split this criterion into separate criteria because both elements of this criterion are necessary to establish insufficient

archeological interest. Fulfilling only one of these two elements (overly redundant or not useful for research) could not result in a determination of insufficient archeological interest. A redundant set of material remains that is still useful for research could have sufficient archeological interest. For instance, two sets of similar material remains derived from different archeological contexts are likely, by virtue of their spatial disparity, to provide some information about the past, even though those material remains may seem similar or identical in a museum setting. Alternatively, material remains not useful for research but not overly redundant could still have archeological interest because: (1) Their uniqueness may render them inherently informative about the past and (2) they may become useful for research in the future as new technologies are developed. Thus, to meet this test, material remains must be both overly redundant and not useful for research.

16. Comment: One commenter suggested that the NPS establish a hierarchy of levels of archeological interest and provide a range of disposition options for each level.

NPS Response: The rule only addresses the ultimate disposition of certain materials that have insufficient archeological interest. Identifying different degrees or levels of insufficient archeological interest and assigning different disposal options for each level would unnecessarily complicate the process.

Costs

17. Comment: Several commenters addressed the costs for Federal agencies and recipient entities of complying with the disposition process under the rule. Several commenters were concerned that the rule would place financial strain on repositories for retaining materials during the disposition process without addressing a general shortfall of personnel and funding. One commenter expressed concern that several methods of disposition (*e.g.,* conveyance to suitable repositories or institutions) would impose unfair financial burdens on recipients of deaccessioned material remains.

NPS Response: The rule will impose little or no direct cost upon the public. Section 79.7 makes Federal agencies responsible for funding the curation of material remains. This includes costs associated with deaccessioning material remains in federally owned or administered collections, including costs borne by repositories that retain materials during the disposition process. Federal agencies must accession and catalog material remains before deaccessioning, and must follow relevant law and agency policy in ensuring that funding decisions address all aspects of collection stewardship, not just deaccessioning. The rule provides a series of options for disposition and does not require any group or individual to accept material remains that are eligible for disposal. The rule does not impose unfair financial burdens on recipients of deaccessioned material remains because those recipients are under no obligation to accept the material remains. A recipient must independently choose to accept deaccessioned material, thus it will have an opportunity in advance to consider the financial impact of its participation in the disposition process. The NPS believes the disposition process in the rule is financially achievable for Federal agencies.

18. Comment: Two commenters inquired about the costs of deaccessioning material remains of insufficient archeological interest. They were concerned that resources, which could be used to catalog and curate collections, might be diverted to deaccessioning instead.

NPS Response: To limit the possibility that Federal agencies allocate resources to deaccessioning rather than to curating collections, the rule provides controls, under section 79.12, on the disposition process, intended to limit its use only to appropriate circumstances. Deaccessioning is one part of a comprehensive curation methodology. In order to be eligible for disposition, material remains must be part of a Federal collection, and thus have undergone appropriate intake and accessioning procedures, which must be documented in accordance with agency protocols. Agency staff responsible for determining whether particular material remains lack archeological interest must consider the relationship of the material remains to the collection as a whole. Any effort to determine the archeological interest of material remains must include a review of the overall collection, along with associated documentation, from which those material remains are derived. For these reasons, the NPS does not believe that the disposition process will divert funds from curation because deaccessioning is part of a responsible curation program.

19. Comment: One commenter suggested that the disposition process will impose new costs for excavation because allowing for disposition will force archeologists to perform a more thorough analysis of material remains prior to curating them in a repository.

NPS Response: The NPS does not consider this scenario as likely to occur. However, a more thorough analysis of collections during an initial excavation project could be a desirable outcome because it means that the documentation concerning material remains will provide a better understanding of the archeological interest and improve the value of the resulting curated collections to the public. Any increase in the initial cost of analysis would be voluntary.

Compliance

20. Comment: Several commenters discussed ways that implementation of the rule will support and interplay with compliance regimes for laws such as the NHPA and the National Environmental Policy Act (NEPA).

NPS Response: Under section 106 of the NHPA, Federal agencies must consider the effect of an undertaking on any historic property that is included in or eligible for inclusion in the National Register. Museum collections, including archeology collections, are not generally considered historic properties (see National Register Bulletin 15). Further, material remains determined to be of insufficient archeological interest are not likely to be included in or eligible for inclusion in the National Register because, characteristically, they would not be worthy of preservation. NEPA requires Federal agencies to fully consider the impacts of proposals that would affect the human environment prior to deciding to take an action. The disposal of material remains under this rule will generally not constitute a Federal action under NEPA that would have a significant effect on the human environment. Nevertheless, FAOs must consider the context related to each proposed disposal of material remains and comply with all applicable laws, including the NHPA and NEPA, before making a final determination. The FAO must consider the opinions, as appropriate, of the collections advisory committee, Indian Tribes, and other available experts in making disposition decisions to ensure compliance with Federal law. In cases where collections are held under a compliance agreement, such as a Memorandum of Agreement under section 106 of NHPA, the FAO must consider the context and the terms of the agreement to determine whether disposal is appropriate.

Administrative Record

21. Comment: Several commenters focused on the creation and preservation of the administrative record of the disposition process. One commenter asked that the

administrative record be provided to tribes and SHPOs, particularly when they possess additional data about the site or collection. Other commenters asked the NPS to clarify the requirement in paragraph 79.15(i)(2)(i) to prepare a detailed list of material remains to be deaccessioned and better define when photographic documentation would be considered appropriate.

NPS Response: Section 79.18 requires Federal agencies to include in their administrative record specific documentation of the determination of disposition. Consistent with these requirements, Federal agencies should follow their own procedures for preparing, preserving, and distributing administrative records. The FAO should follow existing practices that comply with applicable state and Federal standards for recording material remains in archeological collections when preparing the detailed list of material remains required by paragraph 79.15(i)(2)(i). This paragraph specifies that the list must include a description of each object, or lot of objects if there are multiples of a particular type, and photograph(s) of the objects when appropriate. The FAO should also consider standard practices to determine when photographic documentation is appropriate.

Authority and Applicability of Regulations

22. Comment: Two commenters questioned whether the authorities cited in section 79.2 authorize the NPS to allow the disposition of material remains. Two commenters questioned the applicability of the rule to material remains excavated under the Antiquities Act and the interplay with prior regulations.

NPS Response: Section 5 of ARPA (16 U.S.C. 470dd) gives the Secretary the explicit and sole authority to promulgate regulations providing for ''the ultimate disposition'' of ARPA archeological resources and other resources removed pursuant to the Antiquities Act and the RSA. These authorities are cited in paragraph 79.2(b)(2) which, except for updated citations, is not changed by this rule. The explicit statutory authority to promulgate this rule supersedes any preceding regulatory requirements regarding similar subject matter, in particular, 43 CFR 3.17. This more recent statutory authority thus makes it appropriate to include those resources excavated under the Antiquities Act and eligible for disposal via the process described in the new Subpart E as subject to this rule. For clarity, this rule adds a note to 43 CFR 3.17 stating that resources excavated under the Antiquities Act are eligible for disposal via Subpart E of 36 CFR 79.

23. Comment: Several commenters requested clarification about the term ''practical management authority'' and the meaning of ''indirect'' practical management authority.

NPS Response: Part 79 applies to federally owned or administered collections. Section 79.3(a) uses the term ''practical management authority'' to further explain the circumstances under which collections that are owned by the United States are subject to Part 79. Federal agencies have ownership of collections due to specific laws, activities on Federal lands, or other circumstances, and these collections are managed in a variety of ways. In order for those collections to be subject to Part 79, a Federal agency that owns a collection also must have ''practical management authority'' over that collection, either directly or indirectly. Otherwise, Federal agencies would be responsible for curating collections that they do not control. Direct practical management authority generally includes situations where a Federal agency is directly administering collections at Federal facilities. Indirect practical management authority includes situations in which a Federal agency has legal responsibility and control over collections but a non-Federal entity has responsibility for curating the collection. This is usually documented through the terms of an agreement, contract, permit, or authorized expenditures.

24. Comment: One commenter stated that the rule should only apply to federally owned collections and that there should be no question about who has legal title over material remains that are proposed for disposal.

NPS Response: The FAO should be able to discern the ownership of material remains when determining if those remains are eligible for disposal under paragraph 79.12(a) and when reviewing the provenience information to determine if those remains have insufficient archeological interest under paragraph 79.12(e)(2)(i). Directions from ascertainable owners or questions regarding ownership must inform the FAO's proposed disposition determination. Clear legal ownership by the United States is not a prerequisite for disposal of material remains under Part 79; the rule also applies to material remains that are not owned by the United States but that are managed or controlled by a Federal agency pursuant to the Antiquities Act, NHPA, RSA and ARPA. Other provisions of the rule explicitly ensure that certain owners of federally administered collections, such as Indian individuals or tribes under 79.13(a), have an opportunity to receive them or to object to a proposed disposition. This aspect of the rule is intended to ensure that the government cares for archeological collections in its possession in accordance with applicable laws.

25. Comment: Based on established practices that allow for the re-interment of human remains not subject to NAGPRA, several commenters suggested that this rule should apply to human remains not subject to NAGPRA and identify reburial as a method of disposition. One commenter suggested that the rule establish a disposition process for human remains that are not subject to NAGPRA.

NPS Response: During consultation for the proposed rule, Federal agencies, Tribes, and professional organizations suggested that excluding all human remains from the disposition process for materials of insufficient archeological interest described in this subpart would simplify the rule and avoid confusion with NAGPRA and its implementing regulations. As a result, the proposed rule excluded all human remains from disposition and, in doing so, did not distinguish between human remains subject to NAGPRA and other human remains. The final rule clarifies in paragraph 7.12(b)(1) that Native American cultural items under NAGPRA, which can include human remains, are not eligible for disposition under this rule. Native American human remains are subject to disposition or repatriation under NAGPRA. In paragraph 7.12(b)(2), the final rule also states that other human remains not subject to NAGPRA are ineligible for disposition under Subpart E. The NPS does not intend for this subpart to affect established practices that otherwise allow for the disposition and re-interment of human remains not subject to NAGPRA. The final rule clarifies that human remains not subject to NAGPRA are excluded only from the process described in Subpart E. The NPS is reserving section 79.14 to address this issue in the future if necessary.

Disputes

26. Comment: Several commenters addressed the procedures for objecting to determinations of disposition. One commenter asked that the public have 90 days to dispute a determination of disposition, and that the requirement for submission of documentation be removed. Another commenter recommended that those objecting to a disposition should be responsible for finding a new repository. One

commenter suggested that the DCA should make binding decisions for all objections instead of non-binding recommendations to the FAO. Another commenter requested that the rule require the DCA to thoroughly explain their recommendation to the FAO. Two commenters asked that the rule include a dispute resolution process in section 79.16 to help resolve disagreements over which tribes should receive material remains that have been determined to be eligible for disposal. One commenter specifically recommended adopting the dispute resolution language from NAGPRA.

NPS Response: The NPS made several changes in section 79.16 of the final rule to provide a more effective and inclusive process for objecting to a determination of disposition. The NPS lengthened the timeframe to object to a determination of disposition from 30 to 60 days. The NPS believes this will provide sufficient time for interested parties to file an objection, in part because the list of those notified and consulted with prior to the determination of disposition is comprehensive. It is important that the objecting party document the reasons for the objection so that the DCA and the FAO are able to evaluate the merits of the objection. While objecting parties may suggest a different repository, they are not required to as a condition to filing an objection. The NPS also shortened the timeframe for the FAO to respond to the DCA's non-binding recommendation from 60 to 30 days and added a requirement that the DCA forward a copy of the objection to the FAO within 5 days of receipt of the objection. The final rule also requires the DCA to consult with the objecting party and the FAO with the aim of resolving the objection. This will ensure that the DCA plays a significant role in the resolution of disputes over determinations of disposition. The final rule requires that the DCA explain their recommendation to the FAO.

The NPS declines to make the DCA's decision binding because the DCA's role to other government agencies is advisory in nature. The DCA has no authority to broker binding arbitration with other Federal agencies, nor does the DCA have the authority to make decisions on their behalf. Similarly, the NPS declines to outline a dispute resolution process specifically for tribes because such a process would be duplicative of the appeal process in section 79.16. In addition, the NPS notes that the dispute resolution process in NAGPRA is specifically authorized in 25 U.S.C. 3006(c); no such authorization exists in ARPA or the other applicable authorities for this rule.

Rulemaking Process

27. Comment: Several commenters stated that the rulemaking process was inadequate because of insufficient opportunities for public comment. One commenter asked for an extension of the public comment period.

NPS Response: The NPS consulted widely with Tribes and interest groups before publishing the proposed rule. The proposed rule was open for public comment for 90 days, from November 18, 2014, through February 17, 2015. This is 30 days longer that the standard comment period of 60 days that is identified in Department of the Interior Policy (318 Departmental Manual, section 5.3). The NPS received a substantial number of comments and has worked to address or respond to all issues raised by those comments in this final rule.

Impacts to Federal Collections

28. Comment: Two commenters stated that many collections were made with the understanding that they would be held in perpetuity by the government for future study, and that perpetual curation might be required by agreements entered into for purposes of complying with section 106 of the NHPA.

NPS Response: Legal instruments for the curation of materials, including those created under the section 106 consultation process, such as memoranda of agreement or programmatic agreements, may contain provisions requiring curation of materials beyond what otherwise would be required by this rule. When considering the potential disposal of materials covered by any such agreement, the FAO must review the terms of the agreement to determine whether the agreement and section 79.12 can be reconciled to allow disposal. Legally binding requirements for the perpetual curation of materials that appear in an agreement or other written instrument will not be affected by the disposition process established in this rule.

29. Comment: One commenter argued that deaccessioning would greatly reduce the volume of material remains available for study, which would lead to increased excavation.

NPS Response: The disposition process established in this rule applies narrowly to material remains of insufficient archeological interest. The rule does not compel the wholesale divestment by the government of its collections, but instead allows for small reductions in the size of some collections under specific circumstances. Samples of material remains to be deaccessioned under this rule must be retained when those materials are deemed overly redundant and not useful for research. The cautious approach to disposition required by this rule makes it unlikely that the rule will result in a steep reduction in the amount of materials available for study in Federal collections, and a consequential need for additional excavations.

NAGPRA Consultation

30. Comment: Two commenters sought stronger requirements to consult with Tribes regarding the determination that material remains are not subject to NAGPRA. One commenter asked the NPS to clarify the FAO's responsibilities to consider NAGPRA compliance.

NPS Response: Federal agencies have separate procedural requirements under NAGPRA to ensure that NAGPRA cultural items in their collections are included in inventories and summaries. Extensive consultation is required during the inventory and summary process under 43 CFR 10.8 and 10.9. In general, Federal agencies were required to complete their NAGPRA summaries by November 16, 1993, and their NAGPRA inventories by November 16, 1995, so, in most cases, Federal agencies will have already determined which items in their collections are NAGPRA cultural items. Section 79.12 provides an additional measure to ensure NAGPRA cultural items are handled pursuant to NAGPRA and not subject to disposition under this rule. Prior to making a final determination of disposition, the FAO must determine that the material remains are not NAGPRA cultural items. The rule further states that, when Native American material remains are proposed for disposition, the collections advisory committee must include one or more elected officers (or their designees) of federally recognized Indian Tribes that are regularly consulted by the Federal agency. The rule also contains robust notification requirements that will help ensure that interested Tribes are aware of proposed dispositions. Further, any Tribe may object to determinations of disposition if it believes the materials are NAGPRA cultural items. The NPS believes that these requirements are sufficient to ensure that Native American cultural items subject to NAGPRA will not be disposed of under this rule.

Use of Deaccessioned Material Remains

31. Comment: One commenter argued that enforcing the restrictions on disposition of material remains in the proposed rule would constitute a taking of property under the Fifth Amendment of the Constitution, specifically for material remains excavated and removed from Indian lands and returned to the Indian individual or Indian tribe having rights of ownership over the resources. Commenters sought to ensure that deaccessioned material remains may not be sold in the future. Another commenter questioned the ability of the FAO to enforce prohibitions on government employees receiving deaccessioned material remains.

NPS Response: The NPS has clarified in paragraph 79.13(b) that, as a condition of disposal, the FAO will reasonably ensure that material remains from public lands that are not Indian lands may not be traded, sold, bought, or bartered after disposal is completed. This condition will not apply to material remains from Indian lands. The NPS has removed the prohibition on government employees receiving deaccessioned material remains because it is redundant with government-wide ethics requirements that address the concerns originally underlying this proposed restriction. Indian individuals who are also Federal employees must work with their agency's ethics officials to determine a course of action in the event that they wish to receive deaccessioned material remains.

General Support and Opposition

32. Comment: Some commenters expressed general support for the rule, praising its clear language and stringent and rigorous disposition process. Commenters recognized the need for the rule and its potential to improve the value of collections and reduce careless accession of material remains. Other commenters expressed general opposition to the rule, citing their belief that material remains should not be deaccessioned and that the rule will not provide a complete solution to the curation crisis.

NPS Response: Responsible deaccessioning is a necessary tool for maintaining the scientific value of collections. Several Federal agencies requested this rule, which supports the proper curation of Federal collections. This rule establishes a rigorous and deliberative disposition process that, when properly implemented, will prevent the careless deaccessioning of material remains. Supporting agency stewardship of archeological collections is the foundational goal of 36 CFR 79.

Changes in the Final Rule

After considering the public comments and after additional review, the NPS made the following substantive changes in the final rule. The NPS made other non-substantive, editorial changes for clarity and ease of reading. In many places, the NPS replaced outdated citations to Title 16 of the U.S. Code with correct citations to Title 54. The NPS also removed the paragraph designations in section 79.4 and organized the defined terms alphabetically, as recommended in the Office of the Federal Register's Document Drafting Handbook. In order to make these changes, the entire section 79.4 appears below in the regulatory text even though the only changes to that section are to add definitions of ''Departmental Consulting Archeologist'' and ''provenience information.''

Final rule section or paragraph	Change	Reason for change
79.4	Added definitions of the terms ''Departmental Consulting Archeologist'' and ''provenience information''.	Clarifies the meaning of these terms for non-specialists.
79.12(b)(2)	Specified that the term ''human remains'' refers to human remains that are not ''cultural items'' under NAGPRA.	Clarifies that no human remains may be disposed of under this rule, whether or not they are subject to NAGPRA.
79.12(c)	Clarified that only persons who meet the applicable Professional Qualification Standards set by the Secretary may propose the disposal of material remains.	Helps ensure that only qualified experts may initiate the disposition process. Ensures that disposition is not undertaken casually or as a matter of convenience. The professional standards are available here: *https://www.nps.gov/articles/sec-standards-prof-quals.htm.*
79.12(c)(1)	Added a requirement that Federal agency staff members must have verifiable knowledge of the particular material remains that are proposed for disposal.	Helps ensure that disposition is not undertaken improperly because qualified experts were not involved.
79.12(e)	Added a requirement that archeological or museum professionals must have verifiable knowledge of the particular material remains in order to determine whether those material remains have insufficient archeological interest.	Helps ensure that disposition is not undertaken improperly because qualified experts were not involved.
79.12(e)(2)(i)(C)	Clarified that a lack of provenience information may be established if associated records never existed, have been lost, or have been destroyed.	Addresses a legitimate circumstance where there is no existing provenience information.
79.12(e)(2)(iii)	Clarified that representative samples of material remains that are overly redundant and not useful for research must be representative of the population as a whole from which the sample was taken.	Helps ensure that a statistically valid sample is retained in the event that new analytical techniques are developed that allow the sample to generate useful information about the past.
79.13(a)(2)	Clarified that the FAO must receive written consent and relinquishment of ownership from the Indian individual or tribe having rights of ownership before otherwise disposing of material remains excavated from Indian lands.	Helps ensure that the FAO will not dispose of material remains owned by Indian individuals or tribes without their consent.
79.13(b)(5)	Added the following method of disposal for material remains excavated or removed from public lands: Convey to a federally recognized Indian tribe for the purpose of traditional cultural, educational, or religious practices.	Responds to public comment and improves consistency between the acceptable methods of disposition for materials removed from Indian and public lands.

Final rule section or paragraph	Change	Reason for change
79.15(d)	Added a requirement that the FAO consult with qualified museum professionals located in the repository that provides curatorial services for material remains proposed for disposal when those museum professionals did not propose the disposal.	Helps ensure that appropriate experts are involved in the disposition process.
79.15(e)	Added a requirement that the collections advisory committee make consensus recommendations to the FAO about proposed dispositions.	Responds to public comment and helps ensure that disposition is not undertaken lightly or improperly.
79.15(e)(1)	Added a provision stating that the DCA may not participate on a collections advisory committee.	Helps maintain the impartiality of the DCA, who serves as the arbiter of disputes about proposed dispositions.
79.15(e)(3)	Clarified that the requirement that collections advisory committees include at least one representative of an Indian tribe only applies if there are Native American material remains proposed for disposal.	Ensures the appropriate inclusion of tribal viewpoints in considering a disposition of Native American material remains.
79.15(e)(5)	Added a requirement that the collections advisory committee submit a written report to the FAO about any proposed disposition.	Responds to public comments and improves the administrative record of a disposition.
79.15(g)	Added a requirement that, for material remains excavated from Indian land, the FAO provide a copy of the associated records to the appropriate Tribal Historic Preservation Officer or tribal official.	Responds to public comments and improves accountability to tribal governments.
79.15(h)	Added a minimum duration of 60 days for the public comment period for a proposed disposition. Made the FAO responsible for responding only to relevant, substantive comments.	Responds to public comments to improve timeliness and public accountability. Reduces the administrative burden on the FAO during the comment review period.
79.15(h)(1)	Added a requirement that the FAO must give notice of proposed dispositions to the State Archeologist if there is one.	Improves coordination with state officials and improves the administrative record.
79.15(h)(3)	Added a requirement that the FAO must give notice of proposed dispositions to private landowners from whose lands the objects to be disposed were removed.	Responds to public comments to provide additional information to landowners.
79.15(h)(5)	Removed the requirement that the FAO must give notice to organizations and institutions with an active department of or program in archeology or anthropology pertaining to the archeology of the state or region from which the material remains to be disposed of were recovered. Clarified that the FAO must give notice of proposed dispositions to organizations and institutions for which the agency has an existing relationship pursuant to a written instrument (*e.g.,* permit, agreement) for research, excavation, curation, education, or other partnership in the state and region from which the objects to be disposed were recovered.	Removes ambiguity about which institutions and organizations must receive notice of proposed dispositions. Reduces the burden of compliance for the FAO by requiring only notification of those entities that have a formal relationship. Improves communication about proposed disposition actions with interested researchers.
79.16	Lengthened the timeframe to object to a determination of disposition from 30 to 60 days after publication of the notice of determination of disposition in the **Federal Register**.	Responds to public comments and provides more opportunity for the public to object to a proposed disposition.
79.16(a)	Added a requirement that the DCA forward a copy of objections to the FAO within 5 days of receipt.	Improves accountability from the DCA to the FAO and streamlines the objection process.
79.16(c)	Added a requirement that the DCA consult with the objecting party and the FAO with the aim of resolving the objection.	Responds to public comments to improve the fairness of the objection process by providing another opportunity for discussion between the objecting party and the FAO.
79.16(d)	Added a requirement that the DCA must thoroughly explain their non- binding recommendation to the FAO.	Responds to public comment to provide a more effective and inclusive disputes process.
79.16(e)	Shortened the timeframe for the FAO to respond to the DCA and the objector with a final determination from 60 to 30 days.	Streamlines the objection process and encourages timely resolution to objections.
79.16(f)	Clarified that notice of a decision on an objection is a final agency action under the Administrative Procedure Act.	Responds to public comment to make procedures clear to the public.
79.17	Added a requirement that disposition after an objection will occur no sooner than 30 days after the FAO publishes the notice of decision on the objection and any amendments in the **Federal Register**.	Responds to public comment to make procedures clear to the public.
43 CFR 3.17	Added a note that resources excavated under the Antiquities Act may be eligible for disposal under Subpart E of 36 CFR 79.	Responds to public comments questioning the applicability of the rule to material remains excavated under the Antiquities Act.

Compliance With Other Laws, Executive Orders and Department Policy. Regulatory Planning and Review (Executive Orders 12866 and 13563)

Executive Order 12866 provides that the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget will review all significant rules. OIRA has determined that this rule is not significant.

Executive Order 13563 reaffirms the principles of Executive Order 12866 while calling for improvements in the nation's regulatory system to promote predictability, to reduce uncertainty, and to use the best, most innovative, and least burdensome tools for achieving regulatory ends. Executive Order 13563 directs agencies to consider regulatory approaches that reduce burdens and maintain flexibility and freedom of choice for the public where these approaches are relevant, feasible, and consistent with regulatory objectives. Executive Order 13563 emphasizes further that regulations must be based on the best available science and that the rulemaking process must allow for public participation and an open exchange of ideas. The NPS has developed this rule in a manner consistent with these requirements.

Regulatory Flexibility Act

This rule will not have a significant economic effect on a substantial number of small entities under the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*). This certification is based on information contained in the economic analyses found in the report entitled ''Cost-Benefit and Regulatory Flexibility Analyses: Proposed Regulations on the Curation of Federally-Owned or Administered Archeological Collections'' that is available online at the following URL: *https://www.nps.gov/orgs/1187/upload/Regulatory_Analyses_36_CFR_Part_79_12.pdf.*

Congressional Review Act (CRA)

This rule is not a major rule under 5 U.S.C. 804(2), the CRA. This rule:

(a) Does not have an annual effect on the economy of $100 million or more.

(b) Will not cause a major increase in costs or prices for consumers, individual industries, Federal, state, or local government agencies, or geographic regions.

(c) Does not have significant adverse effects on competition, employment, investment, productivity, innovation, or the ability of U.S.-based enterprises to compete with foreign-based enterprises.

The rule relates to internal administrative procedures and management of government function. It does not regulate external entities, impose any costs on them, or eliminate any procedures or functions that would result in a loss of employment or income on the part of the private sector.

Unfunded Mandates Reform Act

This rule does not impose an unfunded mandate on state, local, or tribal governments or the private sector of more than $100 million per year. This rule does not have a significant or unique effect on state, local or tribal governments, or the private sector. A statement containing the information required by the Unfunded Mandates Reform Act (2 U.S.C. 1531 *et seq.*) is not required.

Takings (Executive Order 12630)

This rule does not affect a taking of private property or otherwise have taking implications under Executive Order 12630. A takings implication assessment is not required.

Federalism (Executive Order 13132)

Under the criteria in section 1 of Executive Order 13132, this rule does not have sufficient federalism implications to warrant the preparation of a federalism summary impact statement. This rule does not regulate, change, or otherwise affect the relationship between Federal and state governments. A federalism summary impact statement is not required.

Civil Justice Reform (Executive Order 12988)

This rule complies with the requirements of Executive Order 12988. Specifically, this rule:

(a) Meets the criteria of section 3(a) requiring that all regulations be reviewed to eliminate errors and ambiguity and be written to minimize litigation; and

(b) Meets the criteria of section 3(b)(2) requiring that all regulations be written in clear language and contain clear legal standards.

Paperwork Reduction Act (44 U.S.C. 3501 *et seq.*)

This rule does not contain information collection requirements, and a submission to the Office of Management and Budget under the Paperwork Reduction Act is not required. The NPS may not conduct or sponsor and you are not required to respond to a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act

This rule does not constitute a major Federal action significantly affecting the quality of the human environment. A detailed statement under the NEPA is not required because this rule is covered by a categorical exclusion. This rule is excluded from the requirement to prepare a detailed statement because it qualifies as a regulation of an administrative and procedural nature. (For further information see 43 CFR 46.210(i)). This rule does not involve any of the extraordinary circumstances listed in 43 CFR 46.215 that would require further analysis under NEPA.

Federal Advisory Committee Act

Intergovernmental consultation recommended under this rule is exempt from the Federal Advisory Committee Act (FACA). This rule requires that consultation with Indian tribes be conducted between Federal officials and elected tribal officers or their designated employees acting in their official capacities, who meet solely for the purpose of exchanging views, information, or advice related to the management or implementation of this rule. Consultation with Tribes under this rule thus meets the two-part test for an exemption from the FACA set out in the Unfunded Mandates Reform Act of 1995, Public Law 104–4.

Consultation With Indian Tribes (E.O. 13175 and Departmental Policy)

The Department of the Interior strives to strengthen its government-to-government relationship with Indian Tribes through a commitment to consult with Indian Tribes and recognition of their right to self-governance and tribal sovereignty. The NPS has evaluated this rule under the criteria in Executive Order 13175 and under the Department's tribal consultation policy and has determined that tribal consultation is not required because the rule will have no substantial direct effect on federally recognized Indian tribes. Nevertheless, the NPS conducted outreach to tribes and Native Hawaiian Organizations, initiated consultation through two letters to tribal leaders, and conducted face-to-face consultation on this rule upon request. Additional information regarding the identified effects on Indian Tribes and these outreach and consultation efforts is contained in a document entitled ''Consultation with Indian Tribes (E.O. 13175) regarding the proposed 36 CFR 79.12,'' which is available at the following URL: *https://www.nps.gov/orgs/1187/upload/Tribal_Consultation_36_CFR_Part_79_12.pdf.*

Effects on the Energy Supply (E.O. 13211)

This rulemaking is not a significant energy action under the definition in Executive Order 13211; the rule is not likely to have a significant adverse effect on the supply, distribution, or use of energy, and the rule has not otherwise been designated by the Administrator of OIRA as a significant energy action. A Statement of Energy Effects is not required.

Drafting Information

This rule was written with the cooperation and consultation of the following Federal agencies and bureaus: U.S. Bureau of Indian Affairs, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Air Force, U.S. Army Corps of Engineers, U.S. Navy, and U.S. Forest Service. Each agency and bureau provided a specialist in the curation of archeological collections to participate in an informal interagency working group to provide expert advice during the drafting of this rule.

List of Subjects

36 CFR Part 79

Archives and records, Historic preservation, Indians—lands, Museums, Public lands.

43 CFR Part 3

Agriculture Department, Army Department, Historic preservation, Smithsonian Institution.

In consideration of the foregoing, the National Park Service and Department of the Interior amend 36 CFR part 79, and 43 CFR part 2, as set forth below:

PART 79—CURATION OF FEDERALLY OWNED OR ADMINISTERED ARCHEOLOGICAL COLLECTIONS

■ 1. The authority citation for part 79 is revised to read as follows:

Authority: 16 U.S.C. 470aa–mm, 54 U.S.C. 300101 *et seq.*

■ 2. Revise the part heading to read as shown above.

§§ 79.1 through 79.4 [Designated as Subpart A]

■ 3. Designate §§ 79.1 through 79.4 as subpart A and add a heading for subpart A to read as follows:

Subpart A—Administrative Provisions

§ 79.1 [Amended]

■ 4. In § 79.1 amend paragraph (a) by:
■ a. Removing ''(16 U.S.C. 431–433)'' and adding, in its place, ''(54 U.S.C. 320301–320303)'';
■ b. Removing ''(16 U.S.C. 469–469c)'' and adding, in its place, ''(54 U.S.C. 312501–312508)''; and
■ c. Removing ''(16 U.S.C. 470h-2)'' and adding, in its place, ''(54 U.S.C. 306101–306114)''.

■ 5. In § 79.2:
■ a. Revise paragraph (a).
■ b. In paragraph (b)(2), remove ''(16 U.S.C. 431–433)'' and add, in its place, ''(54 U.S.C. 320301–320303)'' and remove ''(16 U.S.C. 469–469c)'' and add, its place, ''(54 U.S.C. 312501–312508)''.

The revision reads as follows:

§ 79.2 Authority

(a) The regulations in this part are promulgated under 54 U.S.C. 302107 which requires that the Secretary of the Interior issue regulations ensuring that significant prehistoric and historic artifacts and associated records are deposited in an institution with adequate long-term curatorial capabilities. This requirement applies to artifacts and associated records subject to the National Historic Preservation Act (54 U.S.C. 300101 *et seq.*), the Reservoir Salvage Act (54 U.S.C. 312501–312508), and the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm).

* * * * *

■ 6. In § 79.3, revise paragraph (a) to read as follows:

§ 79.3 Applicability.

(a) Except as otherwise stated in this section, the regulations in this part apply to collections, as defined in § 79.4 of this part, that are excavated or removed under the authority of the Antiquities Act (54 U.S.C. 320301–320303), the Reservoir Salvage Act (54 U.S.C. 312501–312508), section 110 of the National Historic Preservation Act (54 U.S.C. 306101–306114) or the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm). Such collections generally include those that are the result of a prehistoric or historic resource survey, excavation or other study conducted in connection with a Federal action, assistance, license, or permit. Such collections include those that are owned by the United States and for which a Federal agency has practical management authority, either directly or indirectly, as a result of that ownership; and those collections that are not owned by the United States but that are managed or controlled by a Federal agency pursuant to the laws cited in this paragraph (a).

* * * * *

■ 7. Revise § 79.4 to read as follows:

§ 79.4 Definitions.

As used for purposes of this part:

Associated records means original records (or copies thereof) that are prepared, assembled and document efforts to locate, evaluate, record, study, preserve or recover a prehistoric or historic resource. Some records such as field notes, artifact inventories and oral histories may be originals that are prepared as a result of the field work, analysis, and report preparation. Other records such as deeds, survey plats, historical maps and diaries may be copies of original public or archival documents that are assembled and studied as a result of historical research. Classes of associated records (and illustrative examples) that may be in a collection include, but are not limited to:

(1) Records relating to the identification, evaluation, documentation, study, preservation, or recovery of a resource (such as site forms, field notes, drawings, maps, photographs, slides, negatives, films, video and audio cassette tapes, oral histories, artifact inventories, laboratory reports, computer cards and tapes, computer disks and diskettes, printouts of computerized data, manuscripts, reports, and accession, catalog, and inventory records);

(2) Records relating to the identification of a resource using remote sensing methods and equipment (such as satellite and aerial photography and imagery, side scan sonar, magnetometers, subbottom profilers, radar, and fathometers);

(3) Public records essential to understanding the resource (such as deeds, survey plats, military and census records, birth, marriage and death certificates, immigration and naturalization papers, tax forms and reports);

(4) Archival records essential to understanding the resource (such as historical maps, drawings and photographs, manuscripts, architectural and landscape plans, correspondence, diaries, ledgers, catalogs, and receipts); and

(5) Administrative records relating to the survey, excavation, or other study of the resource (such as scopes of work, requests for proposals, research proposals, contracts, antiquities permits, reports, documents relating to compliance with section 106 of the National Historic Preservation Act (16 U.S.C. 470f), and National Register of Historic Places nomination and determination of eligibility forms).

Collection means material remains that are excavated or removed during a survey, excavation, or other study of a prehistoric or historic resource, and associated records that are prepared or

assembled in connection with the survey, excavation, or other study.

Curatorial services means managing and preserving a collection according to professional museum and archival practices, including, but not limited to:

(1) Inventorying, accessioning, labeling, and cataloging a collection;

(2) Identifying, evaluating, and documenting a collection;

(3) Storing and maintaining a collection using appropriate methods and containers, and under appropriate environmental conditions and physically secure controls;

(4) Periodically inspecting a collection and taking such actions as may be necessary to preserve it;

(5) Providing access and facilities to study a collection; and

(6) Handling, cleaning, stabilizing, and conserving a collection in such a manner to preserve it.

Departmental Consulting Archeologist means the individual serving as the agent of the Secretary of the Interior in overseeing and coordinating the Department's archeological activities.

Federal Agency Official means any officer, employee or agent officially representing the secretary of the department or the head of any other agency or instrumentality of the United States having primary management authority over a collection that is subject to this part.

Indian lands has the same meaning as in § -.3(e) of uniform regulations 43 CFR part 7, 36 CFR part 296, 18 CFR part 1312, and 32 CFR part 229.

Indian tribe has the same meaning as in § -.3(f) of uniform regulations 43 CFR part 7, 36 CFR part 296, 18 CFR part 1312, and 32 CFR part 229.

Material remains means artifacts, objects, specimens, and other physical evidence that are excavated or removed in connection with efforts to locate, evaluate, document, study, preserve or recover a prehistoric or historic resource. Classes of material remains (and illustrative examples) that may be in a collection include, but are not limited to:

(1) Components of structures and features (such as houses, mills, piers, fortifications, raceways, earthworks, and mounds);

(2) Intact or fragmentary artifacts of human manufacture (such as tools, weapons, pottery, basketry, and textiles);

(3) Intact or fragmentary natural objects used by humans (such as rock crystals, feathers, and pigments);

(4) By-products, waste products or debris resulting from the manufacture or use of man-made or natural materials (such as slag, dumps, cores and debitage);

(5) Organic material (such as vegetable and animal remains, and coprolites);

(6) Human remains (such as bone, teeth, mummified flesh, burials, and cremations);

(7) Components of petroglyphs, pictographs, intaglios, or other works of artistic or symbolic representation;

(8) Components of shipwrecks (such as pieces of the ship's hull, rigging, armaments, apparel, tackle, contents, and cargo);

(9) Environmental and chronometric specimens (such as pollen, seeds, wood, shell, bone, charcoal, tree core samples, soil, sediment cores, obsidian, volcanic ash, and baked clay); and

(10) Paleontological specimens that are found in direct physical relationship with a prehistoric or historic resource.

Personal property has the same meaning as in 41 CFR 100–43.001–14. Collections, equipment (*e.g.,* a specimen cabinet or exhibit case), materials and supplies are classes of personal property.

Provenience information means recorded data about the physical location of an object as it was found during a survey, excavation, or other study of a prehistoric or historic resource.

Public lands has the same meaning as in § -.3(d) of uniform regulations 43 CFR part 7, 36 CFR part 296, 18 CFR part 1312, and 32 CFR part 229.

Qualified museum professional means a person who possesses knowledge, experience and demonstrable competence in museum methods and techniques appropriate to the nature and content of the collection under the person's management and care, and commensurate with the person's duties and responsibilities. Standards that may be used, as appropriate, for classifying positions and for evaluating a person's qualifications include, but are not limited to, the following:

(1) The Office of Personnel Management's ''Position Classification Standards for Positions under the General Schedule Classification System'' (U.S. Government Printing Office, stock No. 906—028–00000–0 (1981)) are used by Federal agencies to determine appropriate occupational series and grade levels for positions in the Federal service. Occupational series most commonly associated with museum work are the museum curator series (GS/GM–1015) and the museum technician and specialist series (GS/GM–1016). Other scientific and professional series that may have collateral museum duties include, but are not limited to, the archivist series (GS/GM–1420), the archeologist series (GS/GM–193), the anthropologist series (GS/GM–190), and the historian series (GS/GM–170). In general, grades GS–9 and below are assistants and trainees while grades GS–11 and above are professionals at the full performance level. Grades GS–11 and above are determined according to the level of independent professional responsibility, degree of specialization and scholarship, and the nature, variety, complexity, type, and scope of the work.

(2) The Office of Personnel Management's ''Qualification Standards for Positions under the General Schedule (Handbook X–118)'' (U.S. Government Printing Office, stock No. 906–030–00000–4 (1986)) establish educational, experience and training requirements for employment with the Federal Government under the various occupational series. A graduate degree in museum science or applicable subject matter, or equivalent training and experience, and three years of professional experience are required for museum positions at grades GS–11 and above.

(3) The ''Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation'' (48 FR 44716, Sept. 29, 1983) provide technical advice about archeological and historic preservation activities and methods for use by Federal, State, and local Governments and others. One section presents qualification standards for a number of historic preservation professions. While no standards are presented for collections managers, museum curators or technicians, standards are presented for other professions (*i.e.,* historians, archeologists, architectural historians, architects, and historic architects) that may have collateral museum duties.

(4) Copies of the Office of Personnel Management's standards, including subscriptions for subsequent updates, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Copies may be inspected at the Office of Personnel Management's Library, 1900 E Street NW, Washington, DC, at any regional or area office of the Office of Personnel Management, at any Federal Job Information Center, and at any personnel office of any Federal agency. Copies of the ''Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation'' are available at no charge from the Interagency Resources Division, National Park Service, P.O. Box 37127, Washington, DC 20013–7127.

Religious remains means material remains that the Federal Agency Official

has determined are of traditional religious or sacred importance to an Indian tribe or other group because of customary use in religious rituals or spiritual activities. The Federal Agency Official makes this determination in consultation with appropriate Indian tribes or other groups.

Repository means a facility such as a museum, archeological center, laboratory, or storage facility managed by a university, college, museum, other educational or scientific institution, a Federal, State, or local Government agency or Indian tribe that can provide professional, systematic, and accountable curatorial services on a long-term basis.

Repository Official means any officer, employee or agent officially representing the repository that is providing curatorial services for a collection that is subject to this part.

Tribal Official means the chief executive officer or any officer, employee or agent officially representing the Indian tribe.

§§ 79.5 through 79.9 [Designated as Subpart B]

■ 8. Designate §§ 79.5 through 79.9 as subpart B and add a heading for subpart B to read as follows:

Subpart B—Archeological Collections Management

§ 79.10 [Designated as Subpart C]

■ 9. Designate § 79.10 as subpart C and add a heading for subpart C to read as follows:

Subpart C—Public Access to and Use of Collections

§ 79.11 [Designated as Subpart D]

■ 10. Designate § 79.11 as subpart D and add a heading for subpart D to read as follows:

Subpart D—Inspections and Inventories of Collections

■ 11. Add subpart E to read as follows:

Subpart E—Disposition of Particular Material Remains

Sec.

79.12 Determining which particular material remains are eligible for disposal.
79.13 Acceptable methods for disposition of particular material remains.
79.14 [Reserved].
79.15 Final determination of disposition of particular material remains.
79.16 Objecting to a determination of disposition of particular material remains.
79.17 Timing of disposition.
79.18 Administrative record of disposition.

§ 79.12 Determining which particular material remains are eligible for disposal.

(a) *Which material remains are eligible for disposal under this subpart?* In order to be eligible for disposal under this subpart, material remains from collections must be:

(1) Archaeological resources, as defined in the Archaeological Resources Protection Act (16 U.S.C. 470bb(1)), or other resources excavated and removed under the Reservoir Salvage Act (54 U.S.C. 312501–312508) or the Antiquities Act (54 U.S.C. 320301–320303); and

(2) Considered to be of insufficient archeological interest under the criteria in paragraph (e) of this section, based on the definition of ''of archaeological interest'' in 43 CFR 7.3(a)(1).

(b) *Which material remains are not eligible for disposal under this subpart?* The following material remains from collections are not eligible for disposal under this subpart:

(1) Native American ''cultural items'' as defined in the Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001(3)), because disposition is governed by that Act and its implementing regulations (43 CFR part 10);

(2) Other human remains not subject to the Native American Graves Protection and Repatriation Act of 1990;

(3) Material remains excavated and removed from Indian lands on or before the enactment of the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm) on October 31, 1979; and

(4) Material remains excavated and removed from Indian lands under the Antiquities Act (54 U.S.C. 320301–320303).

(c) *Who may propose the disposal of particular material remains?* The following individuals who meet the applicable Professional Qualification Standards set by the Secretary of the Interior may propose the disposal of particular material remains from a collection:

(1) Federal agency staff members with verifiable knowledge of the particular material remains, including archeologists, curators, and conservators; and

(2) Qualified museum professionals located in a repository that provides curatorial services for a collection held in that repository.

(d) *Who is responsible for the disposal of particular material remains?* The Federal Agency Official is responsible for ensuring that particular material remains are disposed of according to the requirements of this subpart.

(e) *When are particular material remains considered to be of insufficient archeological interest?* Particular material remains are considered to be of insufficient archeological interest when, on a case-by-case basis, at least one qualified archeological or museum professional who meets the Professional Qualification Standards set by the Secretary of the Interior and possesses verifiable knowledge of and experience in the type of material remains being evaluated makes a determination. The determination must follow the process established in § 79.15 and document that:

(1) Disposition of the material remains will not negatively impact the overall integrity of the original collection recovered during the survey, excavation, or other study of a prehistoric or historic resource; and

(2) At least one of the following three requirements—lack of provenience information; lack of physical integrity; or overly redundant and not useful for research—are met:

(i) *Lack of provenience information.* Lack of provenience information may be established after a concerted effort to recover the information in the related associated records is performed and documented and by one or more of the following circumstances:

(A) The labels on the material remains or the labels on the containers that hold the material remains do not provide adequate information to reliably establish meaningful archeological context for the material remains;

(B) The labels on the material remains or the labels on the containers that hold the material remains have been lost or destroyed over time and cannot be reconstructed through the associated records; or

(C) The associated records of the material remains never existed, have been lost, or have been destroyed.

(ii) *Lack of physical integrity.* Material remains lack physical integrity when, subsequent to recovery during the survey, excavation, or other study of a prehistoric or historic resource, the material remains were irreparably damaged through decay, decomposition, or inadvertent loss. Examples may include human-caused incidents, exposure to elements, or natural disaster.

(iii) *Overly redundant and not useful for research.* Material remains are overly redundant and not useful for research in light of the collection's archeological context, research questions, and research potential. These considerations may vary based on geography, time and culture period, scientific or cultural significance, prior analysis, and other factors. Because it is difficult to predict if future analytical methods will yield

useful information about the material remains proposed for disposal, a sample of the material remains deemed to be overly redundant and not useful for research must be retained for curation, as required by § 79.15(f).

§ 79.13 Acceptable methods for disposition of particular material remains.

(a) *Indian lands.* This paragraph applies to material remains that are determined to be of insufficient archeological interest under § 79.12(e) and that were excavated or removed from Indian lands after October 31, 1979. Under the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm), these material remains are the property of the Indian individual or Indian tribe having rights of ownership over the resources. Under the authority of 16 U.S.C. 470dd, disposition of these material remains is subject to the consent of the Indian individual or Indian tribe. The Federal Agency Official must use the following methods of disposal for these material remains in the following order:

(1) Return them to the Indian individual or Indian tribe having rights of ownership under the Archaeological Resources Protection Act's custody regulations, 43 CFR 7.13(b), 36 CFR 296.13(b), 32 CFR 229.13(b), and 18 CFR 1312.13(b).

(2) If the Indian individual or Indian tribe having rights of ownership does not wish to accept and take physical custody of the material remains, the Federal Agency Official may otherwise dispose of the material remains using the disposition methods in paragraph (b) of this section after receiving written consent and relinquishment of ownership from the Indian individual or Indian tribe having rights of ownership.

(b) *Public lands.* This paragraph applies to material remains that are determined to be of insufficient archeological interest under § 79.12(e) and that were excavated or removed from public lands that are not Indian lands. As a condition of disposal, the Federal Agency Official will reasonably ensure that material remains from such lands may not be traded, sold, bought, or bartered after disposal. The Federal Agency Official must consider the following methods for disposal of the material remains:

(1) Transfer to another Federal agency.

(2) Convey to a suitable public or tribal scientific or professional repository as defined in § 79.4(k) of this part.

(3) Convey to a federally recognized Indian tribe if the material remains were excavated or removed from lands of religious or cultural importance to that tribe and were identified and documented by a Federal land manager under 43 CFR 7.7(b)(1), 36 CFR 296.7(b)(1), 32 CFR 229.7(b)(1), or 18 CFR 1312.7(b)(1).

(4) Convey to a federally recognized Indian tribe from whose aboriginal lands the material remains were removed. Aboriginal occupation may be documented by evidence including, but not limited to, a final judgment of the Indian Claims Commission or the United States Court of Claims, or a treaty, Act of Congress, or Executive Order.

(5) Convey to a federally recognized Indian tribe for the purpose of traditional cultural, educational, or religious practices.

(6) Transfer within the Federal agency for the purpose of education or interpretation, or convey to a suitable institution to be used for public benefit and education including, but not limited to, local historical societies, museums, university or college departments, and schools.

(7) If the Federal Agency Official considers each of these prior methods carefully and is still unable to find an acceptable method of disposition, then the material remains may be destroyed. The Federal Agency Official or their designee must witness and document the destruction, including through photography or video as practicable.

§ 79.14 [Reserved]

§ 79.15 Final determination of disposition of particular material remains.

The Federal Agency Official is responsible for ensuring that the agency disposes of material remains according to the requirements of this subpart. A determination made under this subpart in no way affects a Federal land manager's obligations under other applicable laws or regulations. The Federal Agency Official must take all the following actions before making a final determination that it is appropriate to dispose of material remains.

(a) The Federal Agency Official must determine that the material remains are eligible for disposal under the criteria in § 79.12(a).

(b) The Federal Agency Official must verify in writing that none of the material remains proposed for disposal meet the criteria in § 79.12(b).

(c) The Federal Agency Official must verify that the material remains proposed for disposal are appropriately documented through a professional procedure approved by the Federal agency that is consistent with curatorial services, including accessioning and cataloging, as defined in § 79.4(b).

(d) The Federal Agency Official must consult with qualified museum professionals located in the repository that provides curatorial services for the material remains proposed for disposal if those museum professionals did not propose the disposal under § 79.12(c)(2). This consultation with the qualified museum professionals must address the appropriateness of the proposed disposal.

(e) The Federal Agency Official must establish a collections advisory committee of at least five members to review proposed dispositions of material remains. The committee must make a consensus recommendation to the Federal Agency Official about each proposed disposition based on the adequacy of the documentation addressing the requirements in paragraphs (a) and (b) of this section and the appropriateness of the proposed disposition based on the criteria in § 79.12(e).

(1) The collections advisory committee must consist of qualified employees from Federal agencies who meet appropriate Professional Qualification Standards set by the Secretary of the Interior, and must include the curator and the principal archeologist of the Federal agency that owns or administers the material remains if either or both of these two positions exist. The Departmental Consulting Archeologist may not participate on the collections advisory committee. If the Departmental Consulting Archeologist is the principal archeologist, then the Federal Agency Official must designate another qualified archeologist at the agency instead.

(2) Collections advisory committee members must include Federal employees with subject matter or technical expertise in the object types, cultural period, and culture area of the proposed disposition. These employees may include archeologists, anthropologists, curators, and conservators with expertise in historic, prehistoric, or underwater material remains.

(3) If the material remains being proposed for disposal are Native American, then collections advisory committee members must also include at least one or more individuals who are Tribal Officials acting in their official capacities representing their respective federally recognized Indian tribes that are regularly consulted by the Federal agency regarding the collection containing the material remains being proposed for disposal.

(4) The collections advisory committee must have written

procedures and governing rules, including terms of member appointments and the duration of the committee, approved by the Federal Agency Official, to ensure all recommendations about the appropriateness of disposal are fair, open, timely, and in the best interests of the public.

(5) The collections advisory committee must submit a written report to the Federal Agency Official for each proposed disposition that, at a minimum, documents the information required for the **Federal Register** notice identified in paragraphs (i)(1)(i) through (iii) of this section; membership of the committee and each member's role and expertise pertinent to the proposed disposition; a summary of any comments received on the proposed disposition under paragraph (h) of this section; the recommendations for disposition, including any conditions of transfer or conveyance; and the reasons why other methods of disposal would be of lesser public benefit.

(6) Federal employees or qualified members of federally recognized Indian tribes may be temporarily added to the committee if its existing members determine that specific expertise, including archeological knowledge of the cultural period and cultural area, is needed on a case-by-case basis.

(7) Collections advisory committee members, whether permanent or temporary, and their family members may not benefit financially or in any other way from a disposition of material remains, except to the extent that members of a federally recognized Indian Tribe, when that Indian Tribe is being considered as a potential recipient of material remains, may participate in the collections advisory committee as described in § 79.15(e)(3).

(f) The Federal Agency Official must retain in the curated collection a sample of those material remains determined to be overly redundant and not useful for research that is representative of the population as a whole from which the sample was taken.

(1) The size of the representative sample must be large enough to permit future analysis for research purposes.

(2) The method for establishing a representative sample, including sample size and typology, must be determined by a qualified museum or archeological professional with expertise in the type of prehistoric or historic material remains being sampled.

(3) The sampling method must be documented and consistent with professional prehistoric or historic archeological practice.

(g) The Federal Agency Official must retain all associated records in the archeological collection as defined in § 79.4(a)(2). A copy of the original associated records must be given to the recipient of any transferred or conveyed items subject to the restrictions stipulated in the Archaeological Resources Protection Act (16 U.S.C. 470hh(a)). For material remains excavated and removed from Indian land, a copy of the original associated records must be given to the Tribal Historic Preservation Officer (or other designated tribal representative) from the tribal land where the material remains were recovered.

(h) The Federal Agency Official must notify the entities listed in this paragraph of the proposed disposition and solicit comments on the proposal. Notifications must be made in writing, and must include a deadline for submitting comments that is at least 60 days after notice is issued, in accordance with procedures established by the Federal agency. All written comments must be reviewed by the Federal Agency Official and the collections advisory committee. The Federal Agency Official will respond to all relevant, substantive comments received. Notice must be given to the following:

(1) The State Historic Preservation Officer and, where established, the State Archeologist, from the state(s) where the material remains to be disposed of were recovered.

(2) The Tribal Historic Preservation Officer (or other designated tribal representative) from the Indian land(s) where the material remains to be disposed of were recovered.

(3) Federal, state, tribal, or local agencies that were involved in the recovery of the material remains to be disposed of.

(4) Private landowners from whose lands the material remains to be disposed of were removed, but only in such cases where the Federal agency obtained practical management authority over the material remains as the result of activities conducted in connection with a Federal action, assistance, license, or permit, on those private lands.

(5) Universities, museums, scientific institutions, and educational institutions with which the agency has an existing relationship pursuant to a written instrument (*e.g.,* permit, agreement) for research, excavation, curation, education, or other partnership in the state and region from which the material remains to be disposed of were recovered.

(6) Indian tribes that consider the land to have religious or cultural importance, if the material remains are from a site on public lands that has religious or cultural importance to Indian tribes under 43 CFR 7.7(b)(1).

(7) Indian tribes from whose aboriginal lands the material remains were removed, if aboriginal occupation has been documented by a final judgment of the Indian Claims Commission or the United States Court of Claims, treaty, Act of Congress, or Executive Order.

(i) The Federal Agency Official must, after the comment period described in paragraph (h) of this section has expired and the Federal Agency Official has responded to all relevant, substantive comments received, publish a notice of determination of disposition in the **Federal Register**.

(1) The notice published in the **Federal Register** must include the following:

(i) A general description of the material remains to be disposed.

(ii) The criteria used to determine that the material remains are of insufficient archeological interest under § 79.12(e).

(iii) The method of disposal.

(iv) The name of the Federal Agency Official or their designee as a point of contact.

(v) An explanation of a person's right to object to the determination of disposition under § 79.16 and the name, email, and physical address of the Departmental Consulting Archeologist.

(2) The Federal Agency Official must also prepare a determination of disposition that includes the following:

(i) A detailed list of the material remains to be disposed, including a description of each object, or lot of objects if there are multiples of a particular type, and photograph(s) of the objects when appropriate.

(ii) The report of the collections advisory committee as stipulated in paragraph (e)(5) of this section.

(iii) Documentation that all of the procedures in § 79.15 have been met.

(iv) The name of the recipient entity or method of disposal, as appropriate.

(v) Justification of the method to be used to dispose of the material remains under § 79.13.

(vi) The name of the Federal Agency Official or their designee as a point of contact.

(vii) Other conditions of transfer or conveyance, as appropriate.

(viii) A statement that the determination is a final agency action under the Administrative Procedure Act (5 U.S.C. 704) unless an objection is filed in accordance with § 79.16.

§ 79.16 Objecting to a determination of disposition of particular material remains.

Anyone may object to and request in writing that the Departmental Consulting Archeologist review a Federal Agency Official's determination to dispose of material remains within 60 days of publication of the notice of determination of disposition in the **Federal Register**. The objection must document why the objector disagrees with the Federal Agency Official's decision regarding the disposal. The procedure for objecting to a determination of disposition is as follows:

(a) The objection must be sent to the Departmental Consulting Archeologist. The Departmental Consulting Archeologist must forward a copy of the objection within 5 days of receipt to the Federal Agency Official who made the determination under objection. The Federal Agency Official must halt the planned disposition until the Departmental Consulting Archeologist completes the requested review.

(b) The Departmental Consulting Archeologist must review the objection, and the Federal Agency Official's determination of disposition in § 79.15(i)(2).

(c) The Departmental Consulting Archeologist must consult with the objecting party or parties and the Federal Agency Official with the aim of resolving the objection.

(d) Within 60 days of receipt of the objection, whether or not a formal resolution has been agreed upon, the Departmental Consulting Archeologist must transmit to the Federal Agency Official a non-binding recommendation, including a thorough explanation, for further consideration.

(e) The Federal Agency Official must consider the recommendation of the Departmental Consulting Archeologist prior to making a decision on the objection. Within 30 days of receipt of the recommendation, the Federal Agency Official must respond to the Departmental Consulting Archeologist and the objector with a decision on the objection and a justification for that decision. The decision document must include any information about administrative appeal rights required by internal agency appeal procedures or a statement that the decision document is a final agency action under the Administrative Procedure Act, as appropriate.

(f) The Federal Agency Official must publish notice of the decision on the objection and any amendments made to the determination of disposition in the **Federal Register**. This may only be done after the objector exhausts any internal appeal procedures identified in the decision document sent to the objector under § 79.16(e). Publication of the notice of the decision on the objection constitutes a final agency action under the Administrative Procedure Act (5 U.S.C. 704).

§ 79.17 Timing of disposition.

Disposition will occur no sooner than 60 days after the notice of determination of disposition is published in the **Federal Register** under § 79.15(i). If the Federal agency receives an objection under § 79.16, then disposition will occur no sooner than 30 days after the notice of decision on the objection and any amendments are published in the **Federal Register** under § 79.16(f).

§ 79.18 Administrative record of disposition.

(a) After the Federal Agency Official has made a determination of disposition, he or she must document the determination and retain the administrative record as part of the associated records as defined in § 79.4(a)(2), which must include:

(1) The professional evaluation of the material remains conducted under §§ 79.12(e) and 79.15(b).

(2) The report of the collections advisory committee provided under § 79.15(e)(5).

(3) Notifications of the proposed disposition under § 79.15(h); consent of Indian individuals or tribes, if applicable, under § 79.13(a)(2); and comments received from the parties notified under § 79.15(h).

(4) Objections received by the Departmental Consulting Archeologist, the non-binding recommendation of the Departmental Consulting Archeologist, and the decision on the objection and any amendments made to the determination of disposition, if applicable, under § 79.16.

(5) The disposition action with specific information, including a description and evaluation of objects; the method of disposition and the reason for the method chosen; names and titles of persons initiating and approving the disposition; date of disposition; relevant accession and catalog numbers; evidence of the receipt for the return, transfer, or conveyance of the material remains by the recipient tribe, agency, repository, or institution, including the title to the received material remains, as appropriate; photographic documentation, as appropriate; and the name and location of the recipient institution or entity, as appropriate.

(6) A detailed inventory of the representative sample of material remains retained, when the larger proportion is disposed of because it is overly redundant and not useful for research.

(7) Other activities and decisions pertaining to the disposition of the material remains, such as conditions of use after the disposition is completed, as appropriate.

(b) The administrative record must be made available to the public upon request, unless the information or a portion of it must be withheld under the terms of the Freedom of Information Act (5 U.S.C. 552) or the Archaeological Resources Protection Act (16 U.S.C. 470hh). The latter restricts the government's ability to make sensitive information, such as archeological site location data, available to the public.

(c) After disposition, the accession and catalog records must be reviewed and amended through a procedure established by the Federal agency. The amendments must identify the material remains that were deaccessioned and disposed of, the date of disposition, and the manner in which they were disposed. The documentation prepared under § 79.15, § 79.16, and paragraph (a) of this section must be retained in accordance with Federal agency policy.

TITLE 43: PUBLIC LANDS: INTERIOR

SUBTITLE A—OFFICE OF THE SECRETARY OF THE INTERIOR

PART 3—PRESERVATION OF AMERICAN ANTIQUITIES

■ 12. The authority citation for part 3 is revised to read as follows:

Authority: 54 U.S.C. 320302–320303.

■ 13. Amend § 3.17 by adding a note at the end of the section to read as follows:

§ 3.17 Preservation of Collection

* * * * *

Note to § 3.17: Regulations concerning curation of federally owned or administered archeological collections are found in 36 CFR part 79. Objects excavated under the Antiquities Act may be eligible for disposal under subpart E of 36 CFR part 79.

Shannon A. Estenoz,

Assistant Secretary for Fish and Wildlife and Parks.

[FR Doc. 2022–07471 Filed 4–14–22; 8:45 am]

BILLING CODE 4312–52–P

INTRODUCTION

The following appendix describes the Inadvertent Discovery Plan for Cultural Resources or Human Remains for the "*Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project*." The procedure outlined below conforms to MI-NRCS general Procedure for Construction Discovery but in this instance covers only items of cultural resource not attributable to the architecture of the low-head dams. Any discovered human remains are subject to this Inadvertent Discovery Plan.

RECOGNIZING CULTURAL RESOURCES

A cultural resource discovery is an item of presumed human manufacture and likely to be greater than 50 years of age. Examples include but are not limited to:

- Stone tools or debitage (i.e., arrow head or chipped stone waste flakes),
- Clusters of tin cans, ceramics, bottles, logging implements, agricultural equipment etc., that appears older than 50 years

UPON DISCOVERING CULTURAL RESOURCES

In the event that any NRCS staff, consultant, local agency representative, contractor, landowner, etc. discover a cultural resource during removal of the low-head dams, they must immediately notify the construction manager, who will, in response: 1. cease operations in that location and 2. notify the NRCS Cultural Resources Specialist.

If the action affecting the resource is not halted, continuing to affect the resource may result in withdrawal of NRCS assistance. Pursuant to Section 110(k) of the National Historic Preservation Act and the NRCS National Cultural Resources Procedures Handbook, Subpart C, Section 601.27, the NRCS must ensure that Federal assistance is NOT used to cause or further an adverse impact to a cultural resource.

UPON DISCOVERING HUMAN REMAINS

The following steps will be implemented if human remains and/or materials subject to NAGPRA are inadvertently discovered during this Project. This largely follows the steps set forward in Michigan Attorney General Opinion No. 6585 of 1989, *Cemeteries and Dead Bodies*, those recommended by the State Historic Preservation Office, and those recommended by the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (Gun Lake Tribe) who reviewed and commented on this permit application.

If the action affecting the remains is not halted, continuing to affect the remains may result in withdrawal of NRCS assistance.

Human Remains and Associated Materials

1. Upon the discovery of human remains and any associated materials, excavation in the immediate vicinity is halted. Cover and secure the area and do not handle finds. All Project personnel shall treat any discovery as confidential.

2. The local police authority is immediately notified so that they may evaluate the site.

3. Immediately notify the NRCS, who will then notify the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians THPO, SHPO archaeologists and any additional tribes who requested consultation with NRCS.

4. If the police determine that human remains represent evidence of a crime or missing person, they will complete their investigation.

5. If the police determine that human remains do not represent evidence of a crime or missing person, the burial will be adequately documented and preserved in place or relocated as determined through appropriate consultation. It is preferred that burial sites be preserved and maintained in place. If this is not possible, the remains and any associated materials would need to be moved for their protection.

The following sequence of steps will be employed if it is not possible to preserve and maintain an inadvertently discovered burial in place:

1. Excavations shall be respectful and conducted out of public view, to the extent possible.

2. A qualified archaeologist experienced in human remains recovery shall recover the remains and any related materials that may be present. Archaeological expertise is important in documenting the discovery context and evaluating whether the remains are isolated or if additional remains may be immediately present. Archaeological recovery may be done under the auspices of law enforcement. If law enforcement chooses not to be involved, a permit for disinterment must be obtained from the local Department of Public Health, or through a court order.

3. As soon as possible, the remains shall be examined by a physical anthropologist using standard non-invasive methods and procedures to create a basic biological profile and estimate ethnicity.

4. Draft and final archaeological reports, with related physical anthropological reports and law enforcement case documentation appended, will be submitted to the NRCS, Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians THPO, and SHPO archaeologists.

Discoveries of Native American Ancestors and/or Other Materials Subject to NAGPRA

1. If it can be determined immediately that a discovery is, or has the potential to be, a Native American Ancestor and/or other materials subject to NAGPRA (i.e., associated or unassociated funerary objects, sacred objects, and objects of cultural patrimony), the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (and any other consulting Tribes) will be notified within 72 hours of discovery and potential identification. Tribal notification and consultation will be coordinated by the NRCS and SHPO archaeologists. After notification and initial consultation, consulting Tribes may request that all federally recognized Tribes likely to be culturally affiliated with the discovery be notified in writing by mail or email and further consultation initiated regarding the cultural affiliation, care, handling, excavation (if necessary), and/or disposition per NAGPRA.

2. Known or suspected Native American Ancestors or other materials subject to NAGPRA will not be moved, touched, or further disturbed after discovery until completion of Tribal consultation or emergent circumstances arise.

3. Accommodations will be made for traditional or ceremonial practices in association with discoveries.

4. Photographs shall not be taken, except when necessary for identification and documentation. Tribes may request that any photographs of Native American Ancestors or other materials subject to NAGPRA be destroyed or repatriated at the end of the Project.

5. Pending consultations, documentation of the discovery will include a written description, mapping and sketching, and precise GPS coordinates. This documentation will be curated with other Project records and not be published or made publicly available in any way.

6. To ensure the protection, preservation, and proper respectful treatment of any discovered materials, pursuant to applicable law, the nature and location of any discovery shall remain confidential as best as reasonably possible given the circumstances and location. Only those persons and entities identified in this plan shall be notified of the discovery or given information about the discovery. The Permittee, NRCS, SHPO, and related contractors will ensure all staff and consulting personnel are appropriately trained for their respective roles in implementing this plan.

7. Consulting Tribes will be afforded opportunities to employ proper traditional cultural practices and treatments during periods of non-Tribal holding of discoveries.

8. The permanent care of Native American Ancestors and materials subject to NAGPRA will be determined by the appropriate Tribe or Tribes in consultation with the SHPO.

9. Draft and final archaeological reports, with related physical anthropological reports and law enforcement case documentation appended, will be submitted to the appropriate Tribes for review and comment.

Additional Notes
The Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (Gun Lake Tribe) has notified the NRCS and SHPO that they wish to consult if Native American Ancestors or cultural materials are found. This Tribe will be consulted in addition to those who requested consultation with the NRCS.

Contacts

Local Police
Grand Rapids Police Department
Non-emergency phone number: (616)456-3400
GRPDinfo@grcity.us

Natural Resources Conservation Service - Michigan
E.W. Duane Quates, State Cultural Resources Specialist / Senior Archaeologist
(517)324-5261
Edward.Quates@usda.gov

Michigan State Historic Preservation Office
Sarah Surface-Evans, Senior Archaeologist
(517)282-7959
Surfaceevanss1@michigan.gov

Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (Gun Lake Tribe)
Lakota Pochedley, Tribal Historic Preservation Officer
(269)525-8125 / (269)397-1780
Lakota.pochedley@glt-nsn.gov
Mbpi_thpo@glt-nsn.gov

Michigan Anishinaabek Cultural Preservation and Repatriation Alliance
William Johnson, Chairman
(989)775-4730
wjohnson@sagchip.org

Appendix F - *Contact Information*

The following contact information is to be used for the purposes of this agreement and is the responsibility of each organization to submit updates as information changes.

Natural Resources Conservation Service *3001 Coolidge Rd, Suite 250* *East Lansing, MI 48823-6321* *www.mi.nrcs.usda.gov* *(517) 324-5270*	*Duane Quates* *State Cultural Resources Specialist* *Edward.quates@usda.gov* *(517) 324-5261* *Chris Valvano* *Archaeologist* *Christopher.valvano@usda.gov* *(517) 324-5349* *Melissa Gutierrez* *Cultural Resources Coordinator* *Melissa.gutierrez@usda.gov* *(517) 324-5251*
State Historic Preservation Office *300 North Washington Square* *Lansing, MI 48913* *miplace.org/historic-preservation/* *(517) 335-9840*	*Scott Slagor* Cultural Resource Protection Manager *SlagorS2@michigan.gov* *(517) 285-5120*
City of Grand Rapids *300 Monroe Avenue NW* *Grand Rapids, MI 49503* *grandrapidsmi.gov*	*Mike Staal* *Acting Project Manager* *Engineering Department* *mstaal@grcity.us* *Office: (616) 456-4182* *Cell: (616) 481-2214*
Grand Rapids Whitewater *120 Lyon Street NW* *Grand Rapids, MI 49503* *grandrapidswhitewater.org*	*Matt Chapman* *Project Manager* *matt@grandrapidswhitewater.org* *(616) 608-6922*
Grand Valley Metropolitan Council *Lower Grand River Organization of Watersheds* *678 Front Avenue, NW, Suite 200* *Grand Rapids, MI 49504* *www.gvmc.org*	*Wendy Ogilvie* *Director of Environmental Programs* *Wendy.ogilvie@gvmc.org* *Office: (616) 776-7605* *Cell: (616) 901-8172*

Appendix

Grand Rapids Public Museum *272 Pearl St. NW* *Grand Rapids, MI 49504* *www.grpm.org*	*Alex Forist* *Chief Curator* *aforist@grpm.org* *(616) 929-1700*

Appendix G – *Glossary of Terms*

ACHP – Advisory Council on Historic Preservation is an independent federal agency created solely to address historic preservation issues. It promotes the preservation, enhancement, and sustainable use of our nation's historic resources. The ACHP advises and guides federal agencies and participants through the Section 106 review process.

City – The City of Grand Rapids, Michigan is the sponsoring local organization, EGLE permit applicant and responsible for establishing contracts for demolition work. The City is an invited signatory.

GRPM – Grand Rapids Public Museum, a concurring party.

GRWW – Grand Rapids Whitewater, Inc. is leading the design and engineering of the Project and will closely coordinate with the City and other partners to accomplish the intent of the design. GRWW is an invited signatory.

GVMC – Grand Valley Metropolitan Council is the applicant for federal assistance through the RCPP and is responsible for ensuring habitat restoration work and requirements of the RCPP agreement are met. GVMC is an invited signatory.

MOA – Memorandum of Agreement. This MOA serves to document steps that will be taken to mitigate the adverse effects caused by the removal of the four low-head dams in the Grand River in downtown Grand Rapids as part of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project.

MSF – Michigan Strategic Fund, a signatory.

NHPA – National Historic Preservation Act

NRCS – Natural Resources Conservation Service, a federal agency of the U.S. Department of Agriculture. NRCS is the lead federal agency for this MOA and is a signatory.

SHPO – State Historic Preservation Office, a signatory.

Signatory Status – Parties who may sign a MOA fall into 1 of 3 categories:
(from: https://www.achp.gov/executing_agreement_documents)

1. **Signatory** – In accordance with 36 CFR Part 800.6(c)(1), a signatory has the sole authority to execute, amend, or terminate the agreement. The federal agency and the SHPO/THPO are signatories. The ACHP is a signatory when it chooses to participate. A THPO or tribal representative is a required signatory when the undertaking occurs on or affects historic properties on tribal lands.

2. **Invited Signatory** - In accordance with 36 CFR Part 800.6(c)(2), an invited signatory, upon signing, has the authority to amend and terminate the agreement. The federal agency official may invite additional parties to sign the agreement such

as an Indian tribe who attaches religious and cultural significance to historic properties affected by the undertaking (off tribal lands), or any party that assumes a responsibility under the agreement.

3. **Concurring Party** – In accordance with 36 CFR Part 800.6(c)(3), a concurring party is a consulting party invited to concur in the agreement document but who does not have the authority to amend or terminate the agreement. A concurring signature is essentially an endorsement of the agreement.

Consulting Party – Consulting Party status entitles the person or group to share their views, receive and review pertinent information, offer ideas, and consider possible solutions together with the federal agency and other consulting parties. Each party can decide how active a role they wish to play in consultation.

APPENDIX A

Public Plan, Summary, Comments and Responses

SHPO Letter to NRCS 12/17/2020

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
MICHIGAN STRATEGIC FUND
STATE HISTORIC PRESERVATION OFFICE

MARK A. BURTON
PRESIDENT

December 17, 2020

DUANE QUATES
USDA NATURAL RESOURCES
CONSERVATION SERVICE
3001 COOLIDGE ROAD SUITE 250
EAST LANSING MI 48823-6362

RE: ER20-876 Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, (USDA/NRCS)

Dear Mr. Quates:

We have reviewed the additional information provided on November 2, 2020 for the Lower Grand River Watershed Habitat Restoration Project in Grand Rapids, Michigan that was submitted in order to address the Michigan SHPO's comments dated June 29, 2020. Federal agencies have a responsibility to identify and assess the eligibility of historic resources within the area of potential effect, SHPO's role is concur with the recommendations of eligibility and effect when appropriate. As it stands presently, we do not have enough information regarding eligibility.

After review of the information presented in the report, we require additional information specifically addressing the National Register of Historic Places Eligibility of the low head dams proposed for removal. While the information provides general history of dams in the Grand River watershed, there does not appear to have been any analysis of these dams to address their potential eligibility. There is also no information on the current condition of the dams. At a minimum, a federally qualified architectural historian should be retained to examine the known history as well as survey, photograph and map the current dams. This information should be presented in a clear manner to facilitate review of the materials.

Please note that the Section 106 review process cannot proceed until we are able to consider the information requested above. This letter does not clear the project. If you have any questions, please contact Brian Grennell, Cultural Resource Management Coordinator, at 517-335-2721 or by email at GrennellB@michigan.gov. If you have any question about architectural survey efforts, please contact Katie Kolokithas, Survey Coordinator, at (517) 241-6062 or by email at kolokithask1@michigan.gov. **Please reference our project number in all communication with this office regarding this undertaking.** Thank you for this opportunity to review and comment, and for your

Sincerely,

Brian G. Grennell
Cultural Resource Management Coordinator

for Martha MacFarlane-Faes
Deputy State Historic Preservation Officer

SAT:KAK:BGG

APPENDIX A

Public Plan, Summary, Comments and Responses

June 2020 NRCS submission to SHPO that includes, including 2018 Project Field View Summary - redacted

United States Department of Agriculture

Natural Resources Conservation Service

Michigan State Office

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18 June 2020

Brian G. Grennell
Cultural Resources Management Coordinator
State Historic Preservation Office
Michigan Economic Development Corporation
300 N. Washington Square
Lansing MI 48913

Subject: Update to December 20, 2018, Submittal Regarding Initial Consultation and Scoping Field View, Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, MI, ER19-325.

Dear Mr. Grennell

On December 20, 2018, Environmental Resources Management (ERM), under the direction of the Natural Resource Conservation Service (NRCS), submitted a request for initial consultation regarding the Lower Grand River Watershed Habitat Restoration Project. Please refer to ER No. 19-325. NRCS would like to take this opportunity to provide this update describing the current proposed project design and associated evaluation and recommendations regarding cultural resources, and to invite you to concur with our findings.

Project Overview

To refresh you on the background for the proposed Project, a Regional Conservation Partnership Program (RCPP) grant was awarded to the Grand Valley Metropolitan Council in 2017 to improve aquatic habitat in the Lower Grand River (which runs from Portland, at the confluence of the Looking Glass River, to Grand Haven, at the mouth of the river). This grant provides $8 million in funding for the Lower Grand River Habitat Restoration and Farmland Conservation Project. Of that amount, about $4.1 million was allocated to support instream habitat restoration of the Grand River where it flows through the City of Grand Rapids in Kent County under the U.S. Department of Agriculture NRCS Watershed Protection and Flood Prevention Act, PL 83-566 program. Specifically, the $4.1 million would be used for revitalizing the rapids in downtown Grand Rapids from 130 feet upstream of Bridge Street to Fulton Street (the proposed Project). The proposed Project would include the following activities:

Demolition of four low-head dams;

Restructuring the channel through excavation, grading, and importing boulders, cobble and gravel substrate;

Installing additional scour protection on existing bridge structures; and

Installing four diversified hydraulic features.

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Areas of Potential Effect

The proposed Project includes the following:

A Construction Area—the area within the wetted channel of the Grand River from approximately 130 feet upstream of the Bridge Street Bridge to the upstream edge of the Fulton Street Bridge (see Figure 1); and

The Project Area—the areas where proposed Project activities would occur:

- Portions of the land on both sides of the Grand River from the 6th Street Dam to Fulton Street (where construction access or staging areas would occur as shown on Figure 1)
- The wetted channel of the river from 130 feet upstream of the Bridge Street Bridge to the upstream face of the Fulton Street Bridge (the Construction Area); and
- Three recipient sites in the river for the placement of relocated unionid mussels. The three recipient sites are mussel beds near Ada, Michigan; at Riverside Park just upstream of Grand Rapids; and between Plaster Creek and the M-11 (28th Street) Bridge.

The proposed Project's Area of Potential Effect (APE) is defined for direct effects as the Construction Area and Project Area, and for indirect effects as areas immediately adjacent to the Construction Area. Indirect effects, primarily visual, will only be considered for properties from which the channel modifications will be visible. Potential impacts may result from demolition of four low-head dams; restructuring the channel through excavation, grading, and importing boulders, cobble, and gravel substrate; development and use of staging areas; and installing additional scour protection on existing bridge structures. Proposed earth disturbance is not planned beyond the confines of the active river channel except for construction access points and temporary staging areas on the banks. Temporary access ramps leading from the bank into the river are anticipated to be placed on the existing land surface. There will be little to no alteration or grading and the sites of the temporary ramps will be restored to original state upon completion; therefore, no impacts to historic properties from these temporary ramps are expected. The staging area located south of Bridge Street will have lighting fixtures and 6 to 8 inches of topsoil temporarily removed and stored. Geotextile blanket and stone will be placed to provide temporary driving and storage surfaces. Upon completion of the proposed Project, the stone and geotechnical blanket will be removed, and the lighting fixtures and soil replaced. The staging area located northeast of I-196 will be utilized with limited alteration.

Research Results

As reported in the December 2018 request for consultation, the early phases of Section 106 activities included a background search for previous cultural resources surveys and reported cultural resources. This search, conducted on February 21, 2018, included a 1-mile buffer for archaeological resources and a 2,000-foot buffer for historic and architectural resources. Results of this research have been revised based on the updated APE (see Tables 1 and 2 and Figures 2 and 3). Background research is based on information provided by the Michigan State Historic Preservation Office (SHPO), including the Archaeological Site Index files.

[redacted] prior archaeological surveys and [redacted] previously recorded archaeological sites were identified within the 1-mile buffer. One site, an [redacted], is partially within the updated direct APE; however, the mapped location is based on historical reports, has not been field verified, and ground disturbance activities are not expected to occur in this area. [redacted] The site includes [redacted] In the December 20, 2018 submittal, fencing [redacted] was recommended. Under the current project design, [redacted]

is not immediately adjacent to the direct APE, and no ground disturbance is planned anywhere near the site; therefore, protective fencing is no longer recommended. The NRHP eligibility of the other sites noted below has not been determined.

The potential for isolated human burials and undocumented cemeteries was also considered. According to the Archaeological Site Index [redacted] one of these sites are located in the direct APE.

[redacted]

Seven architectural reconnaissance surveys and nine intensive architectural surveys have been completed near the proposed Project. A total of 39 architectural resources that are listed in the NRHP, recommended as eligible for listing, or have achieved status as a locally designated landmark with national significance are within the indirect APE and/or the 2,000-foot buffer, including six historic districts or extensions of the districts (see Table 2 and Figure 3).

Table 2: Known Architectural Resource Summary of Resources Listed on the NRHP, Recommended for Listing on the NRHP, and Locally Designated Landmarks within 2,000-Foot Buffer

Resource#	Resource Name/Description	Address	Location Relative to APE	NRHP Status
P394	Old Federal Building, United States Post Office and Federal Building	148 Ionia Ave NW	In 2,000-foot buffer	Local National Designated Landmark
P4348	Turner, Eliphalet H., House	731 Front Ave NW	In 2,000-foot buffer	Listed
P4354	German-English School Association	327 Front Ave NW	In 2,000-foot buffer	Local National Designated Landmark
P4356	Ledyard Block Historic District	123-145 Ottaway Ave NW, 104-124 Monroe Center NW	In 2,000-foot buffer	Listed
P4384	Heartside Historic District	Division, Commerce, and Ionia Avenues; Fulton, Weston, Oakes, and Cherry Streets	In 2,000-foot buffer	Listed, National Park Service Certified Local District
P4395	Aldrich Building	98 Monroe Center NW	In 2,000-foot buffer	Listed
P4411	Sixth Street Bridge	Over the Grand River connecting Newberry Street NW and Sixth Street NW	In 2,000-foot buffer	Listed
P5549	8 Ionia SW in Heartside Historic District	8 Ionia Ave SW	In 2,000-foot buffer	Certified Historic Structure
P5555	Lemon and Wheeler Building in Heartside Historic District	25 Ionia Ave SW	In 2,000-foot buffer	Certified Historic Structure
P23718	Fine Arts Building	220 Lyon Street NW	Indirect APE	Listed
P23721	Goodspeed Brothers Building	188 Monroe Ave NW	In 2,000-foot buffer	Listed
P23722	Grand Rapids City Hall	35 Lyon Street NW	In 2,000-foot buffer	Delisted NRHP (Previously Listed on the NRHP)
P23724	Grand Rapids Savings Bank Building	60 Monroe Center NW	In 2,000-foot buffer	Listed
P23731	Michigan Trust Company Building	40 Pearl Street NW	In 2,000-foot buffer	Listed
P23735	Rood Building	139 Pearl Street NW	In 2,000-foot buffer	Listed
P28623	Peck Block	34-50 Monroe Center NW, 209 Division S	In 2,000-foot buffer	Listed
P28714	Aldrich, Godfrey and White Block	89-99 Monroe Center NW	In 2,000-foot buffer	Listed

Resource#	Resource Name/Description	Address	Location Relative to APE	NRHP Status
P29454	Weirich Building	400-402 Bridge Street NW	In 2,000-foot buffer	Eligible
P29456	Oroiquis Building, Iroquois Building in John Ball Park Historic District	404-406 Bridge Street NW	In 2,000-foot buffer	Eligible
P35106	United States Post Office	155 N Division Ave, 135-137 Ionia Ave NW	In 2,000-foot buffer	Listed
P35321	Star Transfer Company Building	134 Grandville Ave SW	In 2,000-foot buffer	Eligible
P38818	Heartside Historic District (Second Proposed Local District Expansion)	Roughly bounded by Cherry Street to the north, Division Street to the east, US 131 to the west and Wealthy Street to the south	In 2,000-foot buffer	Eligible
P38930	Berkey and Gay Furniture Company	940 Monroe Ave NW	In 2,000-foot buffer	Listed
P47552	Grand Rapids Cycle Company Factory	514 Butterworth Street SW	In 2,000-foot buffer	Listed
P47572	Vandenberg Center	300 Monroe Ave NW	In 2,000-foot buffer	Eligible
P47667	P. Steketee & Sons Complex	86 Monroe Ave NW	In 2,000-foot buffer	Eligible
P48253	Fourth Street / Stocking NW Commercial Historic District	Stocking NW, Fourth Street NW	In 2,000-foot buffer	Eligible
P48426	Ionia Avenue Mission Hall	737 Ionia Ave NW	In 2,000-foot buffer	Eligible
P48427	Belknap Lookout Historic District	Bounded by Leonard, College, Michigan, and Division	In 2,000-foot buffer	SHPO recommended district
P48647	John Ball Park Historic District	Roughly bounded by Bridge, Mt. Vernon, Seward, RR Tracks, Butterworth St., Indiana Ave., and Douglas St.	In 2,000-foot buffer	SHPO recommended district
P48654	Downtown Grand Rapids Historic District	Roughly bounded by Fulton, Monroe, Pearl, the Grand River, Lyon, Ramson	In 2,000-foot buffer	Eligible
P48820	Fox Building	83-85 Monroe Center NW	In 2,000-foot buffer	Eligible
P51124	Grand Rapids and Indiana Railroad Grand River Bridge	Over Grand River 300 feet south of Pearl Street	Indirect APE	Eligible
P51170	McKay Tower	146 Monroe Center NW	In 2,000-foot buffer	Eligible
P51324	Lexington School in John Ball Park Historic District	45 Lexington Ave NW	In 2,000-foot buffer	Listed
P57261	Grand Rapids / Kent	56 N Division Ave NE	In 2,000-foot buffer	Eligible
P57471	Keeler Building	56 N Division Ave	In 2,000-foot buffer	Listed

Resource#	Resource Name/Description	Address	Location Relative to APE	NRHP Status
	Civil War Memorial statue	2 Division Ave NW	In 2,000-foot buffer	Local National Designated Landmark
	Slater's Indian Mission	Ah-Nab-Awen Park	In 2,000-foot buffer	Local National Designated Landmark

Scoping Field View

On November 6, 2018, Eric Scuoteguazza (ERM archaeologist) and Danielle McKissic (ERM architectural historian) accompanied Duane Quates (MI NRCS Archaeologist) on a scoping field view of the Project Area to gain an understanding of the proposed Project's potential to impact significant cultural resources, including known resources.

Results of this field view are summarized in the attached "Initial Consultation" letter (dated December 20, 2018). The NRCS field view noted that numerous known cultural resources are located within the indirect APE, including structures and districts that are potentially eligible for listing on the NRHP. Based on the nature of the proposed Project, relatively little viewshed change is expected as a result of the undertaking. For these reasons, the visual APE includes only properties immediately adjacent to and abutting the proposed Project. Both previously recorded and as yet unrecorded resources that met the age threshold (50 years or older) within this potential visual impact area during survey were considered. During the field view, the 19 properties below were considered to fall within the parameters described above (see Figure 4 and Table 3).

Table 3: Previously and Newly Recorded Historic Resources in the Indirect APE

Survey Number/ Field Number	Previously Recorded	Approximate Year	Description	NRHP Recommendation
DM 1	N	ca. 1960	U.S. Post Office Building	Ineligible
DM 2	N	ca. 1910	Commercial Building	Ineligible
DM 3	N	1932	Civic Auditorium	Ineligible
DM 4	N	ca. 1910	Commercial Building	Ineligible
P23733/DM 5	Y	1913	Pantlind Hotel (Amway Grand Plaza Hotel)	Eligible
P23718/DM 6	Y	1923	Fine Arts Building	Listed
DM 7	N	ca. 1915	Commercial Building	Ineligible
DM 8	N	1903	Old Town Riverfront Building	Ineligible
DM 9	N	1915	Gillette Bridge	Ineligible
P51124/DM 10	Y	1892	Grand Rapids and Indiana Railroad Grand River Bridge (Blue Bridge)	Eligible
DM 11	N	ca. 1903	Bridge Street Bridge	Eligible
DM 12	N	1900	Pearl Street Bridge	Eligible
DM 13	N	1927	Fulton Street Bridge	Ineligible
DM 14	N	Undetermined	Garritt's Piling; historic resource in Grand River	Ineligible
DM 15	N	ca. 1980	Grand Rapids Historic Riverwalk	Ineligible (possibly not of age)

DM 16	N	Undetermined	Dam 1	Undetermined
DM 17	N	Undetermined	Dam 2	Undetermined
DM 18	N	Undetermined	Dam 3	Undetermined
DM 19	N	Undetermined	Dam 4	Undetermined

The November 2018 field view included an aboveground reconnaissance-level architectural resource survey. Within properties adjacent to the proposed Project, the field view team attempted to locate and photograph all previously recorded historic properties and validate the reported location and condition, as well as determine whether the Construction Area was visible. The aboveground survey also included documentation of newly identified aboveground resources. For the resources recommended as eligible or ineligible in Table 3, evaluation of eligibility is based on field survey observations. For resources requiring research beyond the field survey observations, NRHP recommendations are as of yet undetermined, pending further research.

Three previously recorded resources were identified within the indirect APE prior to the field survey. The three previously identified resources (P23718, P23733, and P51124) were relocated, documented, and evaluated. The previously recorded resources consist of one commercial building (P23718), one hotel (P23733), and one bridge (P51124). Of these resources, P23718 is listed on the NRHP. Resource P23733 is recommended eligible for listing on the NRHP. Field observations support that P51124 is eligible for listing on the NRHP, as per SHPO staff recommendation.

Of the newly recorded resources, a preliminary NRHP recommendation was provided based on Criterion C findings for all the resources with the exception of the low-head dams (DM 16 through DM 19). Additional research will be needed to evaluate the dams and consideration for inclusion on the NRHP. Furthermore, SHPO consultation and research into other newly recorded resources could alter the NRHP eligibility recommendations provided in Table 3, under Criteria A or B.

Evaluations and Recommendations

While a number of archaeological resources are known to exist within the Project Area and vicinity, earth disturbance is not planned beyond the confines of the active river channel except for construction access points and staging areas. The NRCS field view supported the fact that the Project Area has been heavily urbanized and occurs within a portion of the Grand River that has been historically channelized for flood control purposes. Given the extensive existing land disturbance, and the fact that the majority of the planned activities are limited to the stream channel and some upland areas (for temporary staging and access), the Proposed Action is unlikely to result in impact to stratigraphically intact portions of the soil profile or, therefore, significant archaeological sites or potential culture-bearing soil horizons.

However, if the proposed Project design would change to include grading or significant earth disturbance in upland areas, further archaeological evaluation and possibly testing may be required prior to construction to avoid areas possibly maintaining deeply buried pre-contact or historic archaeological remains. SHPO would be consulted if plans change to include such earthmoving or grading, and a qualified archaeological monitor may be recommended. With the planned avoidance of Site [redacted] and no planned ground disturbance occurring in its vicinity, a finding of no adverse effects to archaeological historic properties is recommended.

Architectural resource assessment and survey identified both previously recorded resources as well as new resources. Three previously recorded resources, P23718, P23733, and P51124, were found to be significant under NRHP criteria. While these resources are adjacent to the proposed Project, a finding of no adverse effects to these resources is recommended due to a lack of visual change as well as a lack of physical changes that could impact resource integrity.

In addition to the three previously recorded resources, 16 new resources were identified during the field survey effort (Table 3). These resources consisted of six buildings (DM 1, DM 2, DM 3, DM 4, DM 7, DM 8), four bridges (DM 9, DM 11, DM 12, DM 13), one historic resource associated with the Grand River (DM 14), one riverwalk (DM 15), and four low-head dams (DM 16, DM 17, DM 18, DM 19). Of these resources, ten are considered to be ineligible for listing on the NRHP. Resources DM 11 and DM 12 are recommended eligible for inclusion on the NRHP; however, due to lack of visual change from the Proposed Action, a finding of no adverse effects to these two resources is recommended. Any visual effects of the proposed Project are planned to be limited to the Grand River channel and properties adjacent to the Project area.

As part of the Proposed Action, the four low-head dams would be demolished. NRHP eligibility for the four low-head dams has not been determined. Resources subject to direct effects (limited to the four low-head dams) may require additional study to determine NRHP significance, potential effect, and the potential need for mitigation of adverse effects to these structures.

The proposed Project would have no effect on the remaining previously recorded and newly recorded architectural resources adjacent to the Project Area. Given that the proposed Project would include the demolition of low-profile dams whose structures are not currently visible above the water surface, and the restoration of rapids that are historic to the natural landscape of the area, there would be no adverse change in the historic viewshed of the identified resources. Additionally, any proposed staging areas for the proposed Project would not directly impact the resources identified within the viewshed, nor would they cause permanent impact on the immediate surroundings that may tie into the significance of that resource. However, should earthmoving, tree-clearing, or terracing activities be proposed as Project planning and design progresses, such viewshed changes may need to be re-evaluated in consultation with SHPO.

We appreciate your participation in our Section 106 consultation process. Please address any comments, questions, and/or additional information requests to me. I can be contacted at my office number (517) 324-5261, my cell number (517) 980-0707, and by email at Edward.Quates@usda.gov. I look forward to discussing this project with you and the MI SHPO staff.

Yours sincerely,



E.W. Duane Quates, Ph.D.
State Cultural Resources Specialist / Archaeologist
Natural Resources Conservation Service - USDA

Attachments

APPENDIX A

Public Plan, Summary, Comments and Responses

Initial Tribal Consultation Letter – 07-03-2019

United States Department of Agriculture

Natural Resources Conservation Service

Michigan State Office

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July 3, 2019

Paula Carrick, Tribal Historic Preservation Officer
Bay Mills Indian Community
12140 West Lakeshore Drive
Brimley, Michigan 49715

RE: Tribal Consultation for the Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, Michigan

Dear Officer Carrick:

The U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) is hereby initiating consultation with the Bay Mills Indian Community regarding the proposed Lower Grand River Watershed Habitat Restoration Project, located in Grand Rapids, Kent County, Michigan (Attachment 1). This effort is being sponsored by the City of Grand Rapids and undertaken by Grand Rapids Whitewater (GRWW), which is a non-profit funding applicant (the Applicant).

Specifically, the project is within the wetted channel of the Grand River and stretches for 0.7 miles from the I-196 Bridge to the Fulton Street Bridge. This project does not include removal of the 6th Street dam or other related work upstream of the I-196 Bridge; that work will be planned and constructed as a separate and independent Section 106 undertaking under the authority of the Great Lakes Fishery Commission with the United States Army Corps of Engineers providing technical support and assistance.

The purpose of the Lower Grand River Watershed Habitat Restoration Project is to revitalize, enhance, and maintain the rapids in downtown Grand Rapids. The project will facilitate the restoration of the ecological, cultural, and recreational functions of the historic rapids by:

- Restoring aquatic habitat diversity and suitability for threatened, endangered, and special concern native Great Lakes fish and mussel species;
- Reducing or eliminating public safety hazards generated by the existing hydraulics;
- Diversifying in-stream features that will improve habitat and create/enhance recreational activities in the river.

This project is funded, in part, by the USDA/NRCS Regional Conservation Partnership Program (RCPP), per the Watershed Protection and Flood Prevention Act, PL-566 program. As such, it is subject to the requirements of the National Environmental Policy Act of 1969, as well as the National Historic Preservation Act of 1966. Therefore, an Environmental Assessment (EA) is being completed to identify and address potential environmental impacts which may result from proposed activities. Accordingly, considerations of potential impacts to archaeological, historic and architectural resources (collectively referred to as *cultural resources*) are being taken into account, and consultation with Michigan's State Historic Preservation Office (SHPO) is in progress with the assistance of NRCS' third-party contractor, Environmental Resources Management (ERM).

USDA is an equal opportunity provider and employer.

While a number of cultural resources are known to exist within the project vicinity, earth disturbance is not planned beyond the confines of the active river channel, and staging areas on its banks are anticipated to be placed on the existing land surface with little to no alteration or grading.

As mentioned above, this project serves to facilitate the restoration of the ecological, cultural, and recreational functions of the historic rapids and **should not be confused with** other efforts that oppose this goal and propose to dredge the grand river for power boat access to and through Ottawa County.

The USDA/NRCS invites your comments and/or guidance regarding the Lower Grand River Watershed Habitat Restoration Project, including information about potential impacts to archaeological sites, burials, and traditional cultural properties. We also welcome your interest in being involved in the project's development, up to and including your being listed as a "consulting party," should you so choose.

If you choose to be included as a consulting party, please notify us in writing within thirty calendar days of receipt of this invitation. We will instruct the Applicant to provide you with forthcoming draft documents for your review and comment, and you will be kept apprised of project progress, including agency consultation. If you are aware of a stakeholder group that is interested in consulting on this planned undertaking, please respond with the appropriate contact information.

Formal responses to this invitation as well as any questions or requests for additional information should be directed to the Cultural Resources Coordinator on my staff:

Melissa Gutierrez
NRCS Michigan
3001 Coolidge Road, Suite 250
East Lansing, Michigan 48823
(517) 324-5251
melissa.gutierrez@mi.usda.gov

Respectfully submitted,

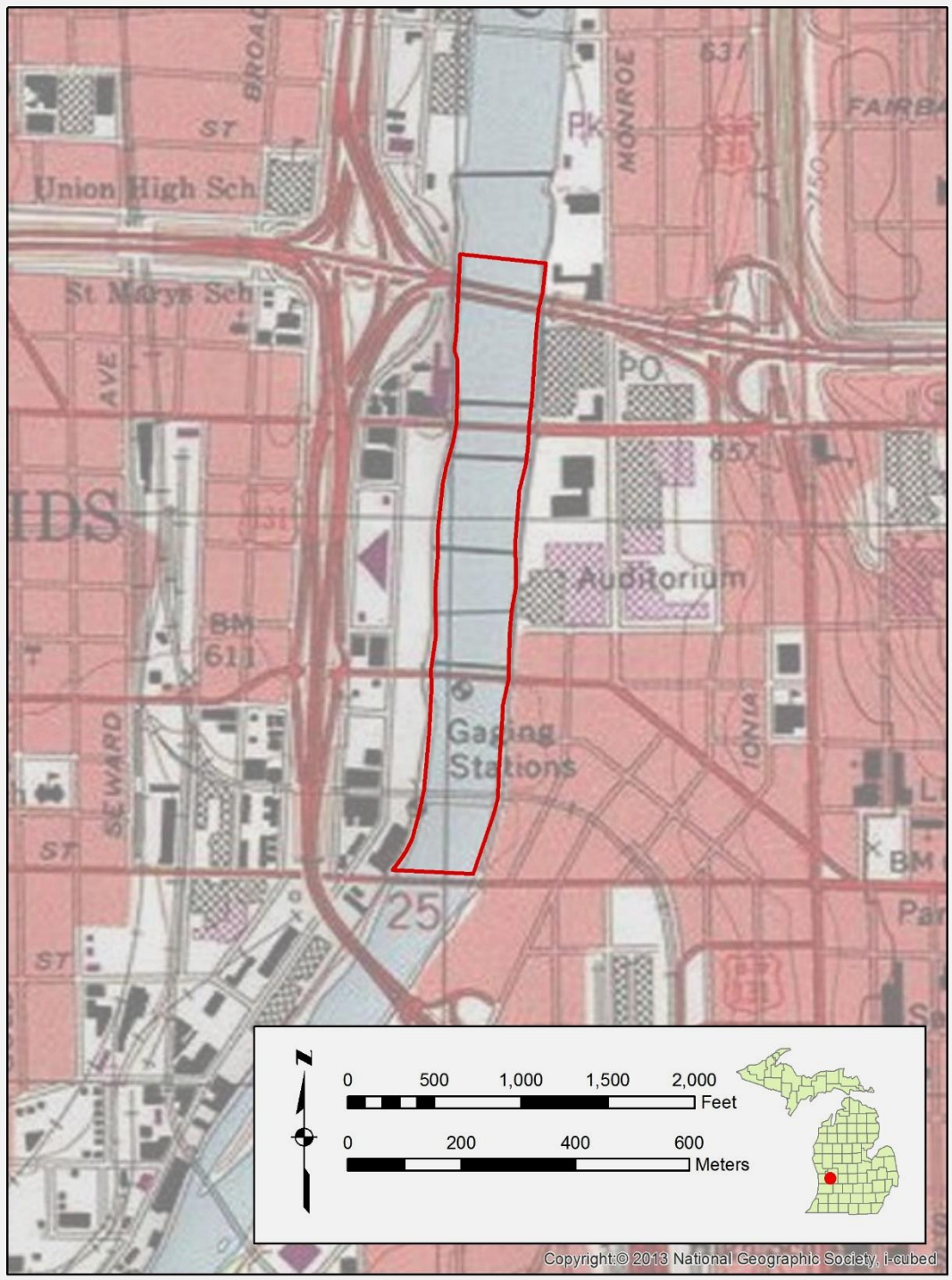
GARRY LEE
State Conservationist

Attachment 1: Project Location Shown on a Portion of the USGS 7.5-Minute Grand Rapids West Quadrangle (1967, rev 1982)

cc:
Chairman Bryan Newland, Bay Mills Indian Community, Brimley, MI
William Elder, Acting Area Conservationist, NRCS, Marquette, MI
Madeleine Cantu, District Conservationist/Tribal Liaison, NRCS, Sault Ste. Marie, MI
Eddie Glover, Area Conservationist, NRCS, Grand Rapids, MI
Melissa Gutierrez, Cultural Resources Coordinator, NRCS, East Lansing, MI
Duane Quates, Cultural Resources Specialist, NRCS, East Lansing, MI
Kim Wieber, Assistant State Conservationist for Programs, NRCS, East Lansing, MI
Steve Koster, Environmental Resources Management, Inc., Holland, MI
Eric Scuoteguazza, Environmental Resources Management, Inc., Cranberry Township, PA

Steve Heacock, President and CEO Grand Rapids Whitewater, Grand Rapids, MI
Wendy Ogilvie, Director of Environmental Programs, Grand Valley Metro Council, Grand Rapids, MI
Jason Chrumka, Acting Project Manager, USACE, Detroit District, Detroit, MI
Curtis Sedlacek, District Archaeologist and Tribal Liaison, USACE, Detroit District, Detroit, MI
Jessica Pruden, Fish and Wildlife Biologist, USFWS, East Lansing, MI
Eric R. DeLong, Deputy City Manager, City of Grand Rapids, MI
Greg Madura, Alpine Township Supervisor, Comstock Park, MI
Darrel Schmalzel, City Manager, Walker, MI
Tim Kelly, President & CEO, Downtown Grand Rapids, Inc., Grand Rapids, MI
Tonya Lewandowski, Senior Engineer, Water Resources, Environmental Consulting & Technology Inc., Traverse City, MI
James Smalligan, Senior Vice President, Fishbeck, Thompson, Carr & Huber, Grand Rapids, MI
Wendy Ogilvie, Director of Environmental Programs, Friends of Indian Mill Creek, Grand Rapids, MI
Dale Robertson, President & CEO, Grand Rapids Public Museum, Grand Rapids, MI
Jessie Schulte, District Manager, Kent County Conservation District, Grand Rapids, MI
Ken Yonker, Kent County Drain Commissioner, Grand Rapids, MI
Douglas R. Sporte, Kent County Deputy County Drain Commissioner, Grand Rapids, MI
Wendy Ogilvie, Director of Environmental Programs, Lower Grand River Organization of Watersheds, Grand Rapids, MI
Luis Saldivia, Field Operations Manager, Michigan Department of Environment, Great Lakes, and Energy, Grand Rapids, MI
Patrick Ertel, Senior Fisheries Biologist, Michigan Department of Natural Resources, Plainwell, MI
Lisa Wozniak, Executive Director, Michigan League of Conservation Voters, Ann Arbor, MI
Gretchen Zuiderveen, President, Rogue River Watershed Partners, Rockford, MI
Bryan Burroughs, Executive Director, Trout Unlimited, Dewitt, MI
Mark Van Putten, Chief Executive Officer, Wege Foundation, Grand Rapids, MI
Jason Zylstra, Director, Foundation Administration, CDV5 Foundation, Grand Rapids, MI
Julie Ridenour, President, Steelcase Foundation, Grands Rapids, MI

ATTACHMENT 1
Project Location Shown on a Portion of the USGS 7.5-Minute Grand Rapids West Quadrangle (1967, rev 1982)



APPENDIX A

Public Plan, Summary, Comments and Responses

Tribal Consultation Outreach and Tribal Consultation Responses 7/3/2019

Example letter - see outreach tables included in Appendix A and below for further information

United States Department of Agriculture

Natural Resources Conservation Service

Michigan State Office

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July 3, 2019

Paula Carrick, Tribal Historic Preservation Officer
Bay Mills Indian Community
12140 West Lakeshore Drive
Brimley, Michigan 49715

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While a number of cultural resources are known to exist within the project vicinity, earth disturbance is not planned beyond the confines of the active river channel, and staging areas on its banks are anticipated to be placed on the existing land surface with little to no alteration or grading.

As mentioned above, this project serves to facilitate the restoration of the ecological, cultural, and recreational functions of the historic rapids and **should not be confused with** other efforts that oppose this goal and propose to dredge the grand river for power boat access to and through Ottawa County.

The USDA/NRCS invites your comments and/or guidance regarding the Lower Grand River Watershed Habitat Restoration Project, including information about potential impacts to archaeological sites, burials, and traditional cultural properties. We also welcome your interest in being involved in the project's development, up to and including your being listed as a "consulting party," should you so choose.

If you choose to be included as a consulting party, please notify us in writing within thirty calendar days of receipt of this invitation. We will instruct the Applicant to provide you with forthcoming draft documents for your review and comment, and you will be kept apprised of project progress, including agency consultation. If you are aware of a stakeholder group that is interested in consulting on this planned undertaking, please respond with the appropriate contact information.

Formal responses to this invitation as well as any questions or requests for additional information should be directed to the Cultural Resources Coordinator on my staff:

Melissa Gutierrez
NRCS Michigan
3001 Coolidge Road, Suite 250
East Lansing, Michigan 48823
(517) 324-5251
melissa.gutierrez@mi.usda.gov

Respectfully submitted,

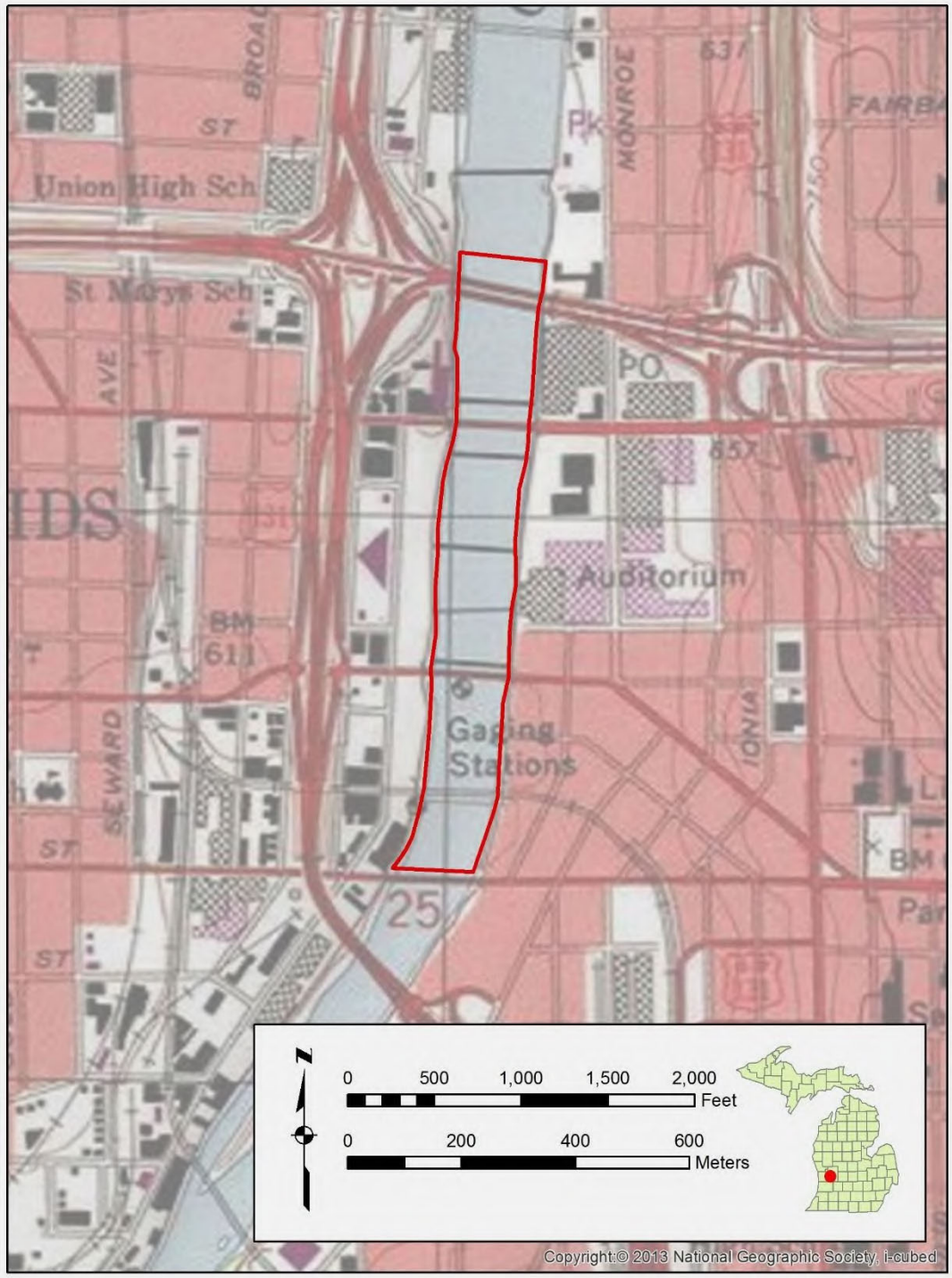
GARRY LEE
State Conservationist

Attachment 1: Project Location Shown on a Portion of the USGS 7.5-Minute Grand Rapids West Quadrangle (1967, rev 1982)

cc:
Chairman Bryan Newland, Bay Mills Indian Community, Brimley, MI
William Elder, Acting Area Conservationist, NRCS, Marquette, MI
Madeleine Cantu, District Conservationist/Tribal Liaison, NRCS, Sault Ste. Marie, MI
Eddie Glover, Area Conservationist, NRCS, Grand Rapids, MI
Melissa Gutierrez, Cultural Resources Coordinator, NRCS, East Lansing, MI
Duane Quates, Cultural Resources Specialist, NRCS, East Lansing, MI
Kim Wieber, Assistant State Conservationist for Programs, NRCS, East Lansing, MI
Steve Koster, Environmental Resources Management, Inc., Holland, MI
Eric Scuoteguazza, Environmental Resources Management, Inc., Cranberry Township, PA

Steve Heacock, President and CEO Grand Rapids Whitewater, Grand Rapids, MI
Wendy Ogilvie, Director of Environmental Programs, Grand Valley Metro Council, Grand Rapids, MI
Jason Chrumka, Acting Project Manager, USACE, Detroit District, Detroit, MI
Curtis Sedlacek, District Archaeologist and Tribal Liaison, USACE, Detroit District, Detroit, MI
Jessica Pruden, Fish and Wildlife Biologist, USFWS, East Lansing, MI
Eric R. DeLong, Deputy City Manager, City of Grand Rapids, MI
Greg Madura, Alpine Township Supervisor, Comstock Park, MI
Darrel Schmalzel, City Manager, Walker, MI
Tim Kelly, President & CEO, Downtown Grand Rapids, Inc., Grand Rapids, MI
Tonya Lewandowski, Senior Engineer, Water Resources, Environmental Consulting & Technology Inc., Traverse City, MI
James Smalligan, Senior Vice President, Fishbeck, Thompson, Carr & Huber, Grand Rapids, MI
Wendy Ogilvie, Director of Environmental Programs, Friends of Indian Mill Creek, Grand Rapids, MI
Dale Robertson, President & CEO, Grand Rapids Public Museum, Grand Rapids, MI
Jessie Schulte, District Manager, Kent County Conservation District, Grand Rapids, MI
Ken Yonker, Kent County Drain Commissioner, Grand Rapids, MI
Douglas R. Sporte, Kent County Deputy County Drain Commissioner, Grand Rapids, MI
Wendy Ogilvie, Director of Environmental Programs, Lower Grand River Organization of Watersheds, Grand Rapids, MI
Luis Saldivia, Field Operations Manager, Michigan Department of Environment, Great Lakes, and Energy, Grand Rapids, MI
Patrick Ertel, Senior Fisheries Biologist, Michigan Department of Natural Resources, Plainwell, MI
Lisa Wozniak, Executive Director, Michigan League of Conservation Voters, Ann Arbor, MI
Gretchen Zuiderveen, President, Rogue River Watershed Partners, Rockford, MI
Bryan Burroughs, Executive Director, Trout Unlimited, Dewitt, MI
Mark Van Putten, Chief Executive Officer, Wege Foundation, Grand Rapids, MI
Jason Zylstra, Director, Foundation Administration, CDV5 Foundation, Grand Rapids, MI
Julie Ridenour, President, Steelcase Foundation, Grands Rapids, MI

ATTACHMENT 1
Project Location Shown on a Portion of the USGS 7.5-Minute Grand Rapids West Quadrangle (1967, rev 1982)



GRWW Tribal Outreach

Tribe or Organization	Outreach Summary	Date
United Tribes of Michigan	Project overview presentation. Frank Ettawageshik, Executive Director of the United Tribes of Michigan, served on the original Grand River Restoration Steering Committee. GRWW believes members of both the Little River Band and Grand River Band participated in the River Restoration Steering Committee.	02/08/18
Gun Lake Tribe Environmental Council	Project walking tour	10/05/18
Various Local Tribes participated	As part of the River For All process, a community dinner was held with 26 tribal members from various local tribes participating in a focus group who provided feedback and guidance with respect to the river edge opportunity sites and design guidelines for the river edge trail.	01/29/18
Gun Lake Tribe Environmental Council	Project walking tour	Fall 2019
Gun Lake Tribe Environmental Council	Sturgeon Research and Monitoring Meeting with Gun Lake Tribe Environmental Department, who provided an update on their Sturgeon Research efforts on the Grand River.	Fall 2020
Grand River Band of Ottawa Indians	Meetings with Ron Yob from the Grand River Band of Ottawa Indians. They are not yet a federally recognized tribe but have been intimately involved in many ongoing conversations around the Grand River project. Ron sits on several committees regarding work in and along the river.	ongoing

APPENDIX A

Public Plan, Summary, Comments and Responses

Other Potential Updated Cultural/Tribal Documents/Information

- Tribal Outreach
- ACHP Response to AE
- 20210323 GRW SHPO Response-AE NR dam eligibility
- 20240118 GRW SHPO Response-revised scope additional info NP

GRWW Tribal Outreach

Tribe or Organization	Outreach Summary	Date
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June 21, 2021

Mr. Duane Quates
Cultural Resource Specialist/Archaeologist
Natural Resources Conservation Service
NRCS Michigan
3001 Coolidge Rd., Suite 250
East Lansing, MI 48823

Ref: *Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project*
Grand Rapids, Kent County, Michigan
ACHP Project Number: 17025

Dear Mr. Quates:

On June 11, 2021, the Advisory Council on Historic Preservation (ACHP) received a notification and supporting documentation regarding the potential adverse effects of the referenced undertaking on a property or properties listed or eligible for listing in the National Register of Historic Places. Based upon the information provided, we have concluded that Appendix A, *Criteria for Council Involvement in Reviewing Individual Section 106 Cases*, of our regulations, "Protection of Historic Properties" (36 CFR Part 800) implementing Section 106 of the National Historic Preservation Act, does not apply to this undertaking. Accordingly, we do not believe our participation in the consultation to resolve adverse effects is needed.

However, if we receive a request for participation from the State Historic Preservation Officer, Tribal Historic Preservation Officer, affected Indian tribe, a consulting party, or other party, we may reconsider this decision. Should the undertaking's circumstances change, consulting parties cannot come to consensus, or you need further advisory assistance to conclude the consultation process, please contact us.

Pursuant to Section 800.6(b)(1)(iv), you will need to file the final Section 106 agreement document (Agreement), developed in consultation with the Michigan State Historic Preservation Office and any other consulting parties, and related documentation with the ACHP at the conclusion of the consultation process. The filing of the Agreement and supporting documentation with the ACHP is required in order to complete the requirements of Section 106 of the National Historic Preservation Act.

Thank you for providing us with your notification of adverse effect If you have questions or require our further assistance, please contact Ms. Alexis Clark at (202) 517-0208 or by e-mail at aclark@achp.gov and reference the ACHP Project Number above.

Sincerely,

LaShavio Johnson

LaShavio Johnson
Historic Preservation Technician
Office of Federal Agency Programs

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
MICHIGAN STRATEGIC FUND
STATE HISTORIC PRESERVATION OFFICE

MARK A. BURTON
PRESIDENT

RECEIVED
APR 09 2021
By

March 23, 2021

MELISSA GUTIERREZ
USDA NATURAL RESOURCES
CONSERVATION SERVICE
3001 COOLIDGE ROAD SUITE 250
EAST LANSING MI 48823-6362

RE: ER20-876 Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County (USDA/NRCS)

Dear Ms. Gutierrez:

Under the authority of Section 106 of the National Historic Preservation Act of 1966, as amended, we have reviewed the proposed undertaking at the above-noted location. We have recently reviewed the report entitled NRHP Evaluation of Four Beautification Dams in the Grand River, Grand Rapids, Michigan submitted to fulfill the U.S. Department of Agriculture's Natural Resource Conservation Service's (NRCS) cultural resource management obligations under Sections 106 and 110 of the National Historic Preservation Act of 1966, as amended.

After review of the eligibility information presented in the report, we concur with the recommendations for the four beautification dams as eligible under Criterion A as series of structures that conveys the long history of the City of Grand Rapids with the Grand River and for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown Grand Rapids. The dams may be individually eligible for listing in the National Register, or as a contributing of a larger historic district associated with the total design of Harland Bartholomew, depending on the extent of the implementation of Bartholomew's design and whether any larger, potential district possesses historic integrity. The lack of a larger historic district or loss of integrity of the larger district does not diminish the individual significance, and thus eligibility, of the dams.

We do not concur that the dams are eligible under Criterion B for their association with city planner Harland Bartholomew. Though Bartholomew may be a significant historical figure, National Register Bulletin 15 states, "architects, artisans, artists, and engineers are often represented by their works, which are eligible under Criterion C." Bulletin 15 further guides that rather than the works of architects, artisans, artists, and engineers, the "homes and studios... can be eligible for consideration under Criterion B, because these usually are the properties with which they are most personally associated" (emphasis added). For these reasons, the structures are not eligible under Criterion B.

Likewise, we do not concur with the recommendation of not eligible under Criterion C. Given these are works of architecture and engineering, they should be more thoroughly examined under Criterion C. We believe these dams embody the distinctive characteristics of a type, period or method of construction and are therefore eligible under Criterion C.

While there are some differences between the SHPO's opinion of eligibility above in terms of the applicable Criterion, it appears that SHPO and NRCS agree that the dams are resources eligible for inclusion in the National Register and requesting additional changes to the report now would be inappropriate. The only additional information that SHPO requires for the NRHP Evaluation report at this time is the acreage of the area surveyed as part of this effort for reporting purposes. Please be sure to include that in all future survey efforts as well.

Therefore, based on the information provided for our review, the State Historic Preservation Officer (SHPO) concurs with the determination of USDA/NRCS that the proposed undertaking will have an **adverse effect** on the Grand Rapids, Grand River Beautification Dams, which appear to meet the criteria for listing in the National Register of Historic Places.

This undertaking meets the criteria of adverse effect because: *the undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association,* 36 CFR § 800.5(a)(1). Specifically, the undertaking will result in physical destruction of or damage to all or part of the property.

Federal agencies are required to avoid, minimize, or mitigate adverse effects. Please note that if the federal agency and the SHPO concur that the adverse effect cannot be avoided, the Section 106 process will not conclude until the consultation process is complete, an MOA is developed, executed, and implemented, and, if applicable, the formal comments of the Advisory Council have been received, 36 CFR § 800.6. For more information on your responsibilities and obligations for projects that will have an adverse effect on historic properties under 36 CFR § 800.6, please review the enclosed materials.

We remind you that federal agency officials or their delegated authorities are required to involve the public in a manner that reflects the nature and complexity of the undertaking and its effects on historic properties per 36 CFR § 800.2(d). The National Historic Preservation Act also requires that federal agencies consult with any Indian tribe and/or Tribal Historic Preservation Officer (THPO) that attach religious and cultural significance to historic properties that may be affected by the agency's undertakings per 36 CFR § 800.2(c)(2)(ii).

The opinion of the SHPO is based on the materials provided for our review. If you believe that there is material that we should consider that might affect our finding, or if you have questions, please contact Brian Grennell, Cultural Resource Management Coordinatoe, at (517) 335-2721 or by email at GrennellB@michigan.gov. **Please reference our project number in all communication with this office regarding this undertaking.**

Finally, the State Historic Preservation Office is not the office of record for this undertaking. You are therefore asked to maintain a copy of this letter with your environmental review record for this undertaking. Thank you for this opportunity to review and comment, and for your cooperation.

Sincerely,

Martha MacFarlane-Faes
Deputy State Historic Preservation Officer

MMF:KAK:TAW:BGG

Enclosures

copy: Duane Quates, USDA/NRCS
Advisory Council on Historic Preservation
Jacquie Payette
Stephen Koster

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
MICHIGAN STRATEGIC FUND
STATE HISTORIC PRESERVATION OFFICE

QUENTIN L. MESSER, JR.
PRESIDENT

January 18, 2024

DUANE QUATES
USDA NATURAL RESOURCES
CONSERVATION SERVICE
3001 COOLIDGE ROAD SUITE 250
EAST LANSING MI 48823-6362

RE: ER20-876 Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, (USDA-NRCS)

Dear Dr. Quates:

We have reviewed the information regarding the hydraulic modeling results for the Lower Grand River Watershed Habitat Restoration Project, Grand Rapids, Kent County, submitted to our office on December 14, 2023. Based on the information provided in "Table 1: Comparison of hydraulic modeling results downstream of project", it appears that there is no elevated risk of downstream erosion associated with this project. Based on this information, the State Historic Preservation Officer (SHPO) concurs with the determination of USDA-NRCS that **no *archaeological* properties are affected** within the area of potential effects of this undertaking.

The revised project information does not change our earlier concurrence (March 21, 2021) of **adverse effect** on the Grand Rapids, Grand River Beautification Dams, which appear to meet the criteria of listing in the National Register of Historic Places. We will continue to consult with the NRCS on implementation of the stipulations outlined in the Memorandum of Agreement among the NRCS, SHPO, the Michigan Strategic Fund, the City of Grand Rapids, Michigan, Grand Rapids Whitewater, Inc., and the Grand Valley Metropolitan Council that was executed on September 30, 2022.

We remind you that federal agency officials or their delegated authorities are required to involve the public in a manner that reflects the nature and complexity of the undertaking and its effects on historic properties per 36 CFR § 800.2(d). The National Historic Preservation Act also requires that federal agencies consult with any Indian tribe and/or Tribal Historic Preservation Officer (THPO) that attach religious and cultural significance to historic properties that may be affected by the agency's undertakings per 36 CFR § 800.2(c)(2)(ii).

The opinion of the SHPO is based on the materials provided for our review. If you believe that there is material that we should consider that might affect our finding, or if you have questions, please contact If you have any questions, please contact Scott Slagor, Cultural Resource Protection Manager, at 517-285-5120 or by email at slagors2@michigan.gov. For questions regarding archaeological resources, please contact Dr. Sarah Surface-Evans, Senior Archaeologist at 517-282-7959 or by email at frederickk1@michigan.gov.**Please reference our project number in all communication with this office regarding this undertaking**.

MICHIGAN SHPO STATE HISTORIC PRESERVATION OFFICE

300 NORTH WASHINGTON SQUARE • LANSING, MICHIGAN 48913
michigan.gov/**shpo** • (517) 335-9840

Finally, the State Historic Preservation Office is not the office of record for this undertaking. You are therefore asked to maintain a copy of this letter with your environmental review record for this undertaking. Thank you for this opportunity to review and comment, and for your cooperation.

Sincerely,



Ryan M. Schumaker
State Historic Preservation Officer

RMS:SSE:SES

APPENDIX B

Project Maps

- Figure 1A – Project Site Map
- Figure 1B – Project Map
- Figure 2 – Project Watershed Boundary
- Figure 3 – Land Use in Project Watershed Boundary

Figure 1A - Project Map

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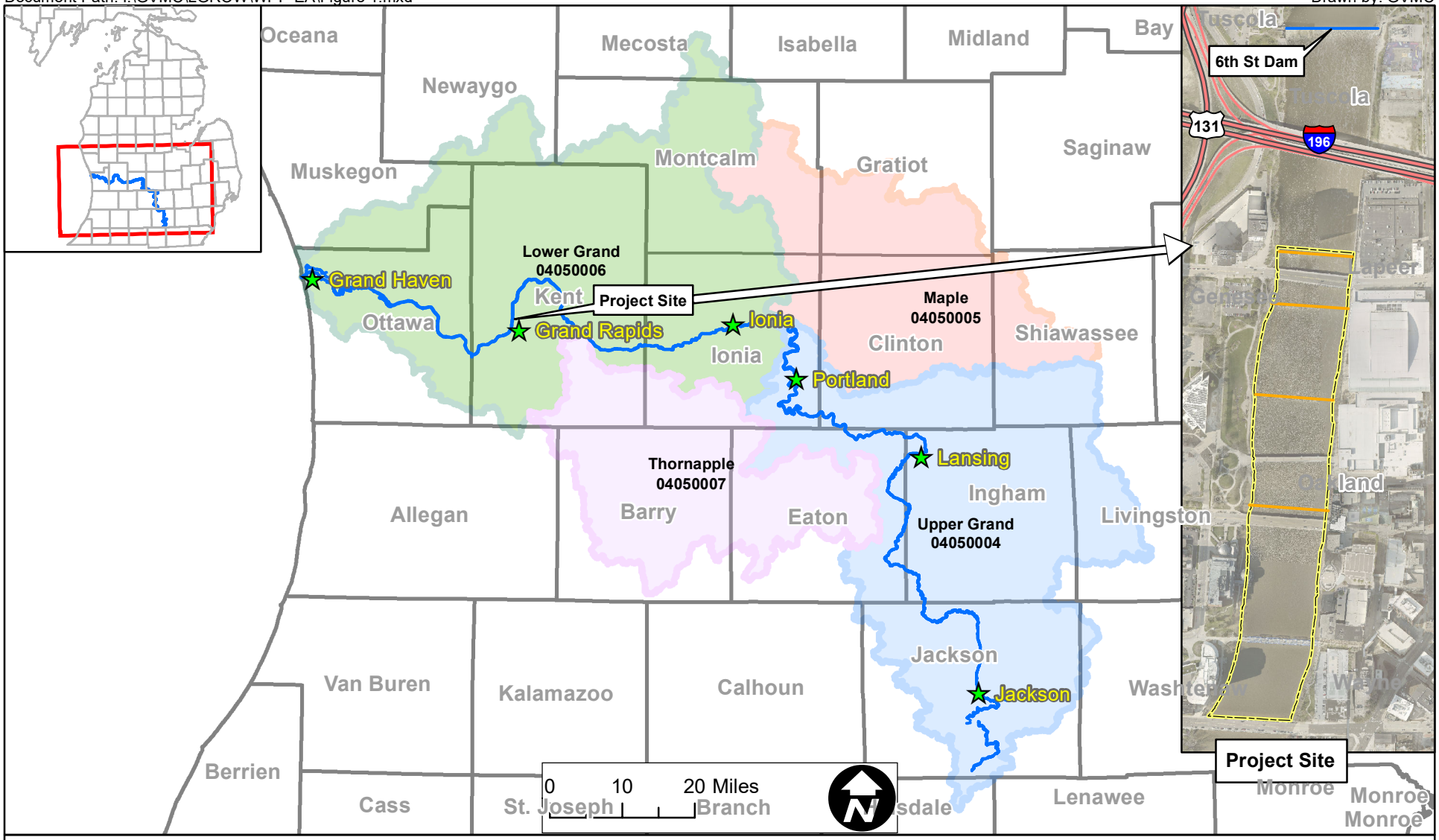
Drawn by: GVMC



Legend

Watershed

- Upper Grand - 04050004
- Maple - 04050005
- Lower Grand - 04050006
- Thornapple - 04050007

- Cities
- Grand River
- Low-head Dam
- Project Site

Lower Grand River Habitat Restoration

GVMC

Grand Rapids WhiteWater

CITY OF GRAND RAPIDS

Figure 1B - Project Map

Document Path: I:\GVMC\LGROW\WPP-EA\Figure 1B.mxd



Emergent Habitat Boulder

Boulder Structure

Constructed Riffle
(Imported Coarse Alluvium)

Stabilizing Structure
(Imported Riprap D50 12")

Project Site

Contours

Lower Grand River Habitat Restoration

GVMC

Grand Rapids WhiteWater

CITY OF GRAND RAPIDS

Figure 2 - Project Watershed Boundary

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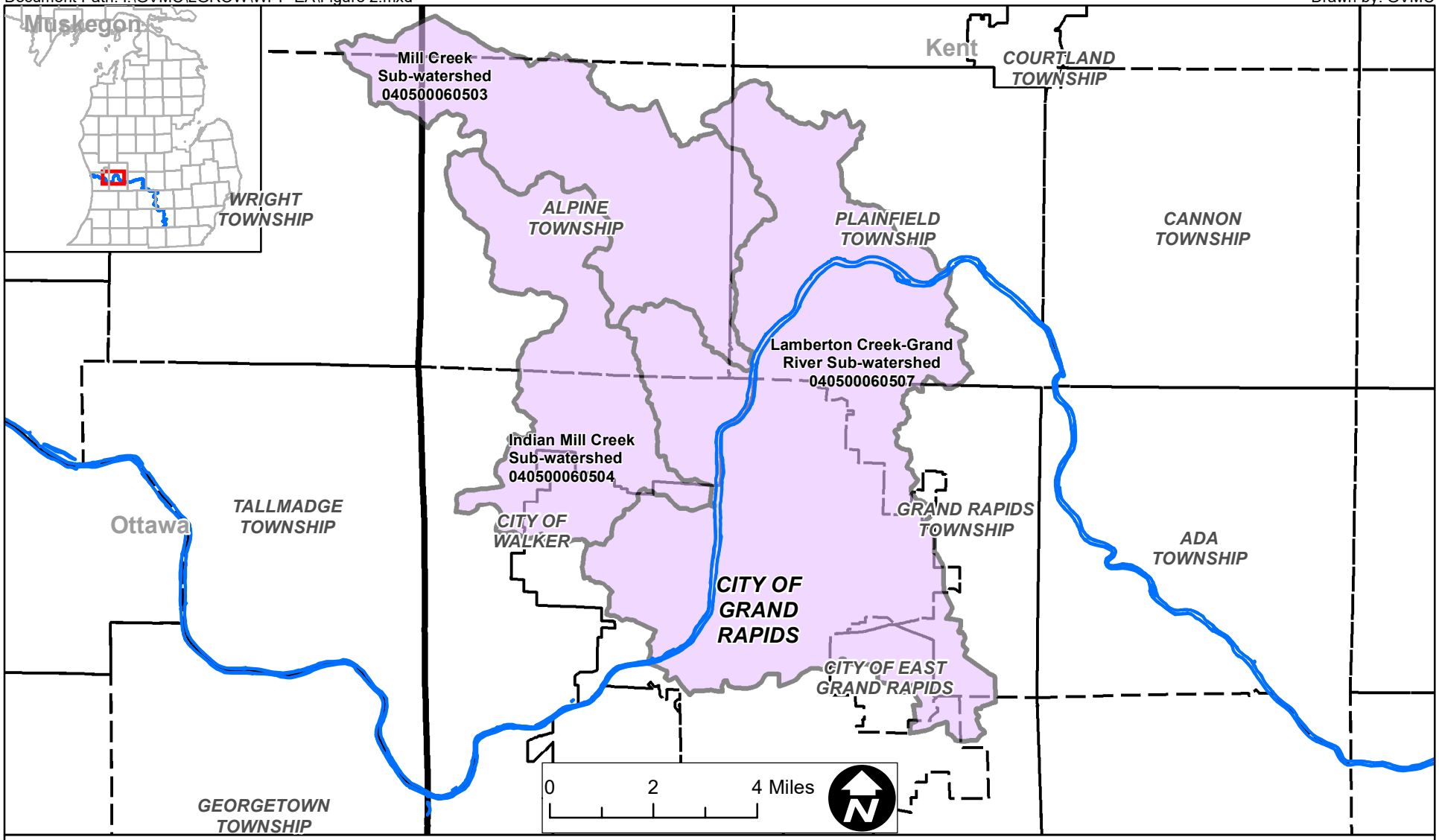
Drawn by: GVMC



Legend

- Watersheds
- Grand River
- Cities & Townships
- County

Lower Grand River Habitat Restoration

GVMC

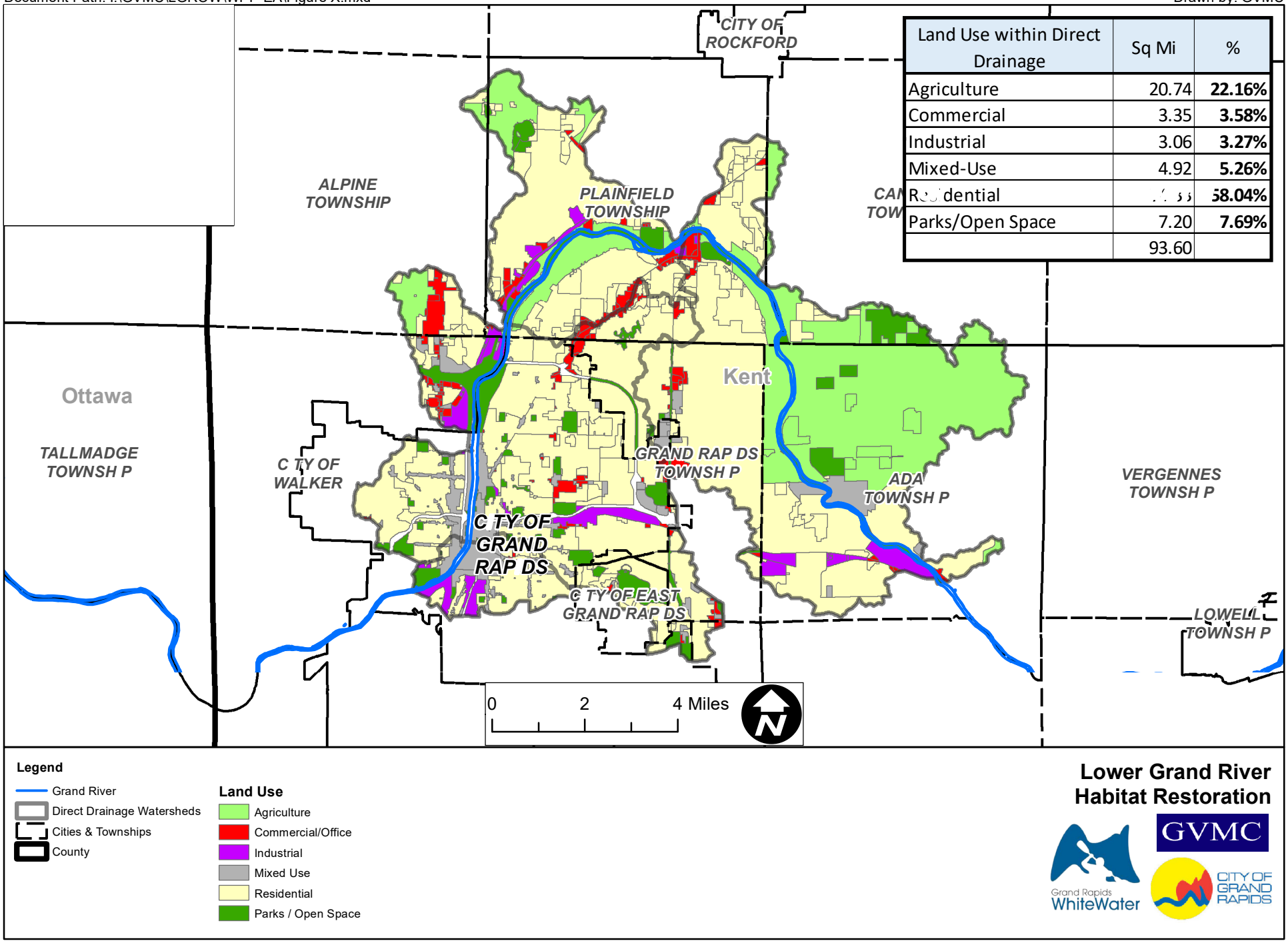
Grand Rapids WhiteWater

CITY OF GRAND RAPIDS

Figure 3 - Land Use in Project Watershed Boundary

Document Path: I:\GVMC\LGROW\WPP-EA\Figure X.mxd

Drawn by: GVMC



Land Use within Direct Drainage	Sq Mi	%
Agriculture	20.74	**22.16%**
Commercial	3.35	**3.58%**
Industrial	3.06	**3.27%**
Mixed-Use	4.92	**5.26%**
Residential	[illegible]	**58.04%**
Parks/Open Space	7.20	**7.69%**
	93.60	

Legend

- Grand River
- Direct Drainage Watersheds
- Cities & Townships
- County

Land Use

- Agriculture
- Commercial/Office
- Industrial
- Mixed Use
- Residential
- Parks / Open Space

Lower Grand River Habitat Restoration

GVMC

Grand Rapids WhiteWater

CITY OF GRAND RAPIDS

APPENDIX C

Supporting Maps, Figures, Photos and Tables

- Figure 4 – Project Area, Mussel Recipient Sites
- Figure 5 – Sediment Sampling Locations
- Figure 6 – City of Grand Rapids Water Quality Sampling Sites
- Figure 7 – Existing Wetlands in Project Area
- Figure 8 – Flood Protection System
- Figure 9 – Cultural Historic Resources - REDACTED
- Figure 10 – Cultural Historic District - REDACTED
- Construction Plans: Draft Permit Planset
- Construction Plans: Ah-Nab-Awen Park
- Construction Plans: GRR Impact Sheets
- Visual Character Photos of Analysis Area
- Groups Contacted for Consultation

List of Tables

- Table 3-1: Summary of Informal Scoping Issues Identified
- Table 3-2: Past, Present, and Reasonably Foreseeable Future Activities
- Table 4-1: Background Air Quality Concentrations for the Grand Rapids-Monroe Street Monitoring Station (No. 260810020)
- Table 4-2: Typical Noise Levels and Possible Human Effects
- Table 4-3: Listed Unionid Mussels Species Potentially Occurring in the Analysis Area
- Table 4-4: Population Trends in Michigan, Kent County and Grand Rapids
- Table 4-5: Demographic Composition in Michigan, Kenty County and Grand Rapids
- Table 4-6: 2022 Economic Characteristics
- Table 4-7: 2022 Industry Employment Characteristics
- Table 4-8: Architectural Resources Listed on or Recommended as Eligible for Listing on the NRHP, and Locally Designated Landmarks within 2000 feet Buffer
- Table 4-9: Previously and Newly Recorded Historic Resources in the Indirect APE
- Table 5-1: Comparison of Alternatives
- Table 6-1: Impact Analysis
- Table 6-2: Construction Equipment Noise Emission Levels
- Table 6-3: Hydraulic Characteristics of the River between the 6th Street Dam and Fulton Street
- Table 6-4: Potential Impacts and Benefits to Aquatics Species and Habitat
- Table 6-5: EGLE Flood Flow Rates
- Table 6-6: Potential Unavoidable Adverse Impacts of the Proposed Action
- Table 6-7: Irreversible and Irretrievable Commitment of Resources by Resource Area
- Table 6-8: Cumulative Effects

APPENDIX C

Supporting Maps, Figures, Photos and Tables

- Table 8-1: Project Measures to be Implemented
- Table 8-2: Anticipated Permitting and Construction Schedule
- Table 8-3: Estimated Installation Cost, Lower Grand River Watershed, Michigan ($22M)
- Table 8-4: Financing of Installation Costs
- Table 8-5: OMRRR schedule for Elements of the Grand River Habitat Restoration Project
- Table 8-6: Estimated Average Annual NED Costs Lower Grand River Watershed, MI ($22M)

APPENDIX C

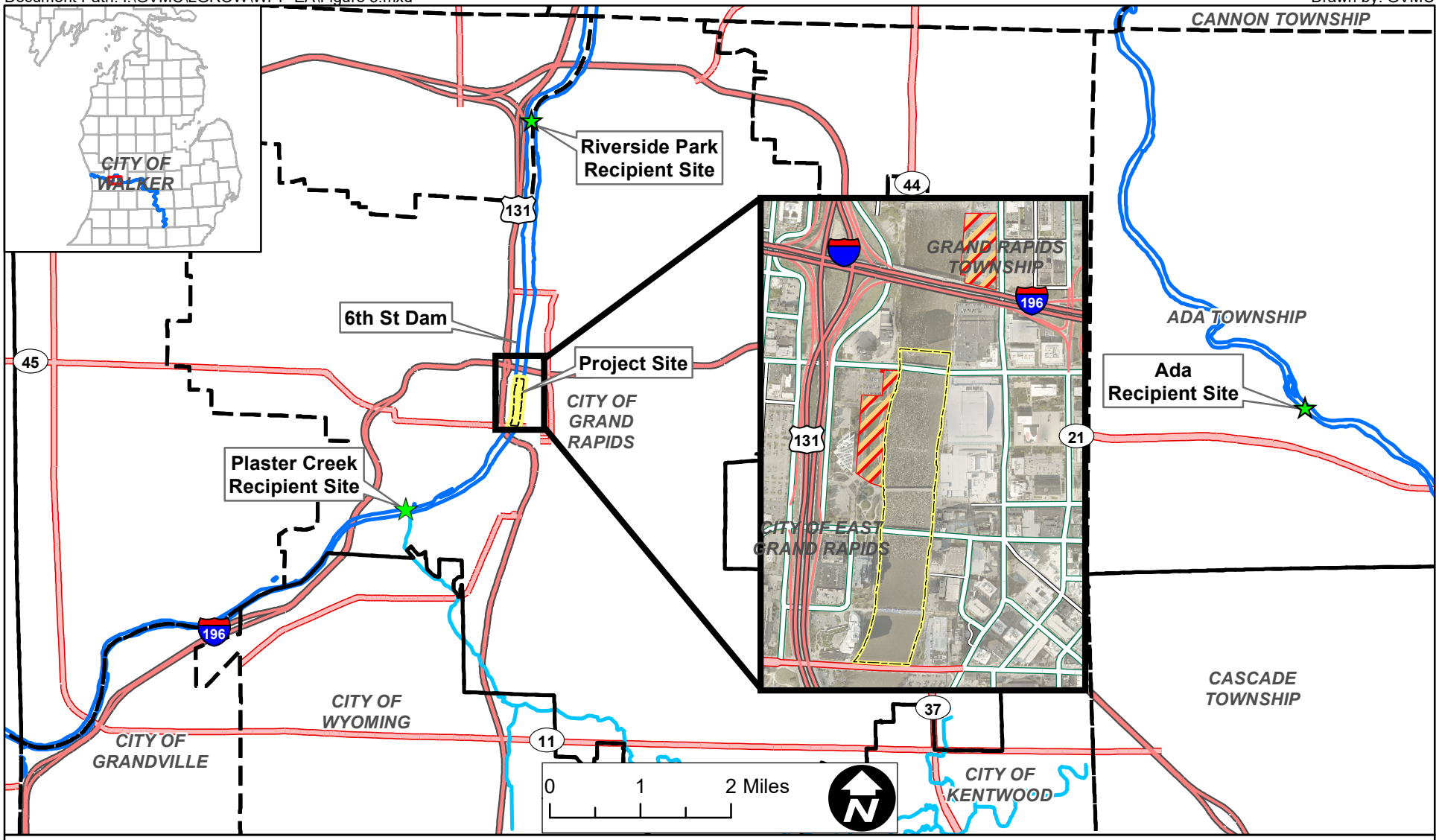
Supporting Maps, Figures, Photos and Tables

Figures

Figure 4 - Project Area, Mussel Recipient Sites

Document Path: I:\GVMC\LGROW\WPP-EA\Figure 3.mxd

Drawn by: GVMC



Legend

- Recipient Sites
- Project Site
- Staging Areas
- Grand River
- Plaster Creek
- Cities & Townships

Lower Grand River Habitat Restoration

GVMC

Grand Rapids WhiteWater

CITY OF GRAND RAPIDS

Figure 5 - Sediment Sampling Locations



N

LEGEND

SAMPLING LOCATION (TYPICAL)

LOW HEAD DAM

NOTE: ALL SAMPLES TO UNDERGO GRADATION AND ANALYTICAL TESTING WITH EXCEPTION TO B-11 WHERE GRADATION TESTING ONLY WILL BE PERFORMED

TITLE: OVERALL SAMPLING LOCATION PLAN			PROJECT: GRAND RIVER REVITALIZATION - SEDIMENT SAMPLING
SCALE: 1"=300'	DATE: 1/14/2020	PROJECT NO.: 141579.5	**Materials Testing Consultants, INC.**
FIG. NO.: 1	DR. BY: JRS	REV. BY: TM	

EGLE-NRD
WRP020481 v1.1
Approved
Issued On:01/23/2020
Expires On:01/23/2025

Figure 6 - City of Grand Rapids Water Quality Sampling Sites

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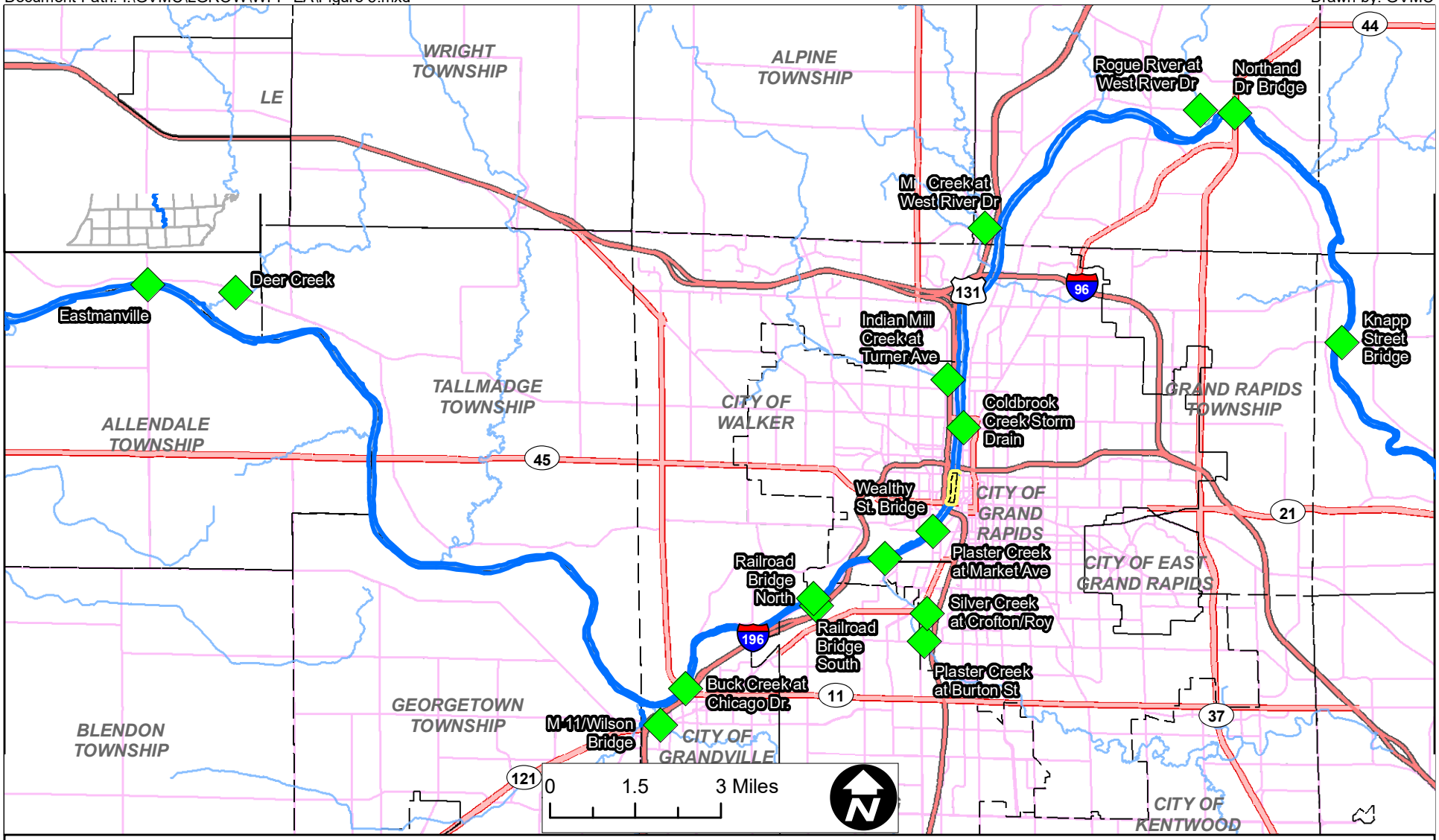
Drawn by: GVMC



Legend

- Sampling Site
- Project Site
- Cities & Townships
- Grand River
- Linear Water Feature

Lower Grand River Habitat Restoration

GVMC

Grand Rapids WhiteWater

CITY OF GRAND RAPIDS

Figure 7 - Existing Wetlands in Project Area

PLOT INFO: Z:\2018\180419\CAD\GIS\ProProj\WetlandDelineation\Wetland Delineation.aprx Layout: FIG01_Site Plan Date: 10/12/2023 10:25 AM User: ahavens

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LEGEND

- Wetland Sampling Point
- Delineated Wetland Boundary (10/10/2023)
- Verified Wetland Boundary (10/10/2023)
- Approximate Waterward Wetland Boundary
- Area of Investigation

Former Wetland 6

See Inset

SP-07

Wetland 7

1:1,200

SP-07

See Inset

Wetland 8

SP-08

See Inset

SP-09

Wetland 9

1:1,200

SP-09

See Inset

SP-10

Wetland 10

Gillett Bridge

Former Wetland 11

1:1,200

SP-08

1:1,200

SP-10

See Inset

Wetland 12

Blue Bridge

SP-12

1:1,800

SP-12

NORTH

SITE PLAN

0 150 300 FEET

DATA SOURCES: 7/30/2017 AERIAL.

FIGURE NO. 1

PROJECT NO. 180419

Grand River Restoration

Grand Rapids, Michigan

Wetland Boundary Verification

Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

fishbeck

Engineers | Architects | Scientists | Constructors

Figure 8. Flood Protection System

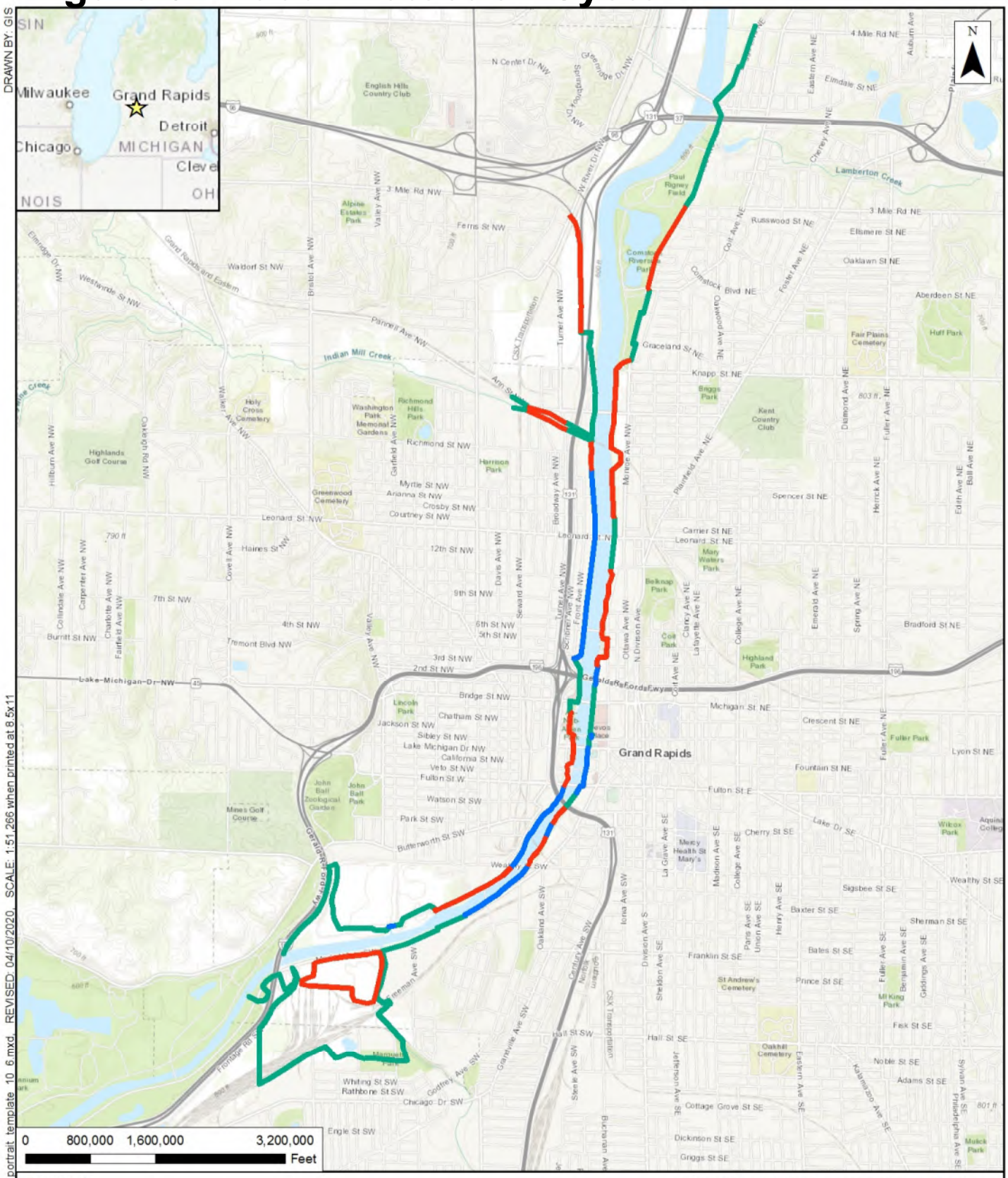
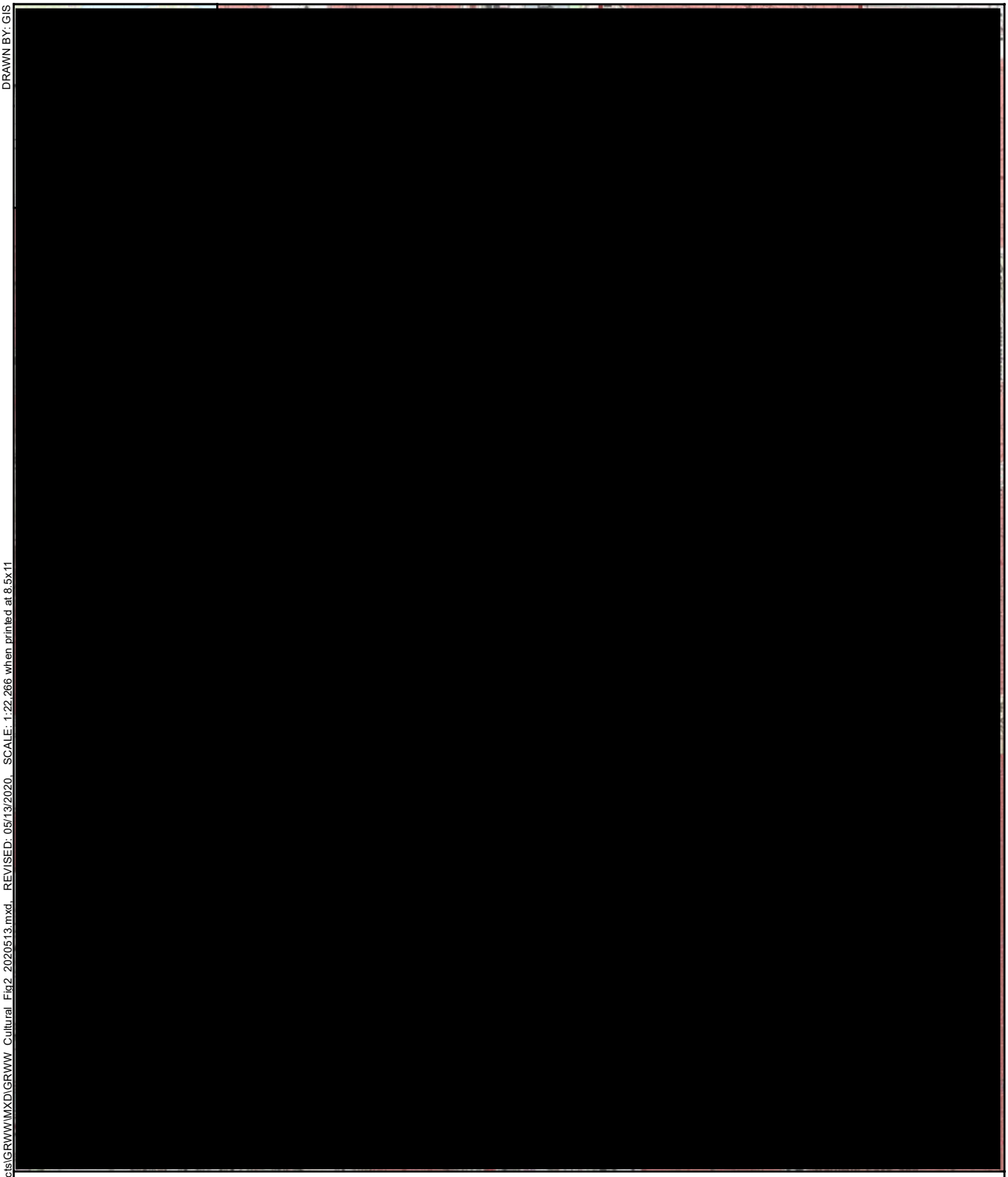


Figure 9 - Cultural Historic Resources (Redacted)



Legend

- Historic Structure
- Historic District
- 1 mi. Buffer
- 2,000 ft. Buffer

Direct APE Areas

- Construction Area
- Staging Area
- Emergency Access

Lower Grand River Habitat Restoration

Grand Rapids WhiteWater

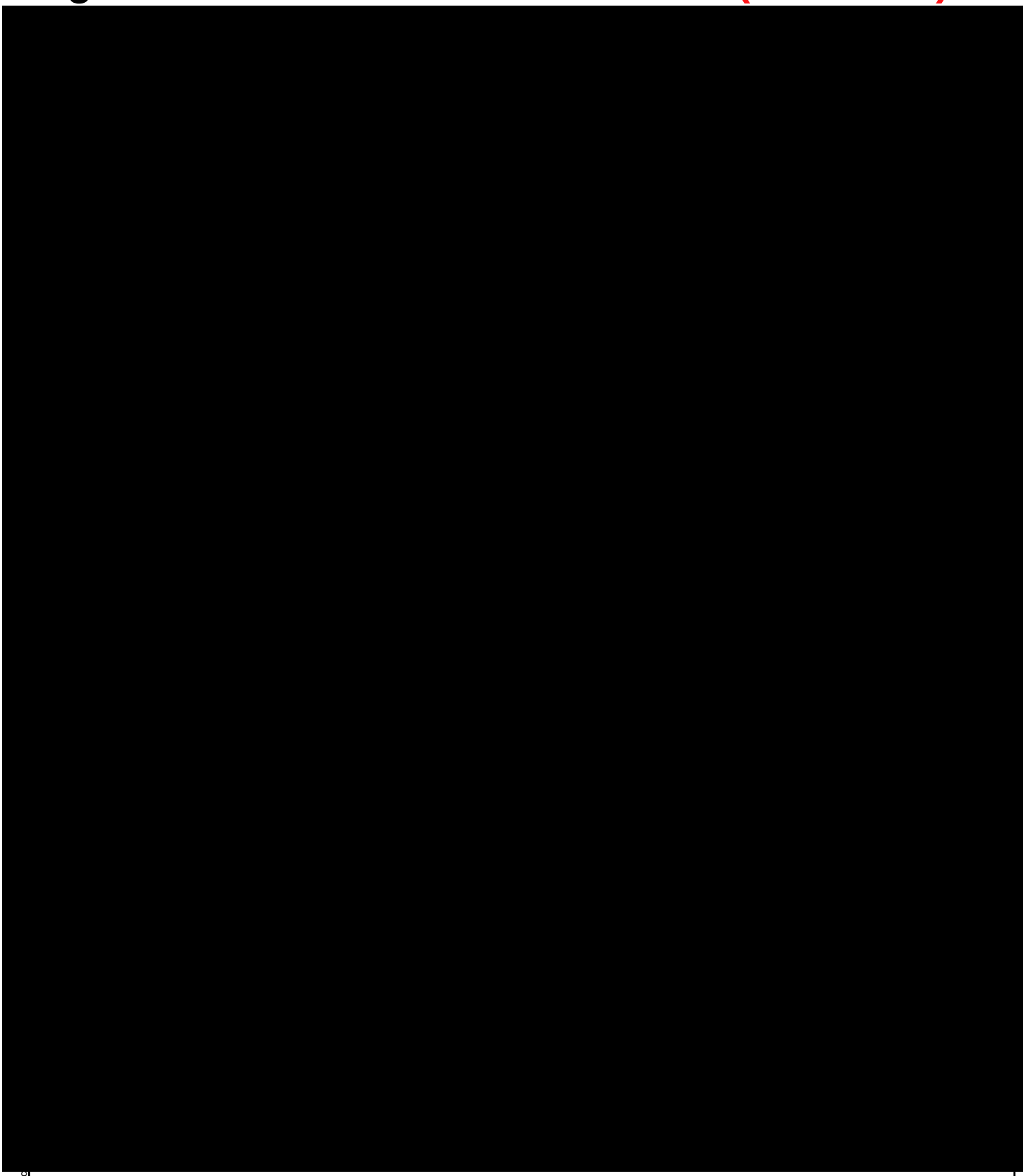
GVMC

NAD 1983 StatePlane Michigan South FIPS 2113 Feet

DRAWN BY: GIS

Q:\Rolling Meadows\Team\GIS\Projects\GRWW\MXD\GRWW_Cultural_Fig2_20205513.mxd, REVISED: 05/13/2020, SCALE: 1:22,266 when printed at 8.5x11

Figure 10 - Cultural Historic District (Redacted)



Legend

- Historic Structure
- Historic Resources
- 2,000 ft. Buffer

Direct APE Areas

- Construction Area
- Staging Area
- Emergency Access
- Historic District

Lower Grand River Habitat Restoration

Grand Rapids WhiteWater

GVMC

Q:\Rolling Meadows\Team\GIS\Projec

NAD 1983 StatePlane Michigan South FIPS 2113 Feet

APPENDIX C

Supporting Maps, Figures, Photos and Tables

Construction Plans

CONSTRUCTION PLANS: DRAFT PERMIT PLANSET

UTILITIES - CONTACT INFORMATION

PUBLIC

CITY OF GRAND RAPIDS TRAFFIC SIGNALS
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3847

CITY OF GRAND RAPIDS STREET LIGHTING
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49503
(616) 456-3281

CITY OF GRAND RAPIDS WATER SYSTEM
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49503
(616) 456-3141

CITY OF GRAND RAPIDS
SANITARY AND STORM SEWER MAINTENANCE
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49503
(616) 456-3141

KENT COUNTY ROAD COMMISSION
1500 SCRIBNER AVE. NW
GRAND RAPIDS, MI 49504
(616) 242-6910

KENT COUNTY DEPT. OF PUBLIC WORKS
(616) 336-2500

M.D.O.T.
1420 FRONT AVE. NW
GRAND RAPIDS, MI 49504
(616) 451-3091

GRAND RAPIDS TOWNSHIP
1836 EAST BELTLINE AVE. NE
GRAND RAPIDS, MI 49505
(616) 361-7391

PRIVATE

CONSUMERS ENERGY COMPANY (ELECTRIC)
4000 CLAY AVE. SW
GRAND RAPIDS, MI 49501-0201
(616) 530-4244 (AERIAL DIST)
(616) 530-4381 (METRO UG)

AT&T (TEL/FIBER OPTIC)
ROOM 5 (PROJECTS N. OF FRANKLIN ST.)
2ND FLOOR (PROJECTS S. OF FRANKLIN ST.)
955 36TH ST. SE
GRAND RAPIDS, MI 49508
(616) 246-7203 (N. OF FRANKLIN ST.)
(616) 246-7210 (S. OF FRANKLIN ST.)

DTE ENERGY/MICHCON (NATURAL GAS)
444 WEALTHY ST. SW
GRAND RAPIDS, MI 49501
(800) 947-5000

COMCAST (CABLE TV)
955 CENTURY AVE. SW
GRAND RAPIDS, MI 49503
(616) 245-5039

VERIZON BUSINESS (TEL/FIBER OPTIC)
2855 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 265-8553

CENTURY TEL (TEL/FIBER OPTIC)
320 N. WASHINGTON SQUARE
LANSING, MI 48933
(989) 239-8110

MCI WORLDCOM (TEL/FIBER OPTIC)
(616) 224-4343

CHOICEONE (TEL/FIBER OPTIC)
(616) 988-7100

SBC AMERITECH (TEL/FIBER OPTIC)
(616) 246-7240

VACINITY ENERGY
156 FULTON ST. W
GRAND RAPIDS, MI 49501
(616) 356-2535

LEVEL 3 COMMUNICATIONS (FIBER OPTIC)
1025 ELDORADO BLVD.
BROOMFIELD, CO 80021
(720) 888-0336

TDS METROCOM (TEL/FIBER OPTIC)
1575 GEZON PARKWAY SUITE B
WYOMING, MI 49509
(616) 301-3033

CALL 811 FOR MISS DIG

FOR PROTECTION OF UNDERGROUND UTILITIES AND IN CONFORMANCE WITH PUBLIC ACT 53, 1974, THE CONTRACTOR SHALL CALL 811 A MINIMUM OF THREE (3) FULL WORKING DAYS (EXCLUDING SATURDAYS, SUNDAYS AND HOLIDAYS) PRIOR TO EXCAVATING IN THE VICINITY OF UTILITY LINES. ALL "MISS DIG" PARTICIPATING MEMBERS WILL THUS BE ROUTINELY NOTIFIED. THIS DOES NOT RELIEVE THE CONTRACTOR OF THE RESPONSIBILITY OF NOTIFYING UTILITY OWNERS WHO MAY NOT BE A PART OF THE "MISS DIG" ALERT SYSTEM.

GENERAL NOTES

1. MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE 1993 EDITION OF THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, EXCEPT AS OTHERWISE INDICATED ON THESE PLANS OR IN THE SUPPLEMENTAL SPECIAL SPECIFICATIONS.
2. IF A WATER SERVICE (COPPER, LEAD OR OTHERWISE) IS DISTURBED, DAMAGED, RELOCATED OR REPLACED FROM THE WATER MAIN TO THE CURB STOP, WHETHER PLANNED OR UNINTENTIONAL, THE CONTRACTOR IS TO HAVE THE SERVICE MATERIAL VERIFIED FROM THE MAIN TO THE METER. IF ANY PORTION IS FOUND TO BE LEAD, THEN THE CONTRACTOR MUST HAVE THE LEAD REPLACED WITH A COPPER WATER SERVICE. ALL WATER SERVICE REPLACEMENTS MUST BE COMPLETED BY A REGISTERED UNDERGROUND CONTRACTOR. IF THE REPLACEMENT INVOLVES WORK ON PRIVATE PROPERTY, THE CONTRACTOR IS TO CONTACT THE ENGINEER IMMEDIATELY TO OBTAIN PERMISSIONS FOR THE SERVICE TO BE REPLACED BY CITY OF GRAND RAPIDS UNDERGROUND CONTRACTORS ON TERM CONTRACT FOR LEAD SERVICE REPLACEMENT. THE CONTRACTOR WILL REIMBURSE THE CITY FOR THIS COST.

CITY OF GRAND RAPIDS

GRAND RAPIDS, MICHIGAN

PUBLIC SERVICES

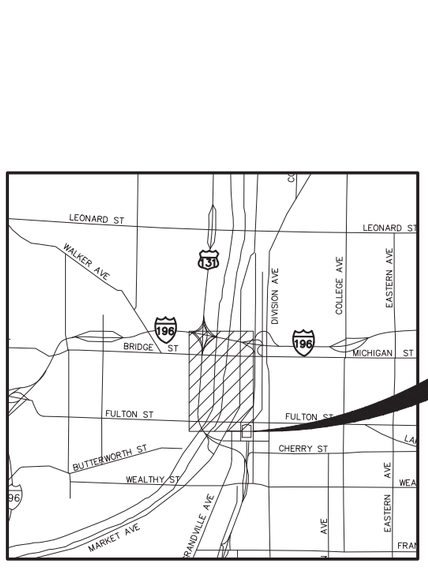
IMPROVEMENTS IN THE

GRAND RIVER

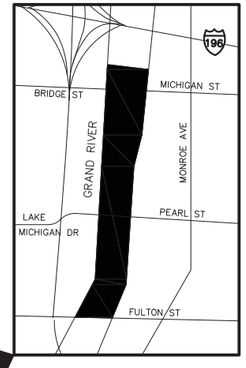
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

DRAFT PERMIT PLANSET



PROJECT LOCATION



JOB SITE

ALL ELEVATIONS ARE IN NAVD 88 DATUM

BID SET

BID SET NO.	DATE	BID SET NO.	DATE

REVISIONS

REV NO.	DATE	SHEET NUMBER(S)	APPROVED BY

AS-BUILT RECORD

CONTRACTOR	
FIELD ENGINEER	
INSPECTED BY	
AS-BUILT BY	
AS-BUILT DATE	
BORINGS BY	
WATER PIPE MANUFACTURER	
SANITARY PIPE MANUFACTURER	
STORM PIPE MANUFACTURER	

PERMITS

M.D.E.Q. WATER SYSTEM PERMIT NO.:	OTHER:	NO.:
M.D.E.Q. WASTEWATER SYSTEM PERMIT NO.:	OTHER:	NO.:
M.D.O.T. RIGHT-OF-WAY PERMIT NO.:	OTHER:	NO.:

CITY COMMISSION PROC. NO. _____ DATE _____

MDOT AGREEMENT ☐ CONTRACT AWARDED ☐

FINANCIAL AGREEMENT ☐ SHPO AGREEMENT ☐

GRANT AGREEMENT ☐ COST SHARING AGREEMENT ☐

PUBLIC UTILITIES EASEMENT (SEE EASEMENT DESCRIPTION SHEET)

ADDITIONAL CITY COMMISSION PROCEEDINGS

PROCEEDING NO. DATE PURPOSE

INDEX OF SHEETS

SEE SHEET 2 FOR PLAN SHEET INDEX

DRAFT DRAWINGS NOT FOR CONSTRUCITON

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

CONSULTANT #2	CONSULTANT #1
PROFESSIONAL PERSON IN RESPONSIBLE CHARGE OF	PROFESSIONAL PERSON IN RESPONSIBLE CHARGE OF
SHEETS: 1-00	SHEETS: 1-00
NAME OF LICENSEE: NAME	NAME OF LICENSEE: NAME
NUMBER: NUMBER	NUMBER: NUMBER
SIGNATURE	SIGNATURE

City of Grand Rapids
PUBLIC SERVICES
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

COVER SHEET

Drawn by _____ Notes in _____

Check: Field _____ Office _____

Approved _____ _____
Tim Burkman, PE. City Engineer — Date

APPROVAL OF SHEET(S) 1 - 35 ONLY

Project No.	GPF No.	Sheet No.
17014	5315	1 of 34 G00

Construction Document - Sheet Index

Sheet Number	Sheet Label	Sheet Title	Sheet Number	Sheet Label	Sheet Title
General			**In-River Design**		
1	G00	COVER SHEET	16	R01	DAMS 3 AND 4 REACH
2	G01	SHEET LIST	17	R02	DAMS 3 AND 4 REMOVAL DETAIL
3	G02	PROPERTY TAX ID MAP (1 OF 3)	18	R03	DAM 2 REACH
4	G03	PROPERTY TAX ID MAP (2 OF 3)	19	R04	DAM 2 REACH CROSS SECTION
5	G04	PROPERTY TAX ID MAP (3 OF 3)	20	R05	DAM 2 REACH PROFILES
			21	R06	DAM 2 REACH EAST TIE-IN DETAIL SECTION
Temporary Construction Access and Care of Water			22	R07	DAM 2 REACH WEST TIE-IN DETAIL SECTIONS
6	T01	MICHIGAN UNIFIED KEYING SYSTEM SOIL EROSION & SEDIMENT CONTROL MEASURES	23	R08	DAM 2 REACH BOULDER STRUCTURE TYPICAL CREST SECTION
7	T02	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - AH-NAB-AWEN PARK STAGING	24	R09	DAM 1 REACH
8	T03	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - 555 MONROE LOT STAGING	25	R10	DAM 1 REACH CROSS SECTION
9	T04	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION PLAN LAYOUT	26	R11	DAM 1 REACH EAST TIE-IN SECTIONS
10	T05	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION PLAN LAYOUT	27	R12	DAM 1 REACH WEST TIE-IN SECTIONS
11	T06	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - PROFILE DETAILS	28	R13	PEARL ST. TO BLUE BRIDGE REACH
12	T07	TEMP. CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION ENTRANCE AND TRACKING PAD DETAIL	29	R14	PEARL ST. TO BLUE BRIDGE CROSS SECTIONS
13	T08	TEMP. CONSTRUCTION ACCESS & CARE OF WATER - STORMWATER INLET PROTECTION DETAIL	30	R15	BLUE BRIDGE TO FULTON ST. REACH
14	T09	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - DETAILS	31	R16	BLUE BRIDGE TO FULTON ST. CROSS SECTIONS
15	T10	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - DETAILS			
			Design Details		
			32	D01	HABITAT BOULDER
			33	D02	RIFFLE STRUCTURE AND EMERGENT BOULDERS
			34	D03	EROSION CONTROL BLANKET INSTALLATION DETAIL

SHEET LIST

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 2 of 34
G01

623 Monroe Ave NW
CONSUMERS ENERGY
COMPANY

555 Monroe Ave NW
CITY OF GRAND
RAPIDS

647 Monroe Ave NW
41-13-24-431-019
City of Grand Rapids

225 Michigan St NW
United States
Postal Service

GRAND RIVER

M.L.34 P. 101

M.L.34 P. 119

M.L.34 P. 125

M.L.34 P. 114

M.L.34 P. 116

M.L.34 P. 142

2160+00

2158+00

2156+00

2154+00

2152+00

2150+00

2148+00

2146+00

GRAND RIVER
CENTER LINE

LIMITS OF
EARTH CHANGE (TYP.)

100 YEAR FLOODPLAIN
LIMITS

W I-196

E I-196

PROJECT LIMIT

BRIDGE ST

624 FRONT AVE NW
CITY OF GRAND RAPIDS

624 FRONT AVE NW
CITY OF GRAND RAPIDS

271 BRIDGE ST NW
CITY OF GRAND RAPIDS

I. NO. 20200

333 Bridge St NW
SH-2 LLC & BT-2
LLC

303 Pe
NAF
STATES OF

335 Bridge
St NW

SCRIBNER AVE NW

NORTH

0 60' 120'

SCALE: 1" = 60'

CITY OWNED PROPERTY LIMITS

OTHER PROPERTY LIMITS

RIVER EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

DAM EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

PROPERTY TAX ID MAP
(1 OF 3)

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
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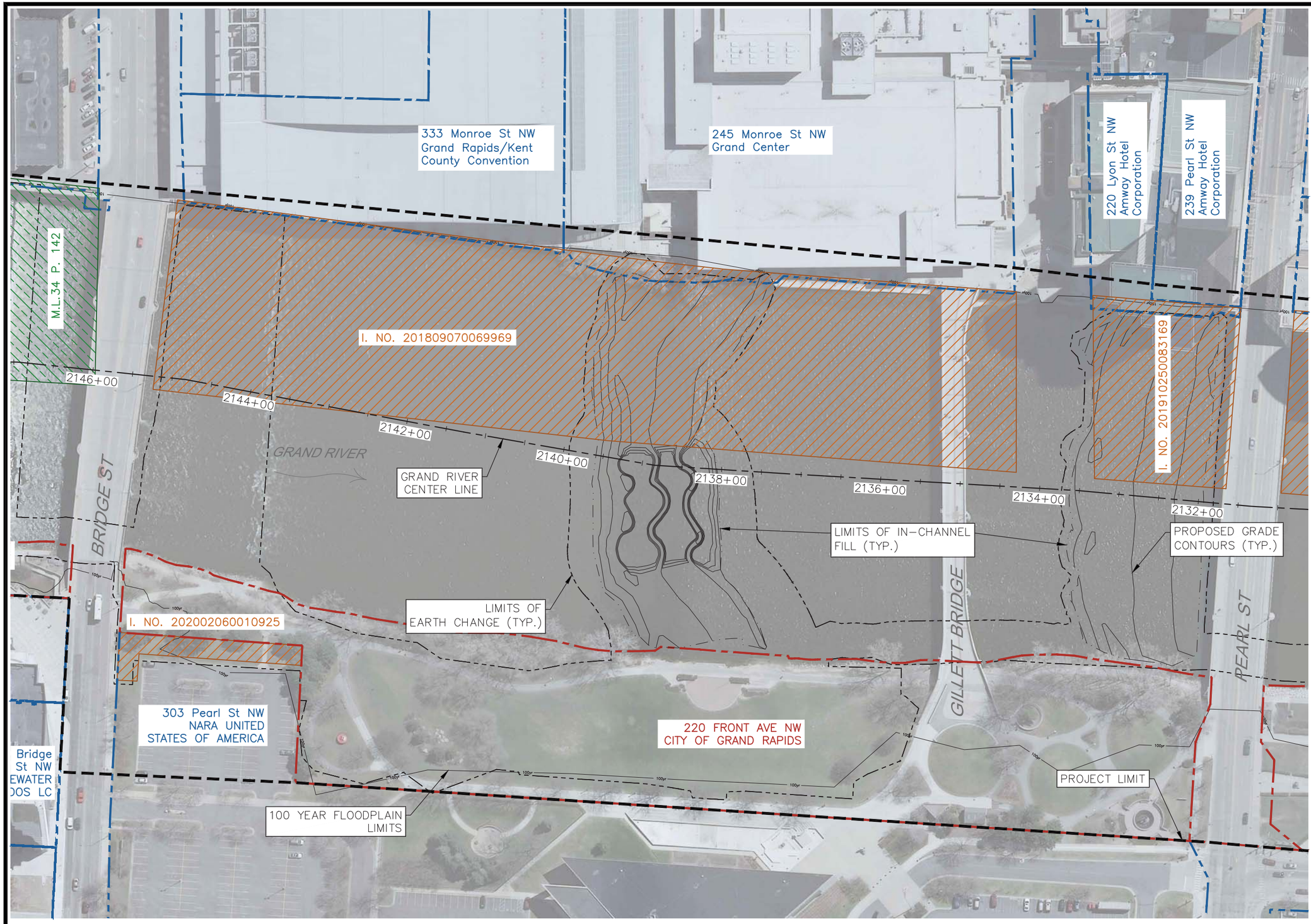
Check: Office _____

GPF No. 5315

Sheet No. 3 of 34 G02



CITY OWNED PROPERTY LIMITS

OTHER PROPERTY LIMITS

RIVER EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

DAM EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

PROPERTY TAX ID MAP
(2 OF 3)

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

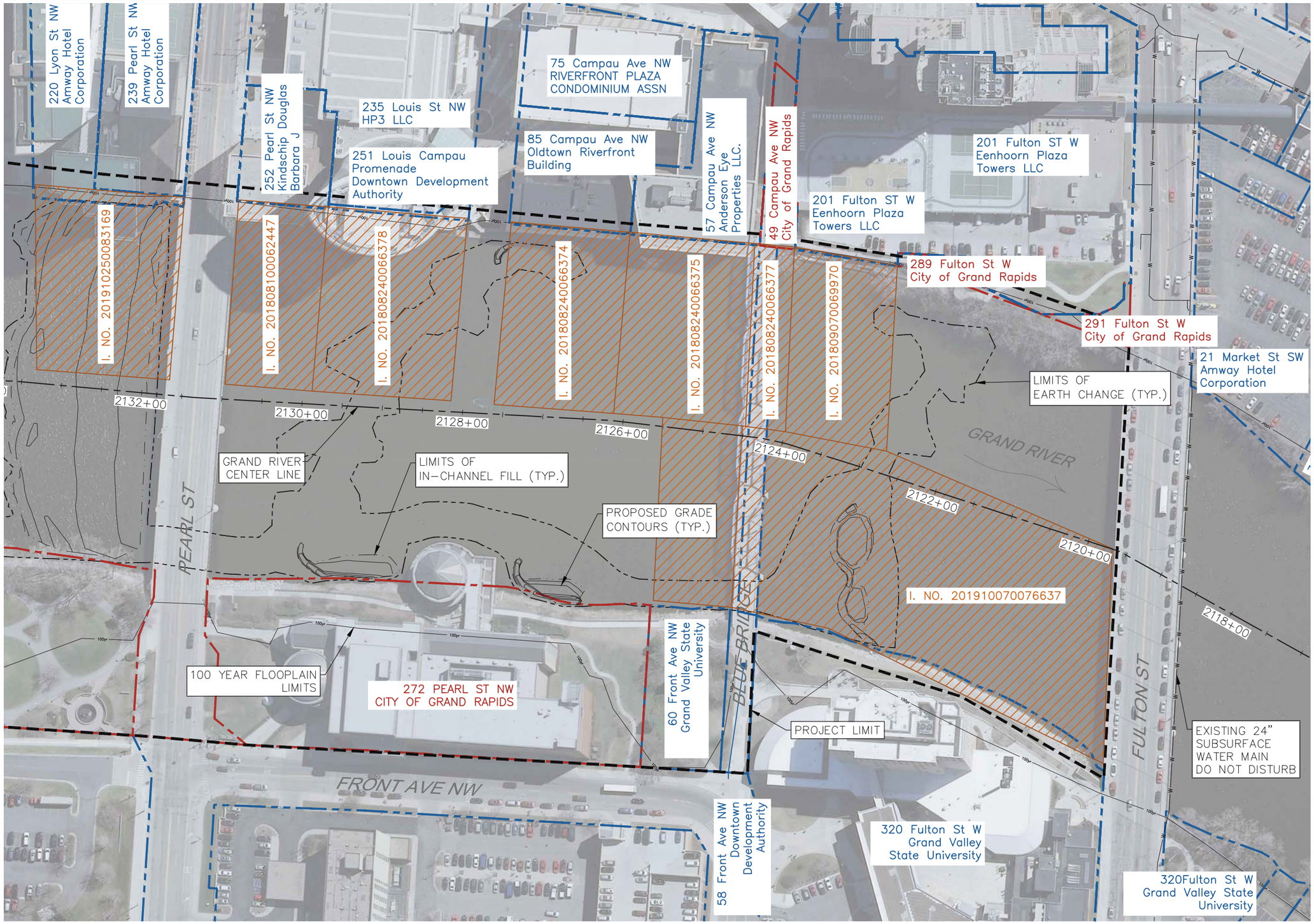
IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by	GPF No.	Sheet No.
Check: Field	5315	4 of 34
Check: Office		G03



NORTH

0 60' 120'

SCALE: 1" = 60'

CITY OWNED PROPERTY LIMITS

OTHER PROPERTY LIMITS

RIVER EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

DAM EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

PROPERTY TAX ID MAP
(3 OF 3)

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 5 of 34 G04

MICHIGAN UNIFIED KEYING SYSTEM SOIL EROSION & SEDIMENTATION CONTROL MEASURES

✳ INDICATES APPLICABILITY OF A SPECIFIC CONTROL MEASURE TO ONE OR MORE OF THE SEVEN PROBLEM AREAS

KEY	DETAIL	CHARACTERISTICS	SLOPES A	STREAMS AND WATERWAYS B	SURFACE DRAINAGEWAYS C	ENCLOSED DRAINAGE (Inlet & Outlet Control) D	LARGE FLAT SURFACE AREAS E	BORROW AND STOCKPILE AREAS F	ADJACENT PROPERTIES G
1	Dust Control – No Detail –	DUST CONTROL APPLICATIONS CAN INCLUDE WATERING, CHEMICAL DUST SUPPRESSION, GRAVEL OR ASPHALT SURFACING, TEMPORARY AGGREGATE COVER AND HAUL TRUCK COVERS	✳				✳	✳	
2	Selective Grading & Shaping	WATER CAN BE DIVERTED TO MINIMIZE EROSION FLATTER SLOPES EASE EROSION PROBLEMS	✳				✳	✳	✳
3	Grubbing Omitted	SAVES COST OF GRUBBING, PROVIDES NEW SPROUTS RETAINS EXISTING ROOT MAT SYSTEM, REDUCES WIND FALL AT NEW FOREST EDGE. DISCOURAGES EQUIPMENT ENTRANCE	✳				✳		✳
4	Vegetative Stabilization	MAY UTILIZE A VARIETY OF PLANT MATERIAL STABILIZES SOIL SLOWS RUNOFF VELOCITY FILTERS SEDIMENT FROM RUNOFF	✳	✳	✳		✳	✳	✳
5	AVAILABLE DETAIL								
6	Sodding with Wire Staked and/or Netting	FACILITATES ESTABLISHMENT OF VEGETATIVE COVER EFFECTIVE FOR DRAINAGEWAYS WITH LOW VELOCITY EASILY PLACED IN SMALL QUANTITIES BY INEXPERIENCED PERSONNEL SHOULD INCLUDE PREPARED TOPSOIL BED	✳		✳			✳	✳
7	AVAILABLE DETAIL								
8	Sodding	PROVIDES IMMEDIATE PROTECTION CAN BE USED ON STEEP SLOPES WHERE SEED MAY BE DIFFICULT TO ESTABLISH. EASY TO PLACE, MAY BE REPAIRED IF DAMAGED SHOULD INCLUDE PREPARED TOPSOIL BED	✳		✳		✳	✳	✳
9	Vegetative Buffer Strip	SLOWS RUNOFF VELOCITY FILTERS SEDIMENT FROM RUNOFF REDUCES VOLUME OF RUNOFF ON SLOPES	✳	✳					✳
10	Mulching	USED ALONE TO PROTECT EXPOSED AREAS FOR SHORT PERIODS PROTECTS SOIL FROM IMPACT OF FALLING RAIN PRESERVES SOIL MOISTURE AND PROTECTS GERMINATING SEED FROM TEMPERATURE EXTREMES	✳				✳	✳	
11	Roughened Surface	REDUCES VELOCITY AND INCREASES INFILTRATION RATES COLLECTS SEDIMENT HOLDS WATER, SAND AND MULCH BETTER THAN SMOOTH SURFACES	✳				✳		
12	AVAILABLE DETAIL								
13	Riprap, Rubble, Gabions	USED WHERE VEGETATION IS NOT EASILY ESTABLISHED EFFECTIVE FOR HIGH VELOCITIES OR IRON CONCENTRATIONS PERMITS RUNOFF TO INFILTRATE SOIL DISSIPATES ENERGY FLOW AT SYSTEM OUTLETS	✳	✳	✳				
14	AVAILABLE DETAIL								
15	AVAILABLE DETAIL								
16	AVAILABLE DETAIL								
17	Benches	REDUCES RUNOFF VELOCITY BY REDUCING EFFECTIVE SLOPE LENGTH COLLECTS SEDIMENT. PROVIDES ACCESS TO SLOPES FOR SEEDING, MULCHING AND MAINTENANCE	✳					✳	
18	Earth Diversion Berm	DIVERTS WATER FROM VULNERABLE AREAS COLLECTS AND DIRECTS WATER TO PREPARED DRAINAGEWAYS MAY BE PLACED AS PART OF NORMAL CONSTRUCTION OPERATION	✳					✳	✳
18A	Earth Diversion Berm With Stone Outlet at Inlet	DIVERTS WATER FROM VULNERABLE AREAS COLLECTS AND DIRECTS WATER TO PREPARED DRAINAGEWAYS MAY BE PLACED AS PART OF NORMAL CONSTRUCTION OPERATION	✳					✳	✳
19	Diversion Ditch	COLLECTS AND DIVERTS WATER TO REDUCE EROSION POTENTIAL MAY BE INCORPORATED IN PERMANENT PROJECT DRAINAGE SYSTEMS	✳					✳	✳
20	Diversion Berm & Ditch	DIVERTS WATER TO A PREPARED DRAINAGEWAY MAY BE USED AT INTERVALS ACROSS SLOPE FACE TO REDUCE EFFECTIVE SLOPE LENGTH	✳					✳	✳
21	Stone Filter Berm	CONSTRUCTED OF GRAVEL OR STONE INTERCEPTS AND DIVERTS RUNOFF TO STABILIZED AREAS OR PREPARED DRAINAGE SYSTEMS SLOWS RUNOFF AND COLLECTS SEDIMENT	✳	✳					✳
21A	Stone Filter Berm with Silt Fence	CONSTRUCTED OF GRAVEL OR STONE INTERCEPTS AND DIVERTS RUNOFF TO STABILIZED AREAS OR PREPARED DRAINAGE SYSTEMS SLOWS RUNOFF AND COLLECTS SEDIMENT – SILT FENCE PREVENTS EROSION AROUND SPILLWAY	✳	✳					✳
22	AVAILABLE DETAIL								
23	AVAILABLE DETAIL								
24	Grassed Waterway	MUCH MORE STABLE FORM OF DRAINAGEWAY THAN BARE CHANNEL GRASS TENDS TO SLOW RUNOFF AND FILTER OUT SEDIMENT USED WHERE BARE CHANNEL WOULD BE ERODED			✳				
25	Slope Drain (Surface Pipe)	PREVENTS EROSION ON SLOPES WHEN RUNOFF CANNOT BE DIVERTED TO EDGES OF SLOPE AREA. USUALLY TEMPORARY CAN BE CONSTRUCTED OR EXTENDED AS GRADING PROGRESSES	✳						
26	Slope Drain – Paved Chute/Flume	PREVENTS EROSION ON SLOPES WHEN RUNOFF CANNOT BE DIVERTED TO EDGE OF SLOPE AREA. USUALLY PERMANENT CAN BE CONSTRUCTED OR EXTENDED AS GRADING PROGRESSES	✳						
27	Slope Drain (Subsurface Pipe)	PREVENTS EROSION ON SLOPES WHEN RUNOFF CANNOT BE DIVERTED TO EDGE OF SLOPE AREA. USUALLY PERMANENT CAN BE CONSTRUCTED AS GRADING PROGRESSES	✳						
28	Drop Spillway	SLOWS VELOCITY OF FLOW, REDUCING EROSIVE CAPACITY		✳	✳				
29	Pipe Drop	REDUCES RUNOFF VELOCITY REMOVES SEDIMENT AND TURBIDITY CAN BE DESIGNED TO HANDLE LARGE VOLUMES OF FLOW			✳				
30	Pipe Spillway	REMOVES SEDIMENT AND TURBIDITY FROM RUNOFF MAY BE PART OF PERMANENT EROSION CONTROL PLAN			✳				
31	Energy Dissipator	SLOWS RUNOFF VELOCITY TO NON-EROSIVE LEVEL PERMITS SEDIMENT COLLECTION FROM RUNOFF	✳		✳	✳			
32	Level Spreader	CONVERTS COLLECTED CHANNEL OR PIPE FLOW BACK TO SHEET FLOW AVOIDS CHANNEL EASEMENTS AND CONSTRUCTION OFF PROJECT SITE SIMPLE TO CONSTRUCT			✳				
33	Sediment Trap	MAY BE CONSTRUCTED OF A VARIETY OF MATERIALS TRAPS SEDIMENT AND REDUCES VELOCITY OF FLOW CAN BE CLEANED AND EXPANDED AS NEEDED			✳				
34	Sediment Basin	TRAPS SEDIMENT RELEASES RUNOFF AT NON-EROSIVE RATES CONTROLS RUNOFF AT SYSTEM OUTLETS CAN BE VISUAL AMENITIES			✳	✳			
35	AVAILABLE DETAIL								
36	Catch Basin Inlet Protection	COLLECTS HIGH VELOCITY CONCENTRATED RUNOFF MAY USE FILTER CLOTH OVER INLET					✳		✳

✳ INDICATES APPLICABILITY OF A SPECIFIC CONTROL MEASURE TO ONE OR MORE OF THE SEVEN PROBLEM AREAS

KEY	DETAIL	CHARACTERISTICS	SLOPES A	STREAMS AND WATERWAYS B	SURFACE DRAINAGEWAYS C	ENCLOSED DRAINAGE (Inlet & Outlet Control) D	LARGE FLAT SURFACE AREAS E	BORROW AND STOCKPILE AREAS F	ADJACENT PROPERTIES G
37	Sod Filter	INEXPENSIVE AND EASY TO CONSTRUCT PROVIDES IMMEDIATE PROTECTION PROTECTS AREAS AROUND INLETS FROM EROSION				✳			
38	AVAILABLE DETAIL								
39	Fabric Filter Curb Inlet Protection	CAN UTILIZE MATERIAL FOUND ON SITE EASY TO CONSTRUCT FILTERS SEDIMENT FROM RUNOFF				✳			✳
40	Inlet Sediment Trap	EASY TO SHAPE COLLECTS SEDIMENT MAY BE CLEANED AND EXPANDED AS NEEDED				✳			
41	Stone and Rock Ford Crossing	MAY BE ROCK OR CLEAN RUBBLE MINIMIZES STREAM TURBIDITY INEXPENSIVE MAY ALSO SERVE AS DITCH CHECK OR SEDIMENT TRAP		✳					
42	Temporary Culvert	ELIMINATES STREAM TURBULENCE AND TURBIDITY PROVIDES UNOBSTRUCTED PASSAGE FOR FISH AND OTHER WATER LIFE CAPACITY FOR NORMAL FLOW CAN BE PROVIDED WITH STORM WATER FLOWING OVER ROADWAY		✳					
43	Culvert Sediment Trap	EASY TO INSTALL AT INLET KEEPS CULVERT CLEAN AND FREE FLOWING MAY BE CONSTRUCTED OF LUMBER OR LOGS		✳					✳
44	AVAILABLE DETAIL								
45	Temporary Stream Channel Change	NEW CHANNEL KEEPS NORMAL FLOWS AWAY FROM CONSTRUCTION REQUIRES STATE PERMIT		✳					
46	AVAILABLE DETAIL								
47	Cofferdam	WORK CAN BE CONTINUED DURING MOST ANTICIPATED STREAM CONDITIONS CLEAR WATER CAN BE PUMPED DIRECTLY BACK INTO STREAM		✳					
48	AVAILABLE DETAIL								
49	Check Dam	REDUCES FLOW VELOCITY CATCHES SEDIMENT CAN BE CONSTRUCTED OF LOGS, STRAW, HAY, ROCK, LUMBER, MASONRY, OR SAND BAGS		✳	✳				
50	AVAILABLE DETAIL								
51	Retaining Wall	REDUCES GRADIENT WHERE SLOPES ARE EXTREMELY STEEP PERMITS RETENTION OF EXISTING VEGETATION, KEEPING SOIL STABLE IN CRITICAL AREAS, MINIMIZES MAINTENANCE	✳						✳
52	AVAILABLE DETAIL								
53	Windbreak	MINIMIZES WIND EROSION MAY BE SNOW FENCE					✳		
54	Silt Fence	USES GEOTEXTILE FABRIC AND POSTS OR POLES EASY TO CONSTRUCT AND LOCATE AS NECESSARY	✳		✳		✳		✳
55	Stone Filter–Before Paving	STONE FILTER TO PROVIDE INEXPENSIVE AND EASILY CONSTRUCTED SEDIMENT CONTROL PRIOR TO PAVING SEE DETAIL AT LEFT			✳	✳			
55A	Stone Filter–After Paving	STONE FILTER TO PROVIDE INEXPENSIVE AND EASILY CONSTRUCTED SEDIMENT CONTROL AFTER PAVING SEE DETAIL AT LEFT			✳	✳			
55B	Catch Basin, Filter Bag	MANUFACTURED FILTER BAG INSERTED UNDER CASTING. COLLECTS SEDIMENT AT CATCH BASIN INLET SEE DETAIL AT LEFT			✳	✳			
56	Turbidity Curtain	A TURBIDITY CURTAIN IS USED WHEN SLACK WATER AREA IS NECESSARY TO ISOLATE CONSTRUCTION ACTIVITIES FROM THE WATERCOURSE. THE STILL WATER AREA CONTAINS THE SEDIMENT WITHIN THE CONSTRUCTION LIMITS		✳					
57	Stream – Liner	MAY BE 6A TYPE STONE, SMALL ROCKS OR SIMILAR–SIZED CLEAN CONCRETE–MASONRY RUBBLE, MINIMIZES STREAM TURBIDITY RELATIVELY INEXPENSIVE MAY BE USED AS DITCH CHECK OR SEDIMENT TRAP			✳				
58	Sediment Sump	CONTROLS SEDIMENTATION IN LARGE STREAMS, CONSIST OF OVER EXCAVATING THE DRAIN BY ONE TO TWO FEET, THE SUMP WILL BE AT LEAST 200 FEET LONG, SEDIMENTS ACCUMULATED DURING CONSTRUCTION WILL BE REMOVED UPON PROJECT COMPLETION			✳				
59	AVAILABLE DETAIL								
60	Temporary Construction Entrance	ASSISTS IN REMOVING SOIL FROM THE TIRES OF CONSTRUCTION VEHICLES AND VEHICLES WHEN EXITING THE CONSTRUCTION SITE. ALSO REDUCES TRACKING EXCESSIVE SEDIMENT/SOIL ONTO THE ADJACENT ROAD							✳

SOIL EROSION & SEDIMENTATION CONTROL NOTES

1. CONTRACTOR SHALL PLACE ALL SOIL EROSION & SEDIMENTATION CONTROL MEASURES AS SHOWN IN THE PLANS, OR AS DIRECTED BY THE ENGINEER IN ACCORDANCE WITH THE MICHIGAN UNIFIED KEYING SYSTEM.
2. CONSTRUCTION OPERATIONS SHALL BE SCHEDULED AND PERFORMED SO THAT PREVENTATIVE EROSION CONTROL MEASURES ARE IN PLACE PRIOR TO EXCAVATION; TEMPORARY STABILIZATION MEASURES ARE IN PLACE IMMEDIATELY FOLLOWING BACK FILLING AND/OR GRADING OPERATIONS.
3. SPECIAL PRECAUTIONS WILL BE TAKEN IN THE USE OF CONSTRUCTION EQUIPMENT TO PREVENT SITUATIONS THAT PROMOTE EROSION.
4. CLEANUP WILL BE DONE IN A MANNER TO ENSURE THAT EROSION CONTROL MEASURES ARE NOT DISTURBED.
5. THE PROJECT WILL BE INSPECTED DAILY FOR SOIL EROSION AND SEDIMENTATION CONTROL COMPLIANCE BY CERTIFIED STORM WATER OPERATOR PROVIDED BY CONTRACTOR. DEFICIENCIES WILL BE CORRECTED BY THE CONTRACTOR WITHIN 24 HOURS.
6. TEMPORARY EROSION CONTROL MEASURES SHALL BE COMPLETELY REMOVED BY THE CONTRACTOR UPON ESTABLISHMENT OF PERMANENT CONTROL MEASURES, WITH PRIOR APPROVAL OF OWNER, ENGINEER, AND/OR AGENCY HAVING JURISDICTION.
7. CONSTRUCTION WILL DISTURB LESS THAN 5 ACRES, THUS AN NPDES STORM WATER DISCHARGE PERMIT WILL NOT BE REQUIRED. CONTRACTOR SHALL MEET THE PERMIT–BY–RULE (RULE 323.2190) HOWEVER FOR AREAS BETWEEN 1 ACRE AND 5 ACRES.
8. ALL ROADS WITHIN THE INFLUENCE OF THE PROJECT MUST REMAIN CLEAN AT ALL TIMES. CONTRACTOR SHALL SWEEP ROADS AS DIRECTED BY THE ENGINEER.
9. BEST MANAGEMENT PRACTICES FOR SOIL EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE USED ON THIS PROJECT AS SHOWN ON THE PLANS AND AS DEFINED BY THE ENGINEER.
10. ALL EROSION CONTROL MEASURES SHALL BE CONSTRUCTED AND MAINTAINED IN ACCORDANCE WITH THE CITY OF GRAND RAPIDS AND THE OFFICE OF THE KENT COUNTY DRAIN COMMISSIONER REQUIREMENTS AND PROJECT SPECIFICATIONS
11. ANY EROSION OR SEDIMENT FROM WORK ON THIS SITE SHALL BE CONTAINED ON THE SITE AND NOT ALLOW3ED TO COLLECT ON ANY OFF SITE AREAS OR IN WATERWAYS: WATERWAYS INCLUDE BOTH NATURAL AND MAN–MADE OPEN DITCHES, STREAMS, STORM DRAINS, LAKES AND PONDS.
12. WORK TO BE PERFORMED WITHIN THE GRAND RIVER FOR 2,756 FEET BETWEEN I–196 AND FULTON STREET AND ALONG THE GRAND RIVER FOR 900 FEET IN AH–NAB–AWEN PARK. STAGING AREAS 0 FEET AWAY FROM RIVER AT AH–NAB–AWEN PARK AND 25 FEET AWAY AT MONROE LOT.
13. THE SOIL TYPE WITHIN THE PROJECT IS IDENTIFIED AS URBAN LAND BY THE UNITED STATES DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
14. PROVIDE TRAFFIC CONTROL BARRICADES, SIGNS, LIGHTS, ETC. IN ACCORDANCE WITH THE LATEST EDITION OF THE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES AS NECESSARY FOR THE PROTECTION AND SAFETY OF THE PUBLIC. MAINTAIN THESE DEVICES AT ALL TIMES DURING CONSTRUCTION.
15. PROTECT TREES NOT SHOWN FOR REMOVAL FROM DAMAGE DURING CONSTRUCTION IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
16. ALL REMOVED MATERIALS ARE THE PROPERTY OF THE CONTRACTOR. CLEANUP AND DISPOSE OF ALL EXCESS MATERIALS OFF SITE AT A LOCATION DESIGNATED FOR THIS USE AND IN ACCORDANCE WITH LOCAL REGULATIONS OR AT N ON SITE LOCATION DESIGNATED BY THE OWNER, UNLESS OTHERWISE NOTED.
17. USE (2) TWO BENCH MARKS FOR VERIFICATION OF ALL CONSTRUCTION ELEVATIONS. SET ADDITIONAL BENCH MARKS TO COMPLY WITH THIS REQUIREMENT.
18. RESTORE ALL STREET SURFACES, DRIVEWAYS, CULVERTS, ROADSIDE DRAINAGE DITCHES, AND OTHER PUBLIC OR PRIVATE STRUCTURES THAT ARE DISTURBED OR DAMAGED AS A RESULT OF CONSTRUCTION ACTIVITIES TO A CONDITIONS EQUAL TO OR BETTER THAN EXISTING CONDITIONS AND TO THE SATISFACTION OF THOSE HAVING JURISDICTION, UNLESS NOTED OTHERWISE IN THE PLANS.

CONSTRUCTION SEQUENCE

1. IMPLEMENTATION OF TEMPORARY EROSION CONTROL MEASURES; SELECTIVE GRADING, DIVERSIONS AS REQUIRED IN FIELD, PROTECTION OF STORM SEWER FACILITIES
2. EXCAVATION AND STOCKPILING OF SOIL.
3. PERIODIC MAINTENANCE OF AFFECTED EROSION CONTROL MEASURES.
4. PERMANENT MEASURES; FINAL GRADING, SEEDING AND MULCHING.

SEE UNIFIED KEYING SYSTEM FOR EROSION CONTROL KEY NUMBERS

TO BE COMPLETED BY CONTRACTOR FOR PERMIT

SOIL EROSION / SEDIMENTATION CONTROL
OPERATION TIME SCHEDULE

CONSTRUCTION SEQUENCE	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
STRIP & STOCKPILE TOPSOIL													
ROUGH GRADE / SEDIMENT CONTROL													
TEMP. CONTROL MEASURES													
STORM FACILITIES													
TEMP. CONSTRUCTION ROADS													
FOUNDATION / BLDG. CONSTRUCTION													
SITE CONSTRUCTION													
PERM. CONTROL MEASURES													
FINISH GRADING													
LANDSCAPING													

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.



ZONES

ZONE 1

TYPE OF SEED	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	RATE OF APPLICATION * PER/1000 S.F.	PER ACRE
OATS / BARLEY ANNUAL RYE						15TH		2 LBS. 3/4 LB.	3 BUSHELS 25 LBS.
SUDANGRASS				15TH				1 LB.	35 LBS.
CEREAL RYE							15TH	1.5 LBS.	2 BU.
WINTER WHEAT						20TH	15TH	1.5 LBS.	2 BU.

TEMPORARY SEEDING GUIDE

RECOMMENDED PLANTING SEASON

* RATE OF APPLICATION APPLIES TO ALL ZONES

ZONE	TYPE OF IRRIGATION	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
ZONE 1	IRRIGATED and/or MULCHED							
	without IRRIGATION or MULCH							
ZONE 2	IRRIGATED and/or MULCHED							
	without IRRIGATION or MULCH							
ZONE 3	IRRIGATED and/or MULCHED							
	without IRRIGATION or MULCH							

PERMANENT SEEDING GUIDE

RECOMMENDED PLANTING SEASON

EGLE STREAM CROSSING NOTES

1. CONSTRUCTION OF STREAM CROSSING SHALL BE SUBJECT TO THE SPECIFICATIONS FOR PROTECTION OF NATURAL RESOURCES AT UTILITY CROSSING AS GIVEN IN THE ADMINISTRATIVE RULES PART NO. 301 OF PUBLIC ACT 451, AS AMENDED, 1994.
2. A SILTATION BARRIER SHALL BE CONSTRUCTED IMMEDIATELY DOWNSTREAM OF THE CONSTRUCTION SITE PRIOR TO THE COMMENCEMENT OF ANY CONSTRUCTION ACTIVITIES. (SEE MICHIGAN UNIFIED KEYING SYSTEM FOR SPECIFIED BARRIER) THE SILTATION BARRIER SHALL BE MAINTAINED IN GOOD WORKING ORDER THROUGHOUT THE DURATION OF THE PROJECT.
3. BACKFILL SHALL CONSIST OF INERT MATERIALS WHICH WILL NOT CAUSE SILTATION NOR CONTAIN SOLUBLE CHEMICALS OR ORGANIC MATTER WHICH IS BIODEGRADABLE. ALL FILL SHALL BE CONTAINED IN SUCH MANNER SO AS NOT TO ERODE INTO ANY WATERCOURSE.
4. ALL RAW BANKS SHALL BE STABILIZED WITH RIPRAP TO THREE FEET ABOVE ORDINARY HIGH WATER MARK, THEN SEEDED, FERTILIZED AND MULCHED, OR SODDED TO PREVENT EROSION
5. UPON PROJECT COMPLETION THE EXCESS SPOILS SHALL BE REMOVED AND DISPOSED IN AN APPROPRIATE UPLAND SITE.
6. SILTATION BARRIER MAY BE REMOVED UPON PLACEMENT OF PERMANENT EROSION CONTROL BARRIERS.

MICHIGAN UNIFIED KEYING SYSTEM SOIL EROSION & SEDIMENT CONTROL MEASURES

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

REVISIONS

NO.	DATE	DESCRIPTION

Drawn by _____
Check: Field _____
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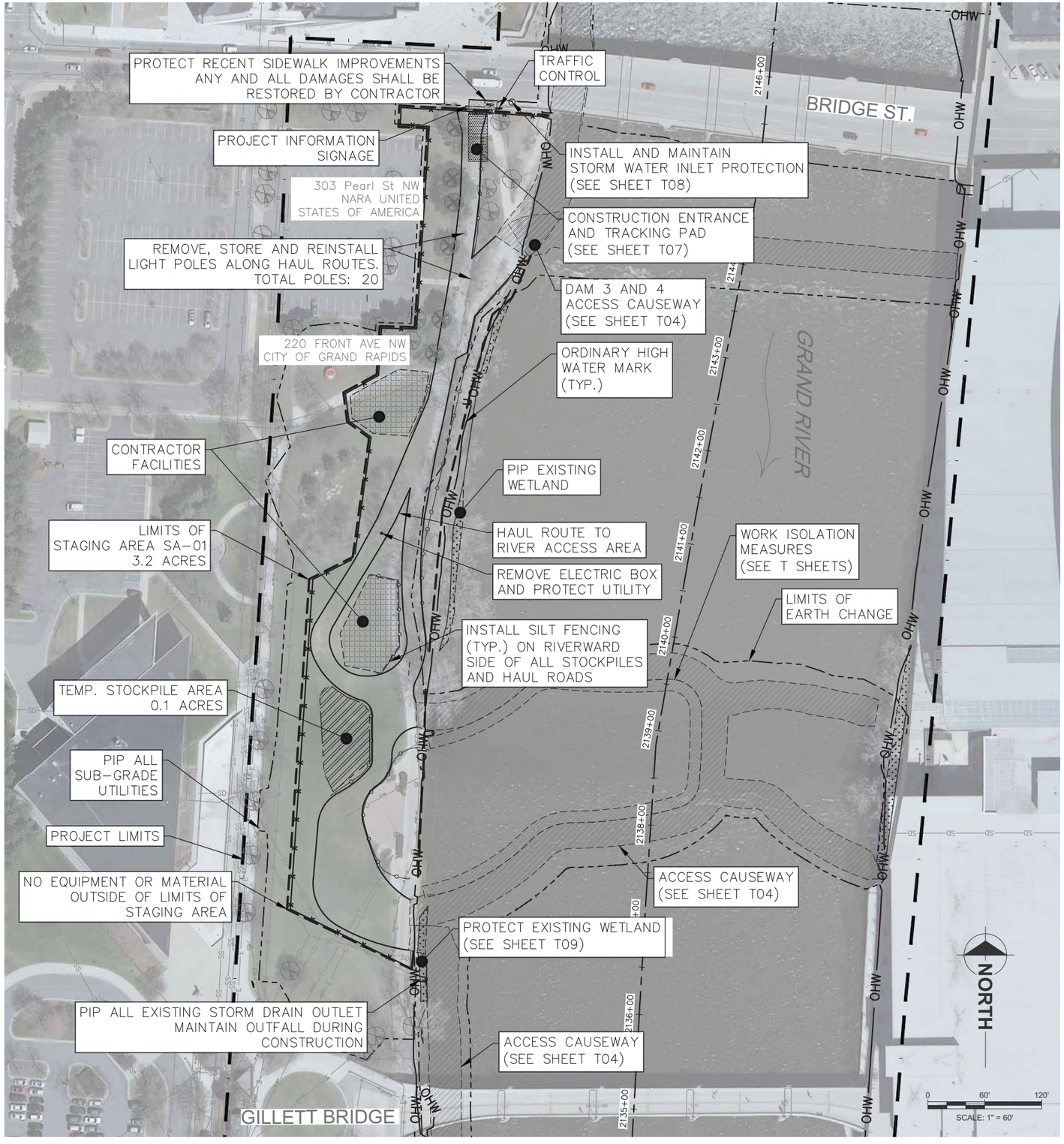
GPF No. 5315

Sheet No. 6 of 34 T01



LEGEND

- CONTRACTOR FACILITIES: INCLUDES TRAILER, SANITATION FACILITIES, FUELING AREA, ETC.
- STOCKPILE AREA: INCLUDES DEWATERING AREA
- CONSTRUCTION FENCING
- SILT FENCING
- GATE
- PIP TREE
- REMOVE TREE
- PIP LIGHT POLE
- DELINEATED WETLAND

GENERAL NOTES:

1. THE CONSTRUCTION STAGING PLAN SHOWN HERE IS FOR PERMITTING AND COST ESTIMATION PURPOSES ONLY. THIS CARE OF WATER PLAN IS BASED ON CORRESPONDENCE WITH THE CITY OF GRAND RAPIDS AND THE CONSTRUCTION MANAGER ADVISOR. THE CONTRACTOR WILL ULTIMATELY BE RESPONSIBLE FOR DEVELOPING AND MAINTAINING A CONSTRUCTION STAGING PLAN TO MEET PERMITTING CONDITIONS AND CONSTRUCTION NEEDS.
2. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL.
3. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
4. THE CONTRACTOR SHALL CONDUCT OPERATIONS IN COMPLIANCE WITH DIVISION 1 OF THE 2021 CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS AND THE PROVISIONS OF SECTIONS 107.15 "DUST CONTROL" AND 812 "TEMPORARY TRAFFIC CONTROL FOR CONSTRUCTION ZONE OPERATIONS" OF THE MDOT STANDARD CONSTRUCTION SPECIFICATIONS.
5. NO MATERIAL OR EQUIPMENT SHALL BE PLACED, STORED, OR OPERATED OUTSIDE THE STAGING AREA LIMITS SHOWN ON PLANS.
6. TEMPORARY EARTHWORK NECESSARY TO ESTABLISH STAGING AND ACCESS FACILITIES SHALL HAVE A MAXIMUM TOPSOIL REMOVAL DEPTH OF 1 FOOT.
7. THE CONTRACTOR IS RESPONSIBLE TO DEVELOP AND MAINTAIN A TRAFFIC CONTROL PLAN THROUGHOUT CONSTRUCTION.

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - AH-NAB-AWEN PARK STAGING

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
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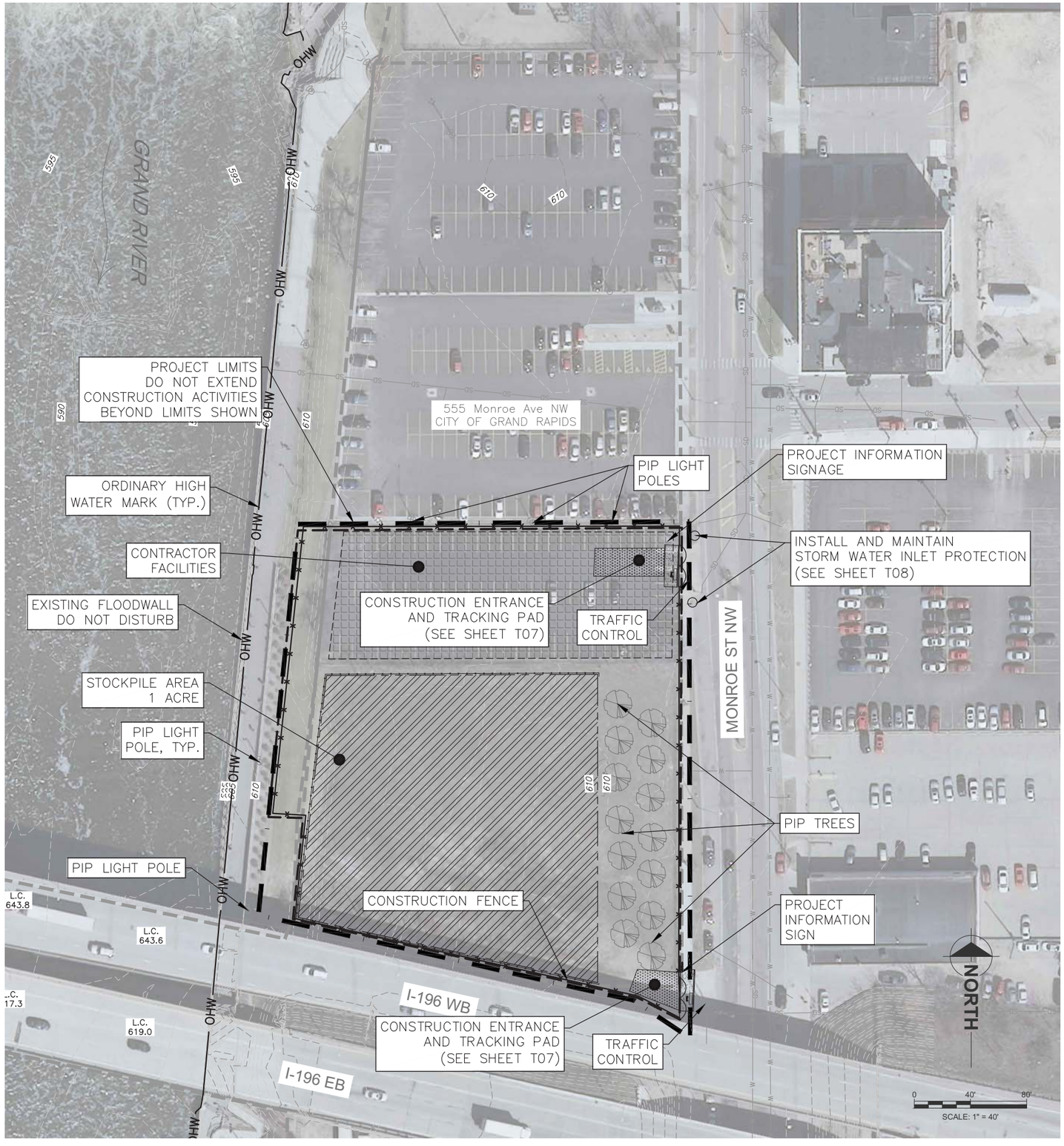
GPF No. 5315

Sheet No. 7 of 34 T02



LEGEND

- CONTRACTOR FACILITIES: INCLUDES TRAILER, SANITATION FACILITIES, FUELING AREA, ETC.
- STOCKPILE AREA: INCLUDES DEWATERING AREA
- CONSTRUCTION FENCING
- SILT FENCING
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GENERAL NOTES:

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2. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL.
3. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
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5. NO MATERIAL OR EQUIPMENT SHALL BE PLACED, STORED, OR OPERATED OUTSIDE THE STAGING AREA LIMITS SHOWN ON PLANS.
6. TEMPORARY EARTHWORK NECESSARY TO ESTABLISH STAGING AND ACCESS FACILITIES SHALL HAVE A MAXIMUM TOPSOIL REMOVAL DEPTH OF 1 FOOT.
7. THE CONTRACTOR IS RESPONSIBLE TO DEVELOP AND MAINTAIN A TRAFFIC CONTROL PLAN THROUGHOUT CONSTRUCTION.

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - 555 MONROE LOT STAGING

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

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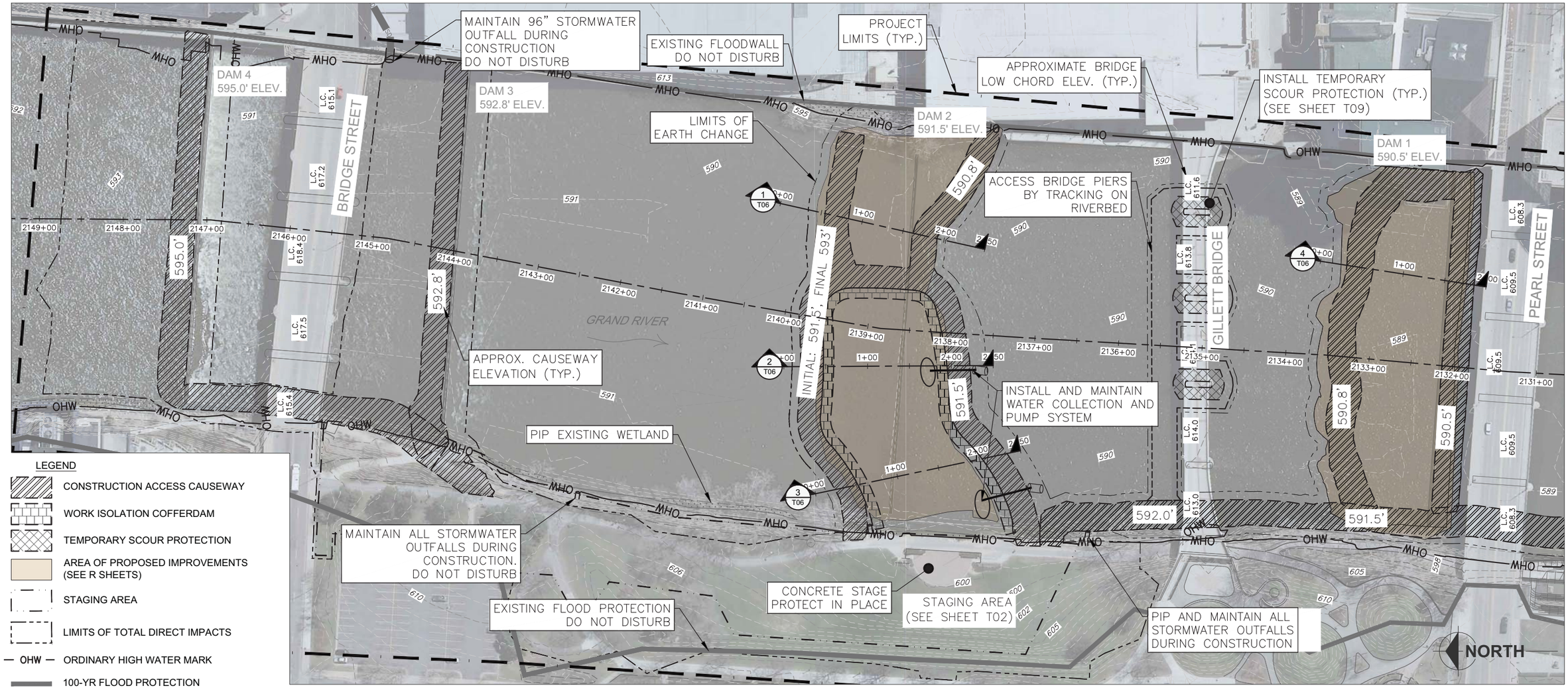
GPF No. 5315

Sheet No. 8 of 34 T03



LEGEND

- CONSTRUCTION ACCESS CAUSEWAY
- WORK ISOLATION COFFERDAM
- TEMPORARY SCOUR PROTECTION
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- STAGING AREA
- LIMITS OF TOTAL DIRECT IMPACTS
- OHW — ORDINARY HIGH WATER MARK
- 100-YR FLOOD PROTECTION

0 60' 120'

SCALE: 1" = 60'

GENERAL NOTES:

1. THE CARE OF WATER PLAN AND TEMPORARY STRUCTURES SHOWN HERE ARE FOR PERMITTING AND COST ESTIMATION PURPOSES ONLY. THIS CARE OF WATER PLAN IS BASED ON CORRESPONDENCE WITH THE CITY OF GRAND RAPIDS AND THE CONSTRUCTION MANAGER ADVISOR. THE CONTRACTOR WILL ULTIMATELY BE RESPONSIBLE FOR DEVELOPING AND MAINTAINING A CARE OF WATER PLAN TO MEET PERMITTING CONDITIONS AND CONSTRUCTION NEEDS.
2. BRIDGE LOW CHORDS REPRESENT LOW CHORD OF BRIDGE DECKS. GILLETT AND PEARL STREET BRIDGES HAVE ARCHED BAYS; LOW CHORDS SHOWN REPRESENT APPROXIMATE HIGH POINT OF ARCHES. CONTRACTOR IS RESPONSIBLE TO VERIFY LOW-CHORD ELEVATIONS AND CLEARANCE HEIGHTS.
3. ALL IN WATER WORK REQUIRES USE OF APPROVED BMP'S TO PREVENT IMPACTS TO WATER QUALITY.
4. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL OR IMPACT.
5. BE PREPARED TO UN-ISOLATE WORK AREA AND ALLOW FLOW ON BOTH SIDES OF CHANNEL UPON SHORT NOTICE IF OWNER'S REPRESENTATIVE DETERMINES BED SCOUR NEAR BRIDGE PIERS, FLOODWALLS, OR OTHER INFRASTRUCTURE SHOULD BE INSPECTED.
6. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
7. ACCESS CAUSEWAYS, WORK ISOLATION MEASURES, AND TEMPORARY GRADE CONTROLS SHALL BE INSTALLED IN THE FLOWING RIVER. REFER TO THE TECHNICAL SPECIFICATIONS FOR FLOW RATE AND DEPTH INFORMATION. CONTRACTOR SHALL SUBMIT PLAN TO PERFORM WORK IN THE FLOWING RIVER WITH MAXIMUM DEPTHS TO PERFORM WORK.
8. SURFACES FOR ALL TEMPORARY CAUSEWAYS AND COFFERDAMS CAN BE PROVIDED TO CONTRACTOR

CONSTRUCTION SEQUECNING NOTES:

1) CAUSEWAYS MUST BE INSTALLED BEFORE REMOVAL OF DAMS OR CONSTRUCTION OF PROPOSED IMPROVEMENTS CAN BEGIN AT ANY GIVEN LOCATION.
2) PROPOSED IMPROVEMENTS AT DAM 3 SHALL BE HELD UNTIL AFTER COFFERDAM AT DAM 2 HAS BEEN REMOVED.
3) PROPOSED IMPROVEMENTS AT DAM 4 SHALL BE HELD UNTIL AFTER COMPLETION OF PROPOSED IMPROVEMENTS AT DAM 2.

MUSSEL RELOCATION NOTES:

1) MUSSEL RELOCATION IS ANTICIPATED TO OCCUR BY OTHERS, PRIOR TO IN-CHANNEL CONSTRUCTION ACTIVITIES BEGINNING WITH THE EXCEPTION OF NOTE 3 BELOW.
2) LOCATIONS UNABLE TO BE ACCESSED FOR MUSSEL RELOCATION WOULD BE RELOCATED DURING CONSTRUCTION, IF FLOW CONDITIONS ALLOW AND RELOCATION IS ABLE TO BE COMPLETED AHEAD OF CONSTRUCTION ACTIVITIES.
3) THE AREA WITHIN THE WORK ISOLATION AT DAM 2 WOULD BE RELOCATED PRIOR TO WORK COMMENCING IN THAT AREA. RELOCATION ACTIVITIES HERE WOULD HAVE UP TO 10 DAYS TO CLEAR THE AREA.

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REVISIONS

NO.	DATE	DESCRIPTION

CONSTRUCTION PLAN LAYOUT

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
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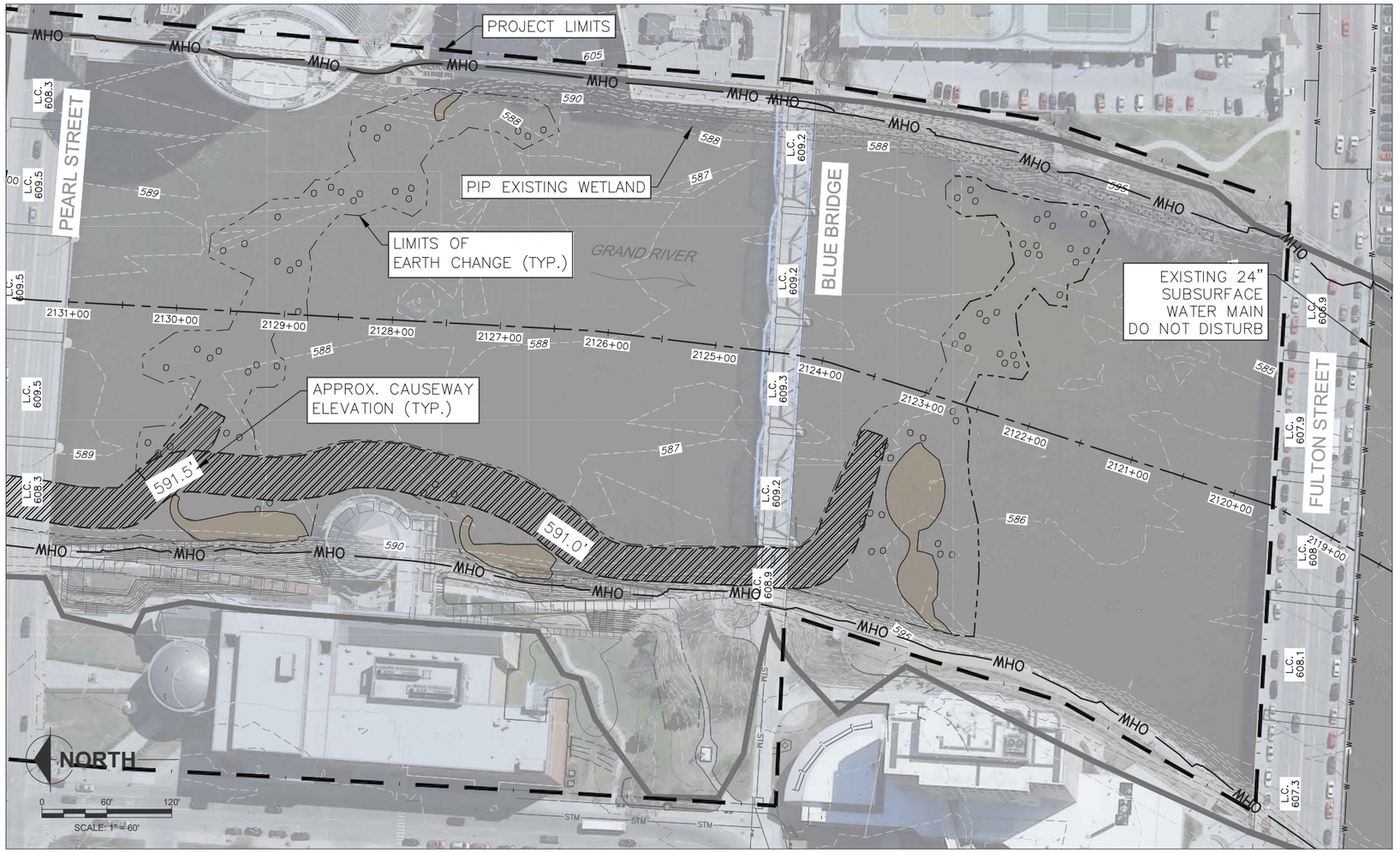
GPF No. 5315

Sheet No. 9 of 34 T04

LEGEND

- CONSTRUCTION ACCESS CAUSEWAY
- WORK ISOLATION COFFERDAM
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- STAGING AREA
- LIMITS OF TOTAL DIRECT IMPACTS
- OHW — ORDINARY HIGH WATER MARK
- 100-YR FLOOD PROTECTION



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MUSSEL RELOCATION NOTES:

1) MUSSEL RELOCATION IS ANTICIPATED TO OCCUR BY OTHERS, PRIOR TO IN-CHANNEL CONSTRUCTION ACTIVITIES BEGINNING WITH THE EXCEPTION OF NOTE 3 BELOW.
2) LOCATIONS UNABLE TO BE ACCESSED FOR MUSSEL RELOCATION WOULD BE RELOCATED DURING CONSTRUCTION, IF FLOW CONDITIONS ALLOW AND RELOCATION IS ABLE TO BE COMPLETED AHEAD OF CONSTRUCTION ACTIVITIES.
3) THE AREA WITHIN THE WORK ISOLATION AT DAM 2 WOULD BE RELOCATED PRIOR TO WORK COMMENCING IN THAT AREA. RELOCATION ACTIVITIES HERE WOULD HAVE UP TO 10 DAYS TO CLEAR THE AREA.

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

CONSTRUCTION PLAN LAYOUT

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

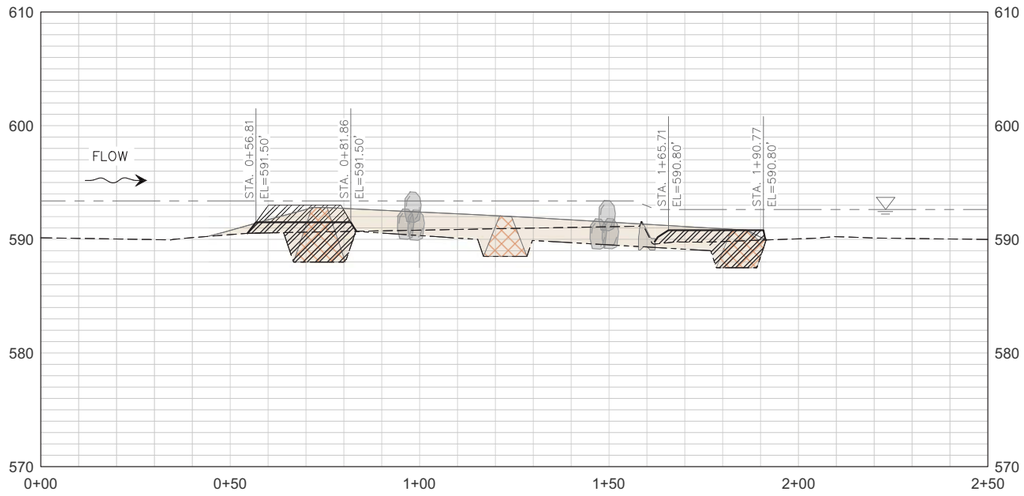
IMPROVEMENTS ALONG THE

GRAND RIVER

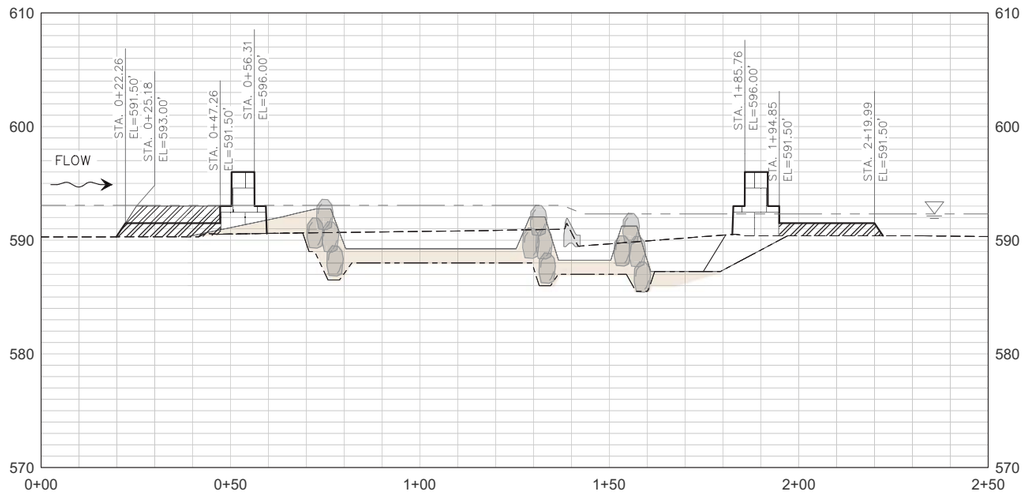
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

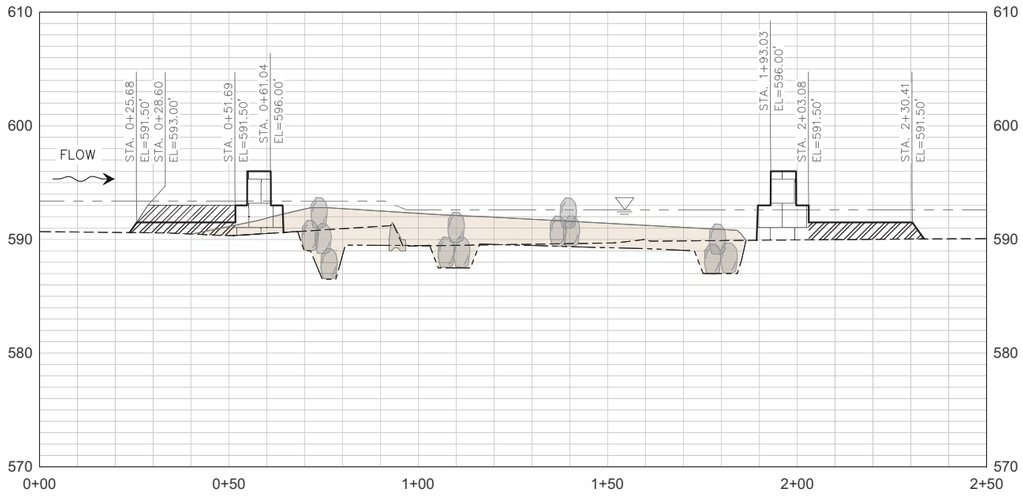
Drawn by / Check: Field / Check: Office	GPF No.	Sheet No.
	5315	10 of 34 T05



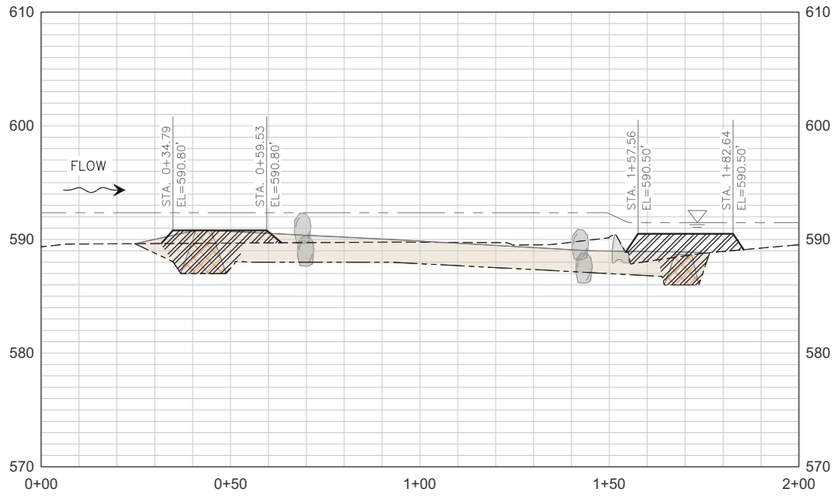
1 / T06 DESIGN PROFILE
CONSTRUCTED RIFFLE – EAST



2 / T06 DESIGN PROFILE
DIVERSIFIED BOULDER DROP STRUCTURES



3 / T06 DESIGN PROFILE
CONSTRUCTED RIFFLE – WEST



4 / T06 DESIGN PROFILE
CONSTRUCTED RIFFLE

0 20' 40'
SCALE: 1" = 20'

LEGEND

- CONSTRUCTION ACCESS CAUSEWAY, INTITIAL
- CONSTRUCTION ACCESS CAUSEWAY, FINAL
- WORK ISOLATION COFFERDAM
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- PROPOSED RIPRAP STRUCTURE
- PROPOSED BOULDER (SEE R SHEETS)
- EXISTING CONDITIONS WATER SURFACE ELEVATION, 3,900 CFS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

CONSTRUCTION PLAN DETAIL PROFILES

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
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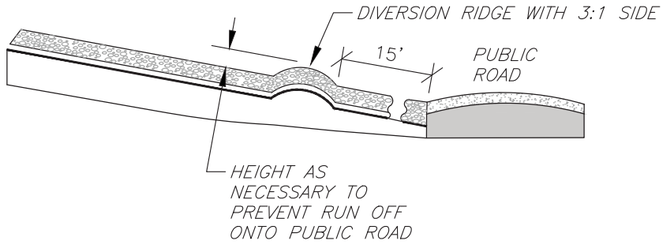
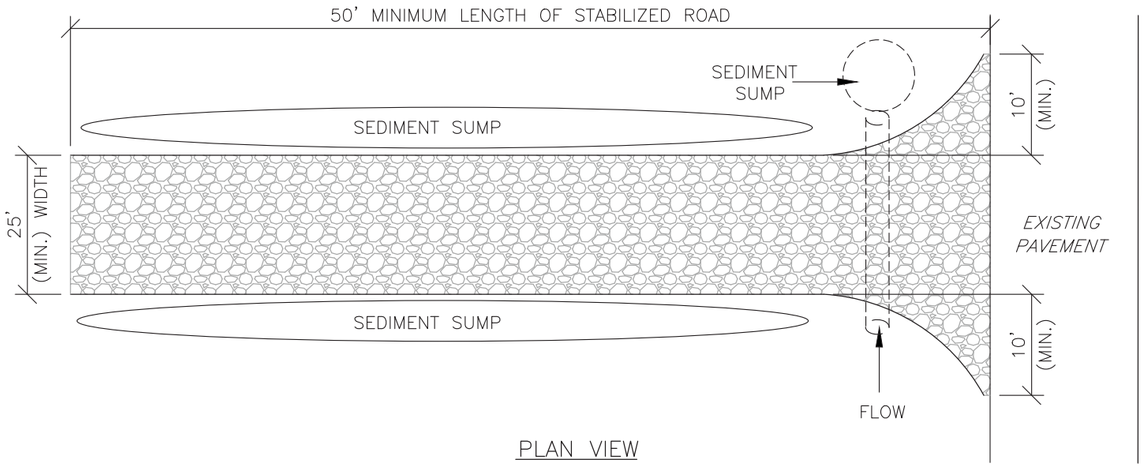
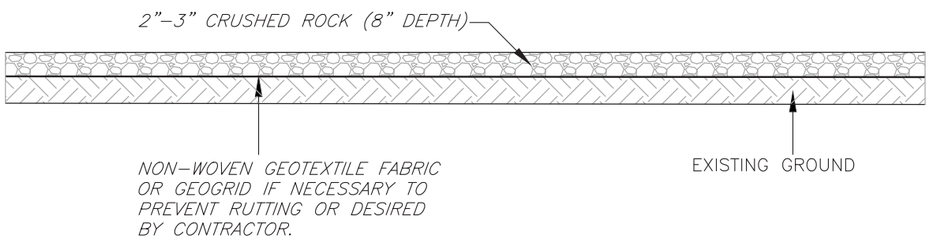
Sheet No. 11 of 34 T06



DIVERSION RIDGE CROSS–SECTION



PLAN VIEW



PROFILE

60 STABILIZED CONSTRUCTION ACCESS
NO SCALE

1
T07

NOTES:

1. ESTABLISH STABILIZED CONSTRUCTION ENTRANCE PRIOR TO THE INITIATION OF SITE CONSTRUCTION ACTIVITIES IN LOCATON SHOWN ON THE PLANS OR AS DIRECTED BY THE ENGINEER.
2. REMOVE ALL VEGETATION, TOPSOIL, AND OTHER OBJECTIONABLE MATERIAL FROM THE FOUNDATION AREA.
3. GRADE FOUNDATION AND CROWN FOR POSITIVE DRAINAGE AWAY FROM PUBLIC ROAD IF POSSIBLE. IF THE SLOPE OF THE CONSTRUCTION ENTRANCE IS TOWARD A PUBLIC ROAD AND EXCEEDS TWO PERCENT, CONSTRUCT AN EIGHT INCH HIGH DIVERSION RIDGE WITH A RATIO OF 3–TO–1 SIDE SLOPES ACROSS THE FOUNDATION AREA ABOUT 15 FEET FROM THE ENTRANCE TO DIVERT RUNOFF AWAY FROM THE ROAD.
4. INSTALL A CULVERT PIPE UNDER THE PAD IF NEEDED TO MAINTAIN PROPER PUBLIC ROAD DRAINAGE.
5. PLACE AGGREGATE TO THE DIMENSIONS AND GRADE SHOWN IN THE CONSTRUCTION PLANS, LEAVING THE SURFACE SMOOTH AND SLOPED FOR DRAINAGE.
6. DIVERT ALL STORM WATER RUNOFF AND DRAINAGE FROM THE INGRESS,/EGRESS PAD TO A SEDIMENT TRAP OR BASIN.
7. INSPECT DAILY.
8. RESHAPE PAD AS NEEDED FOR DRAINAGE AND RUNOFF CONTROL.
9. TOP DRESS WITH CLEAN AGGREGATE AS NEEDED.
10. IMMEDIATELY REMOVE MUD AND SEDIMENT TRACKED OR WASHED ONTO PUBLIC ROADS.
11. FLUSHING SHOULD ONLY BE USED IF THE WATER CAN BE CONVEYED INTO A SEDIMENT TRAP OR BASIN.

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION ENTRANCE AND TRACKING PAD DETAIL

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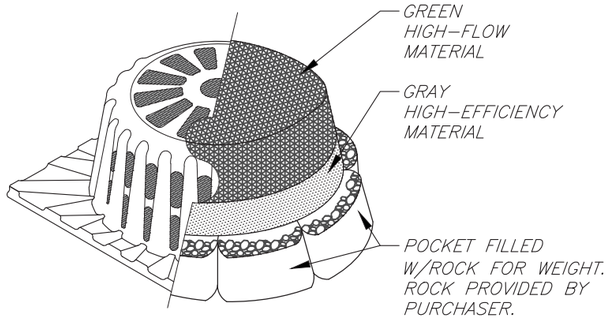
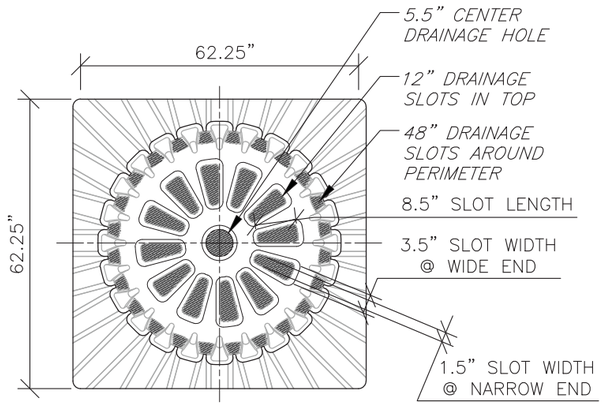
Sheet No. 12 of 34 T07

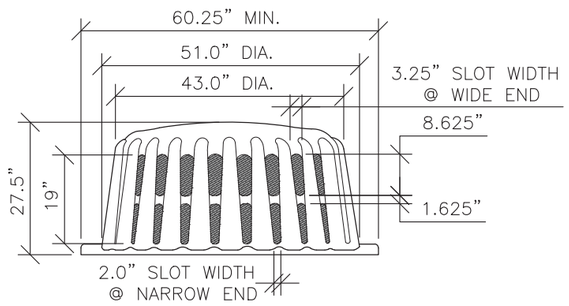


ISOMETRIC VIEW

SHOWN WITH ROADWAY PROJECTS FILTER HAT



PLAN VIEW



ELEVATION VIEW

Model #S–200A
REPLACEMENT FILTERS: MODEL #S–240

55 SQUARE FRAME & FILTER ASSEMBLY
NO SCALE

1
T08

FILTER OPTIONS

FILTER HAT IS AVAILABLE IN THREE OPTIONS:
1) ALL HIGH–FLOW MATERIAL
2) ALL HIGH–EFFICIENCY MATERIAL
3) HIGH–FLOW MATERIAL ON TOP HALF OF HAT, HIGH–EFFICIENCY MATERIAL ON BOTTOM HALF (THIS FILTER COVER IS RECOMMENDED FOR ALL ROADWAY PROJECTS.)

IT IS THE PURCHASERS RESPONSIBILITY TO PURCHASE APPROPRIATE FILTER HAT. PURCHASER SHALL PROVIDE ROCK FOR FILTER POCKETS.

FILTER HAT INSTALLATION

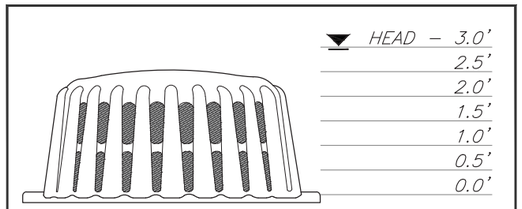
FILTER HAT SLIDES DIRECTLY OVER FILTER FRAME. TO KEEP FILTER FRAME IN PLACE OVER STORM STRUCTURE, ROCK POCKETS ARE SEWN DIRECTLY INTO FILTER HAT MATERIAL. EVERY FILTER HAT COMES IN ONE PIECE FOR EASY INSTALLATION.

MAINTENANCE

ALL TEMPORARY EROSION, SEDIMENTATION, & POLLUTION CONTROL PRACTICES SHOULD BE INSPECTED DAILY. CONTRACTOR SHALL REMOVE SEDIMENT AND DISPOSE OF IN A PROPER MANNER. INSPECT S–200A DAILY FOR CUTS, ABRASIONS, AND PROPER INSTALLATION. REPLACE OR REPOSITION AS NECESSARY.

SPECIFICATIONS

FILTER FABRIC SILT–SAVER HAT SHALL BE BASED ON DESIGN PROFESSIONAL'S SPECIFICATIONS.



FRAME & FILTER DISCHARGE ANALYSIS

HEAD (FT)	EQUATION USED	OPENING AREA (SF)	FRAME FLOW (CFS)	FILTER AREA (SF)	FILTERED FLOW (CFS)
0.5	O	2.1	7	6	2
1.0	O	3.9	19	12	3
1.5	O	7.0	41	18	5
2.0	O	8.0	54	24	7
2.5	O	9.2	70	30	9
3.0	O	9.2	77	—	77

DUE TO NARROW SLOT, A TRANSITION WILL OCCUR BETWEEN WEIR AND ORIFICE CONDITIONS. ORIFICE FLOW WILL PROVIDE A MORE CONSERVATIVE ESTIMATE OF FLOW, THEREFORE THE LESSER OF THE ORIFICE AND WEIR FLOWS WILL BE USED FOR EACH STAGE CALCULATION.

FILTER MATERIAL ALLOWS 129 gpm/SF OR 0.29cfs/SF
ORIFICE EQUATION (O) = Q=0.6A(2gh)^0.5
P = FEET PERIMETER
h = HEAD IN FEET
Q = CAPACITY IN cfs
A = FREE OPEN AREA OF FRAME
g = 32.2 FEET-PER-SECOND/SECOND

FRAME MATERIAL: BLACK 0.25" HMWPE

FILTER FABRIC MATERIAL: REFER TO SPEC

SCALE: NOT TO SCALE

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

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TEMP. CONSTRUCTION ACCESS & CARE OF WATER - STORM WATER INLET PROTECTION DETAIL

SURVEYED & DESIGNED BY:

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Public Services
Engineering Department

IMPROVEMENTS ALONG THE

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DRAFT 60% PLAN SET
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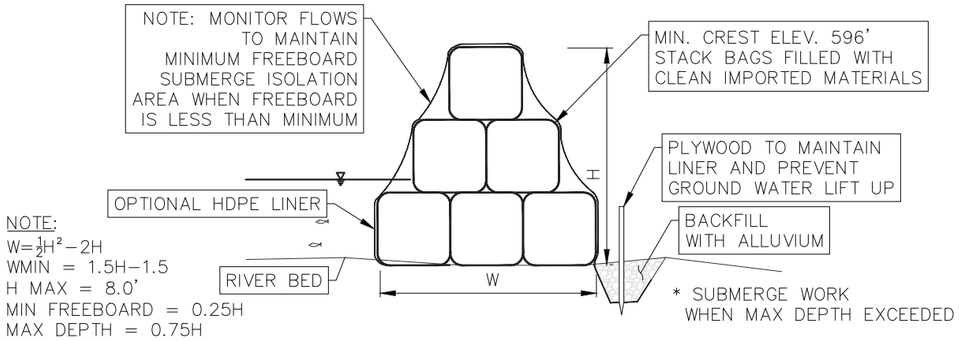
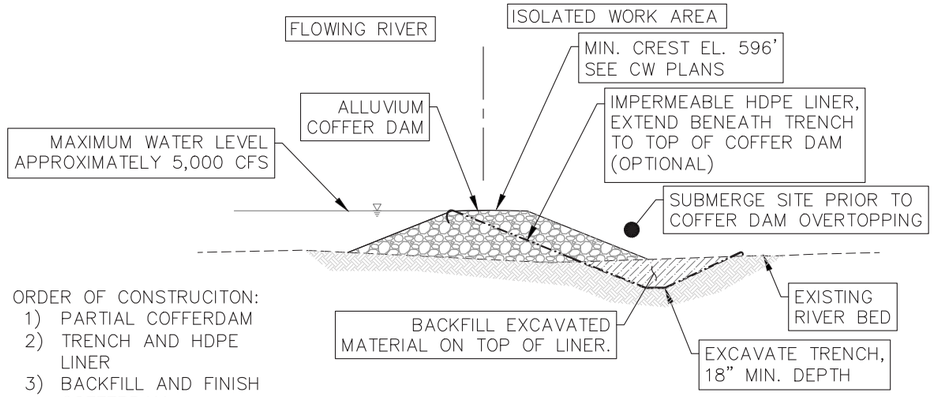
Sheet No. 13 of 34
T08



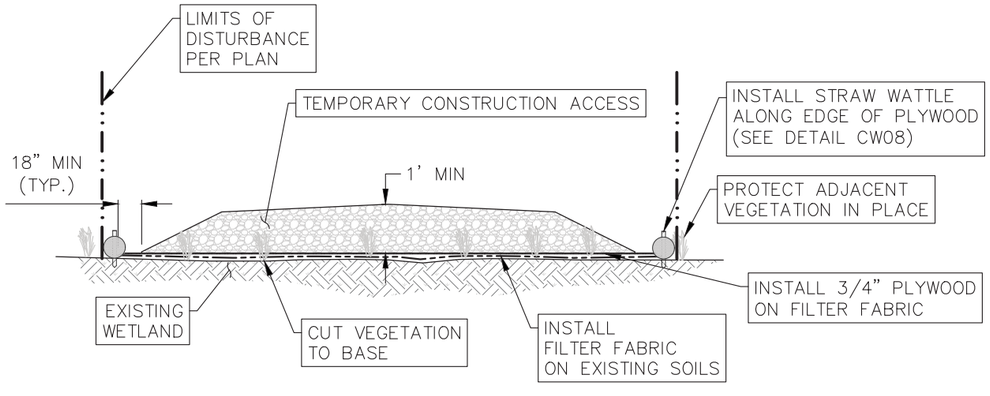
47 AGGREGATE BAGS COFFER DAM (TYPICAL) — 1 / T09

SECTION VIEW – NTS



47 ALLUVIUM COFFER DAM WITH LINER (TYPICAL) — 2 / T09

SECTION VIEW – NTS

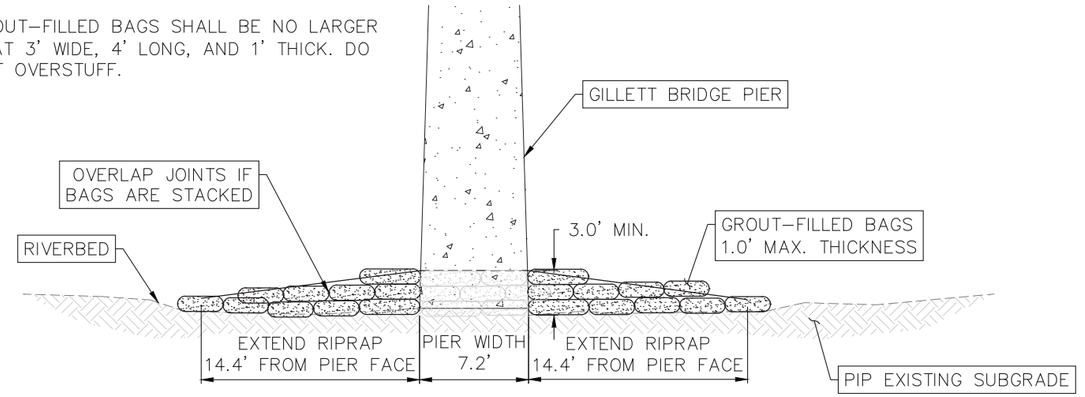


TEMPORARY WETLAND PROTECTION — 3 / T09

NTS

LEGEND: 47 MICHIGAN UNIFIED KEYING SYSTEM – SOIL EROSION & SEDIMENTATION CONTROL MEASURES – SEE SHEET CW00

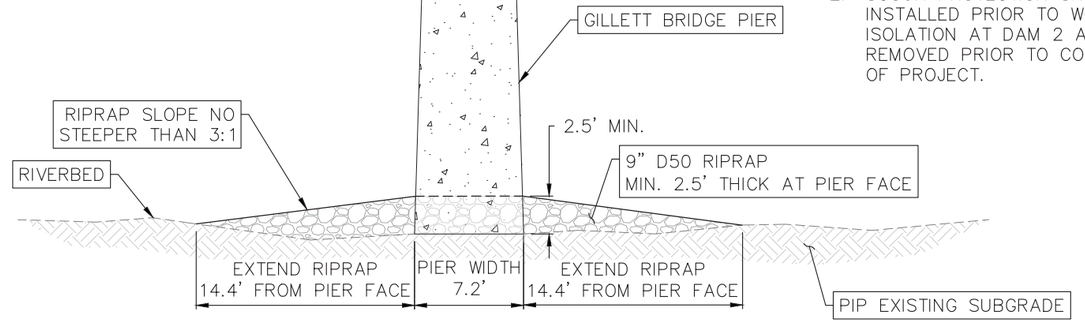
NOTES:
1. GROUT–FILLED BAGS SHALL BE NO LARGER THAT 3' WIDE, 4' LONG, AND 1' THICK. DO NOT OVERSTUFF.



TEMPORARY SCOUR PROTECTION AT GILLETT BRIDGE PIERS GROUT BAG OPTION — 4 / T09

SECTION VIEW – NTS

NOTES:
1. SCOUR PROTECTION SHALL BE PLACED ENTIRELY AROUND BRIDGE PIER AND EXTENDED TO THE LENGTHS SHOWN IN DETAIL.
2. SCOUR PROTECTION SHALL BE INSTALLED PRIOR TO WORK ISOLATION AT DAM 2 AND REMOVED PRIOR TO COMPLETION OF PROJECT.



TEMPORARY SCOUR PROTECTION AT GILLETT BRIDGE PIERS RIPRAP OPTION — 5 / T09

SECTION VIEW – NTS

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - DETAILS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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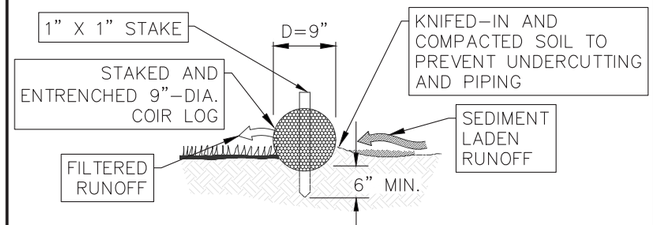
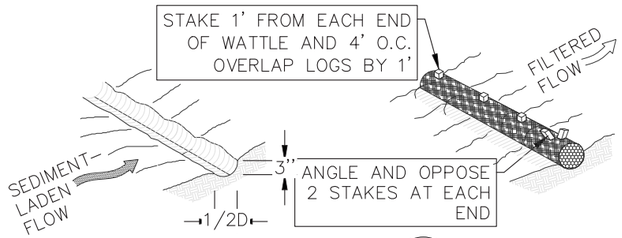
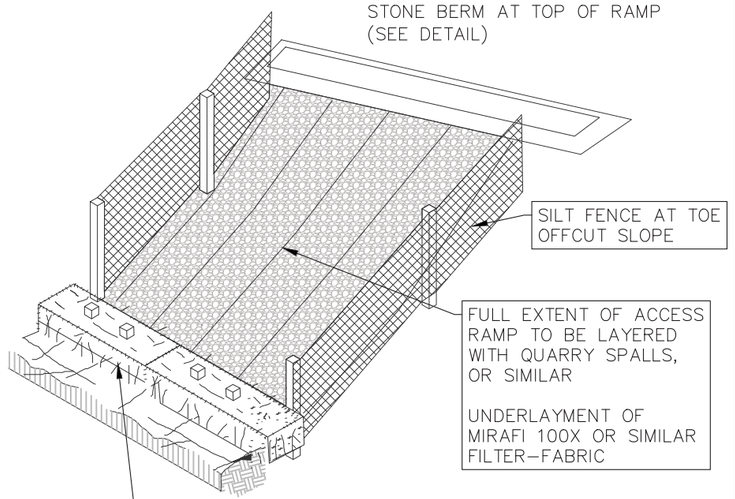


PROPERLY INSTALLED COIR LOG
(CROSS-SECTION)

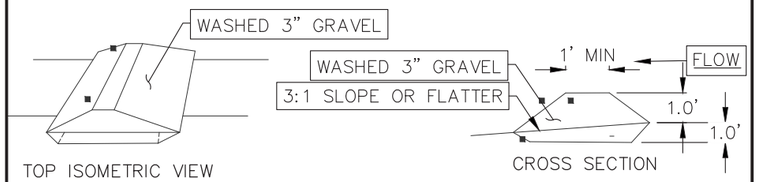
INSTALLATION STEPS:
1. EXCAVATE THE TRENCH
2. PLACE AND STAKE STRAW WATTLES
3. PLACE SPOILS UP-SLOPE FROM LOG, KNIFE-IN AND COMPACT



COIR LOG (TYPICAL) NTS — 1 / T10



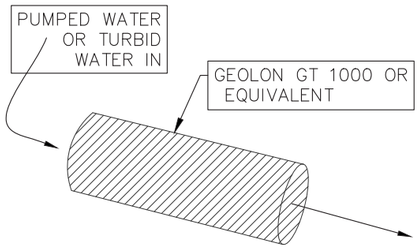
TEMPORARY EQUIPMENT ACCESS (TYPICAL) NTS — 2 / T10



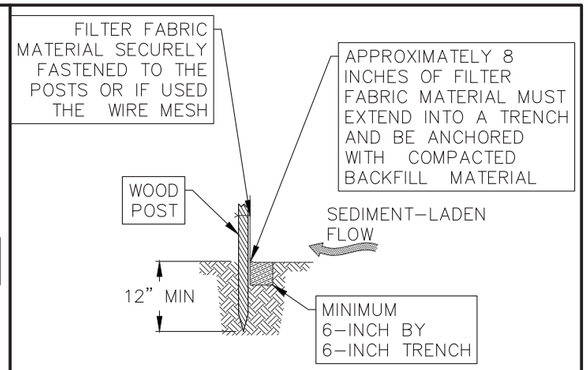
TOP ISOMETRIC VIEW

CROSS SECTION

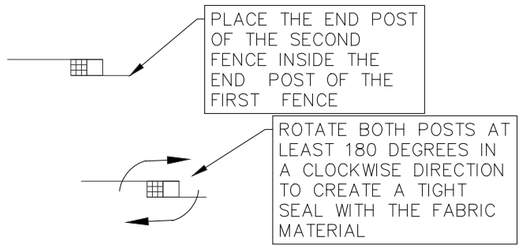
21 STONE BERM NTS — 3 / T10

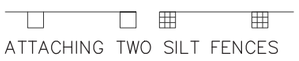


GEO-TUBEFILTER (TYPICAL) NTS — 5 / T10

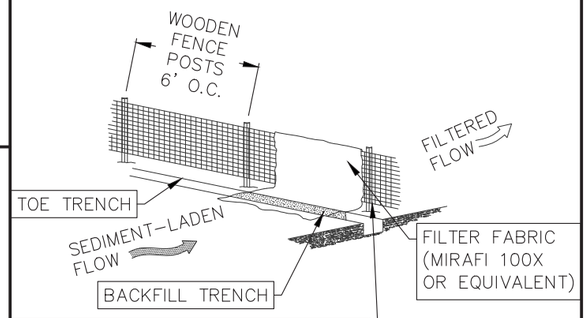


TOE TRENCH
(CROSS SECTION)





ATTACHING TWO SILT FENCES



21A SILT FENCE (TYPICAL) NTS — 6 / T10

LEGEND:

47 MICHIGAN UNIFIED KEYING SYSTEM – SOIL EROSION & SEDIMENTATION CONTROL MEASURES – SEE SHEET CW00

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TEMP. CONSTRUCTION ACCESS & CARE OF WATER - DETAILS

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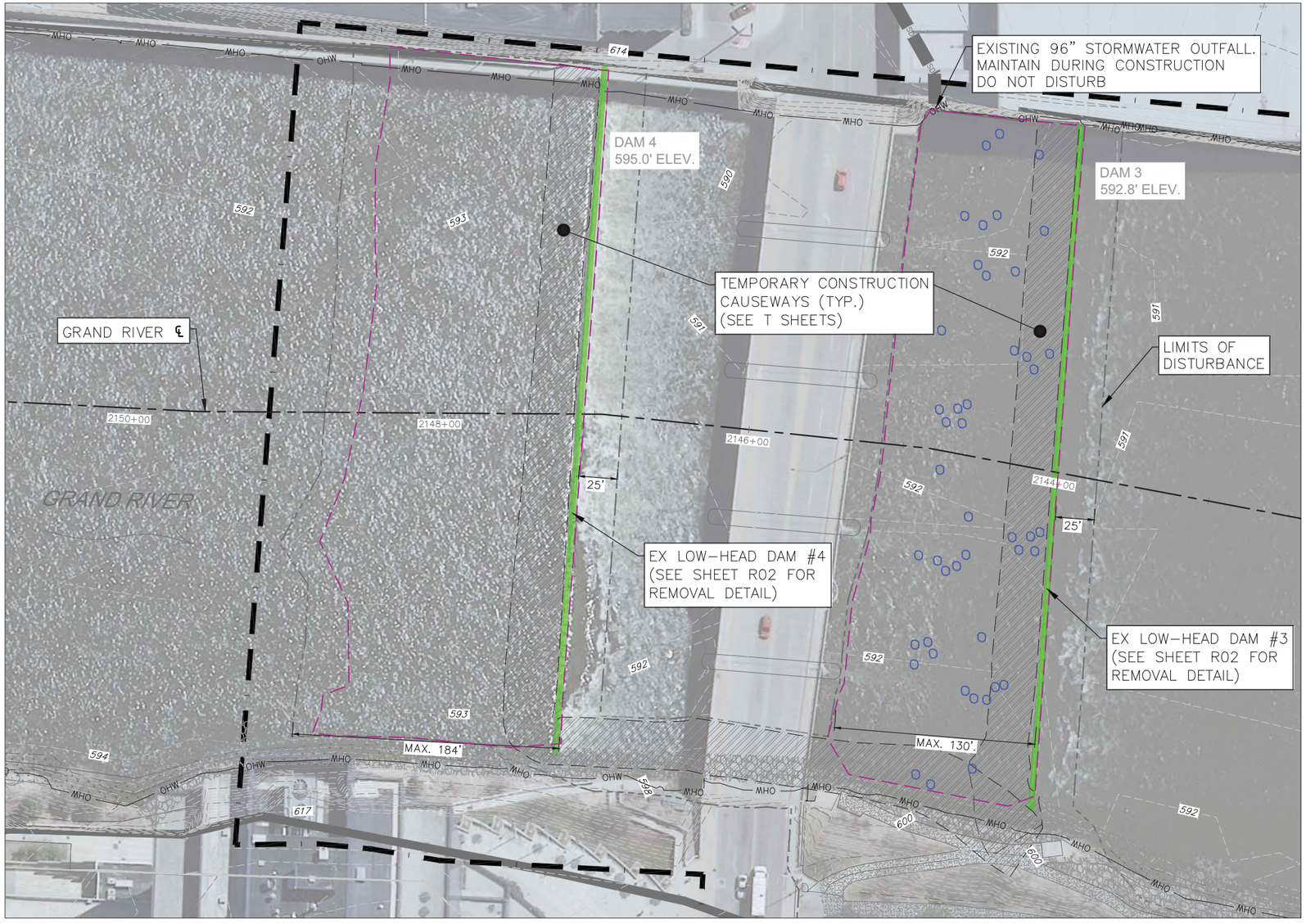


LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

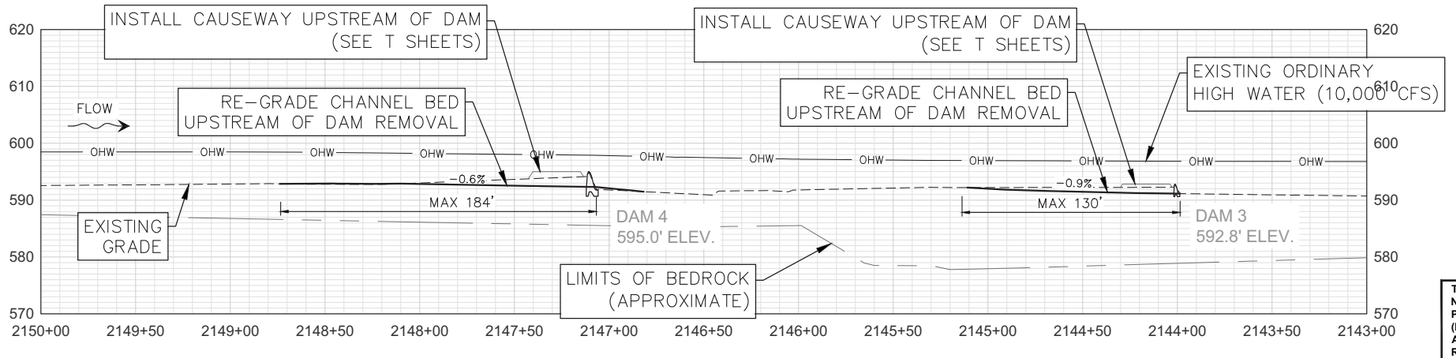
NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

SEE SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED

NORTH

0 40' 80'

SCALE: 1" = 40'



THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAMS 3 AND 4 REACH

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

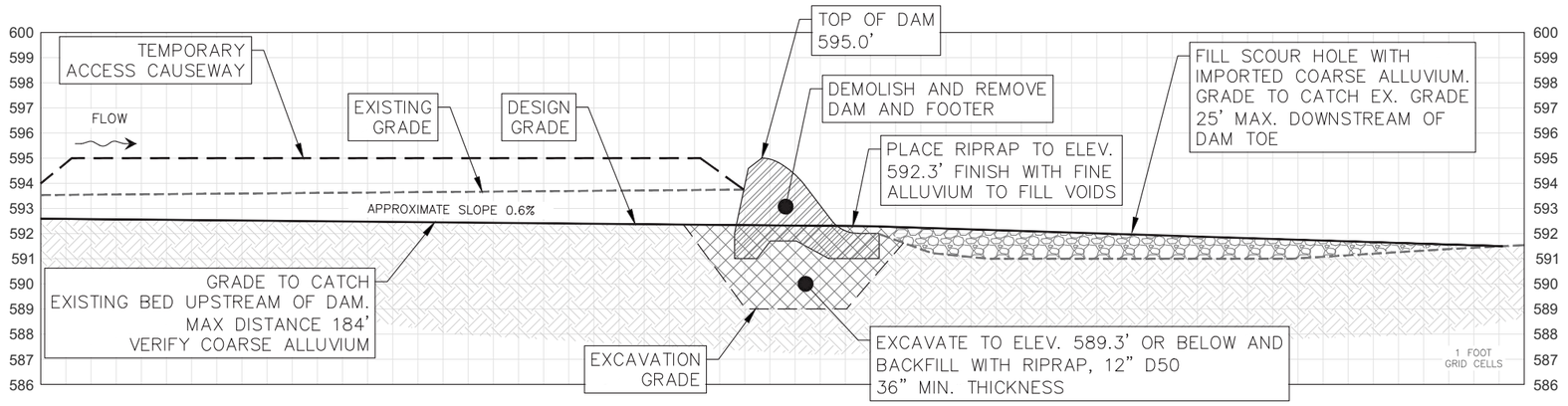
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

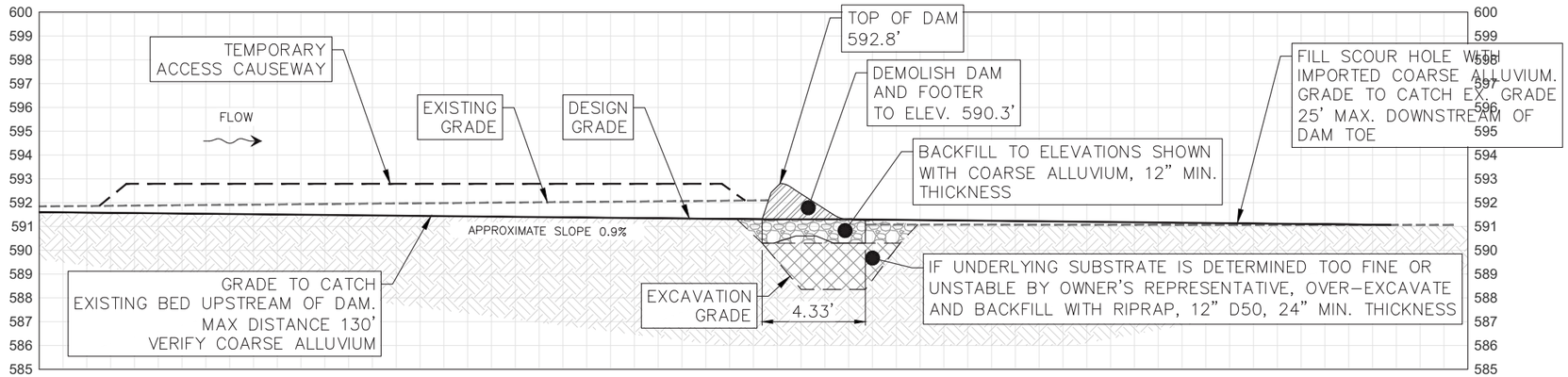
Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 16 of 34 R01



1 / R02 DEMOLITION AND REMOVAL OF DAM 4



2 / R02 LOW-HEAD DAM 3 DEMOLITION

NOTE:

VERIFY PRESENCE OF COARSE ALLUVIUM GRADATION OR LARGER AT EXCAVATION GRADE BENEATH HEAVY RIPRAP. IF UNSUITABLE, NOTIFY OWNERS REPRESENTATIVE. IF DETERMINED NECESSARY, OVER-EXCAVATE 12 INCHES MINIMUM AND BACKFILL WITH COARSE ALLUVIUM TO EXCAVATION GRADE.

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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DAMS 3 AND 4 REMOVAL DETAIL

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GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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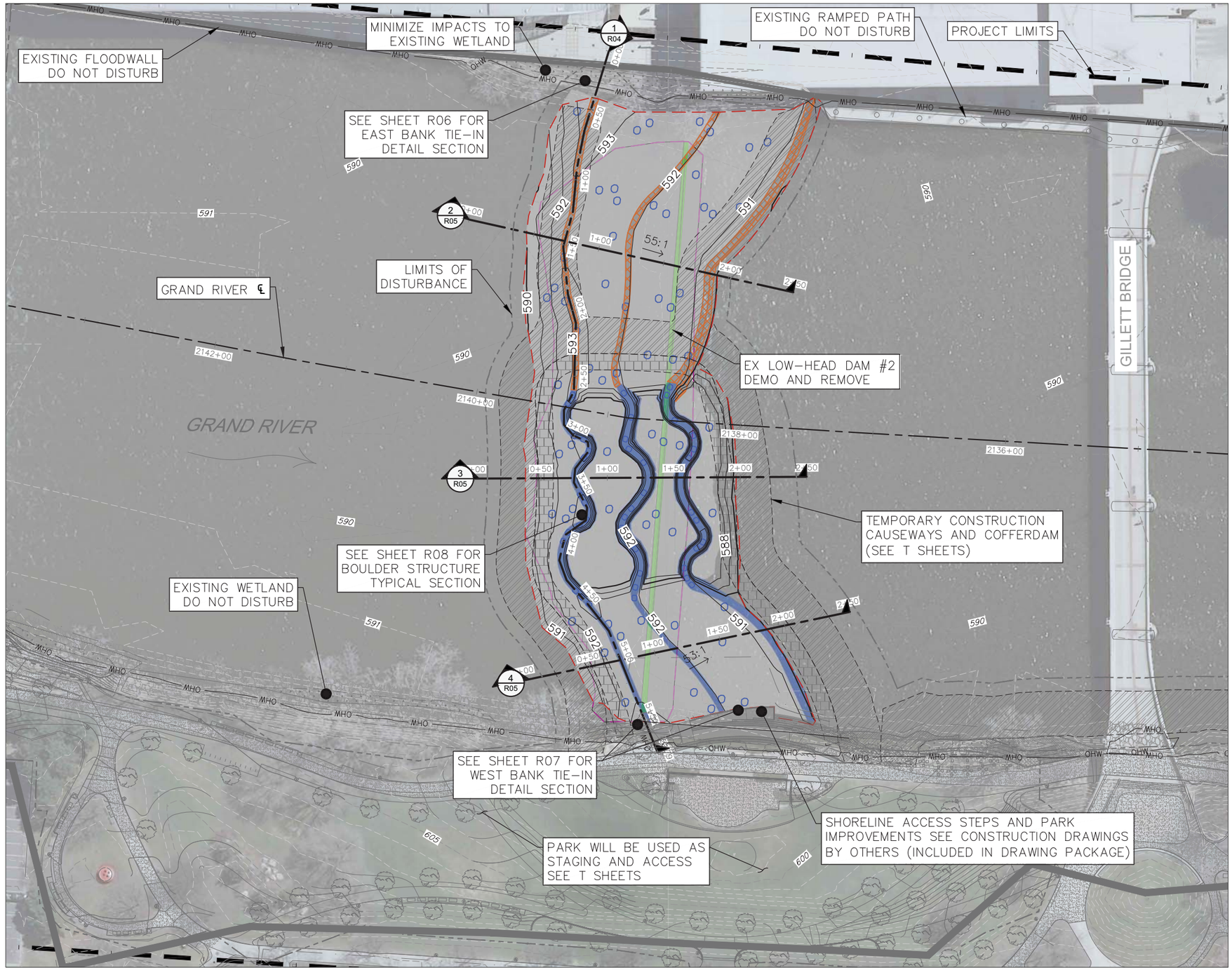
GPF No. 5315

Sheet No. 17 of 34 R02



LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

SEE SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED

NORTH

0 40' 80'

SCALE: 1" = 40'

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH

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IMPROVEMENTS ALONG THE

GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
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Drawn by _____
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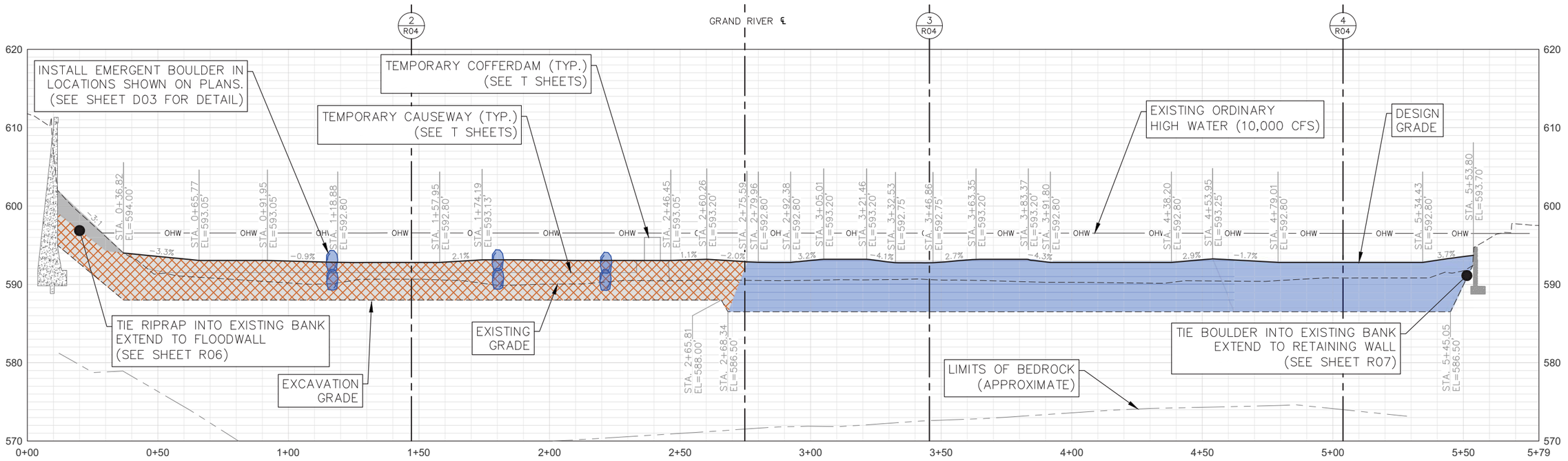
GPF No. 5315

Sheet No. 18 of 34 R03



1 R04 DESIGN SECTION
CREST INVERT

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- BOULDER (PLAN) SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH CROSS SECTION

SURVEYED & DESIGNED BY:

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Drawn by _____
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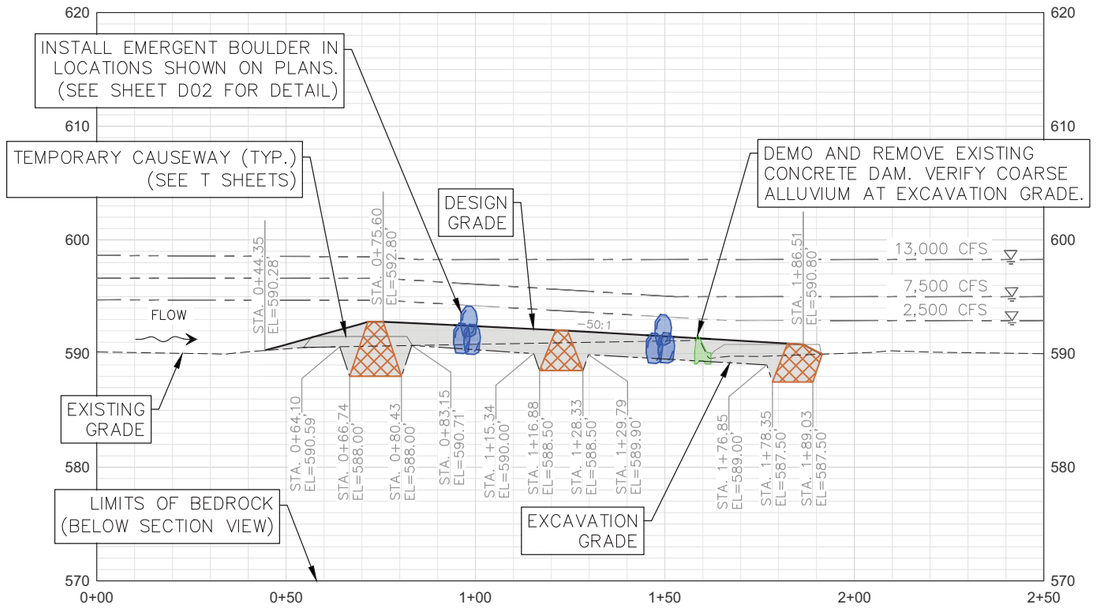
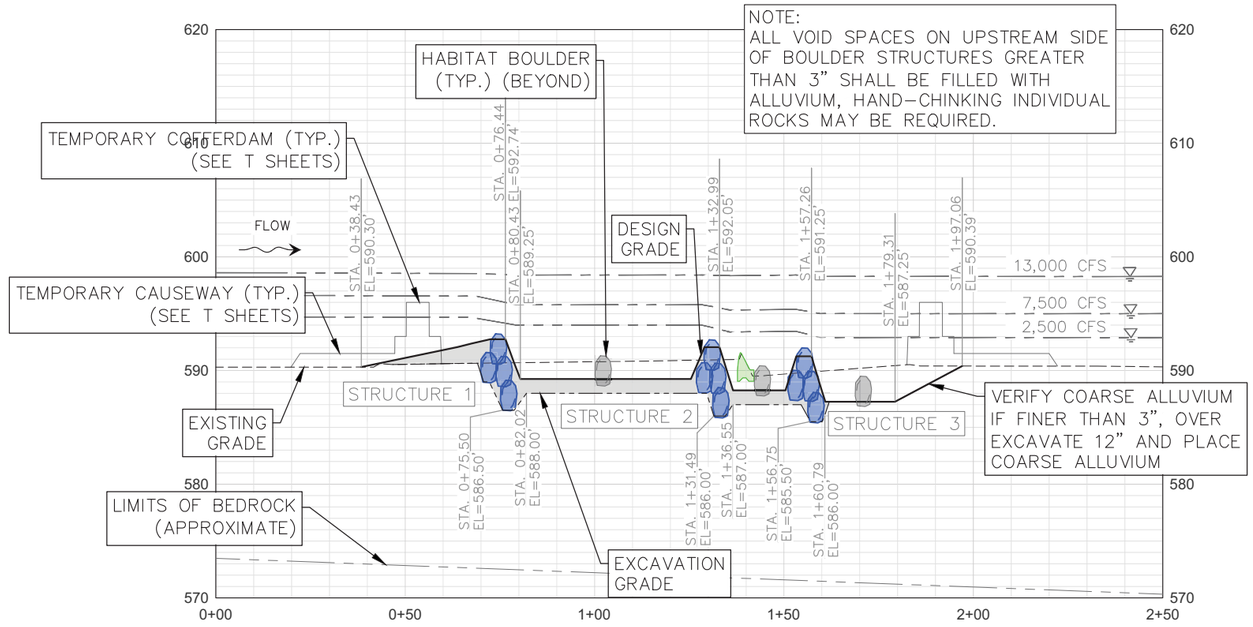
GPF No. 5315

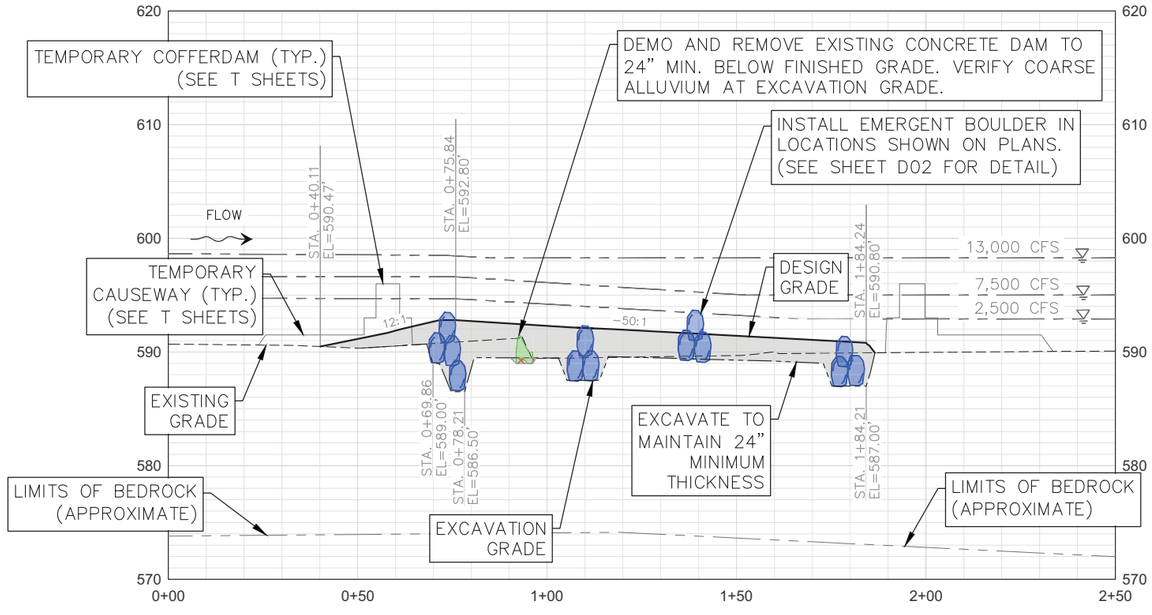
Sheet No. 19 of 34 R04



2 R05 DESIGN PROFILE
CONSTRUCTED RIFFLE – EAST



3 R05 DESIGN PROFILE
BOULDER ARCH STRUCTURES



4 R05 DESIGN PROFILE
CONSTRUCTED RIFFLE – WEST

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION

MODELED HEADLOSS OVER BOULDER ARCH STRUCTURES

Flow rate (cfs)	Headloss over arch structure (ft)		
	Structure 1	Structure 2	Structure 3
1,200	0.5	0.7	0.7
2,500	0.4	0.6	0.7
3,900	0.3	0.7	0.7
5,000	0.2	0.5	0.7
7,500	0.2	0.3	0.7
10,000	0.1	0.1	0.5
13,000	0.1	0.1	0.2

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH PROFILES

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(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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Drawn by _____
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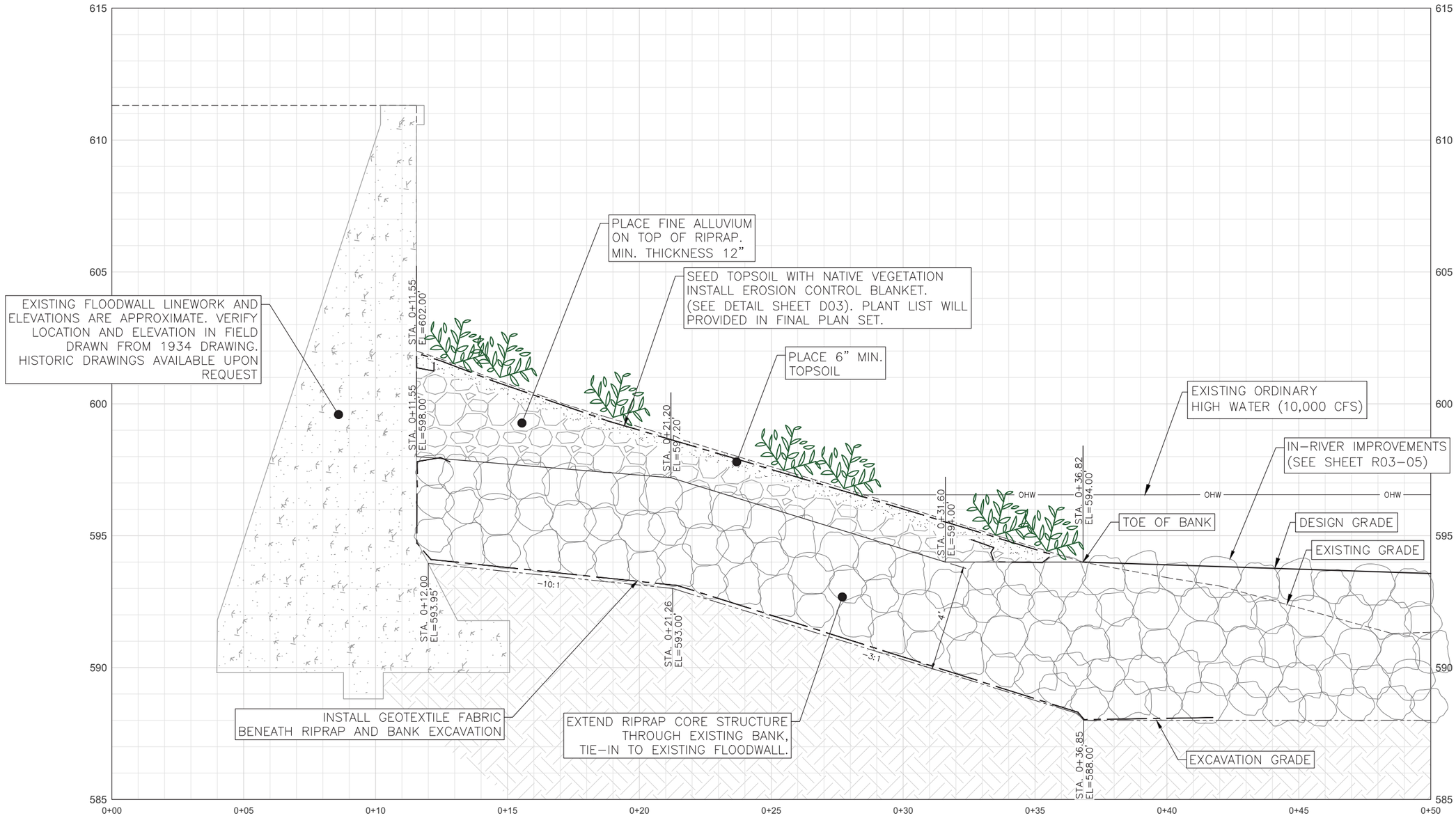
GPF No. 5315

Sheet No. 20 of 34 R05



1 R06 EAST TIE-IN DETAIL SECTION

0 2' 4'
SCALE: 1" = 2'
NO VERTICAL EXAGGERATION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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DAM 2 REACH
EAST TIE-IN DETAIL SECTION

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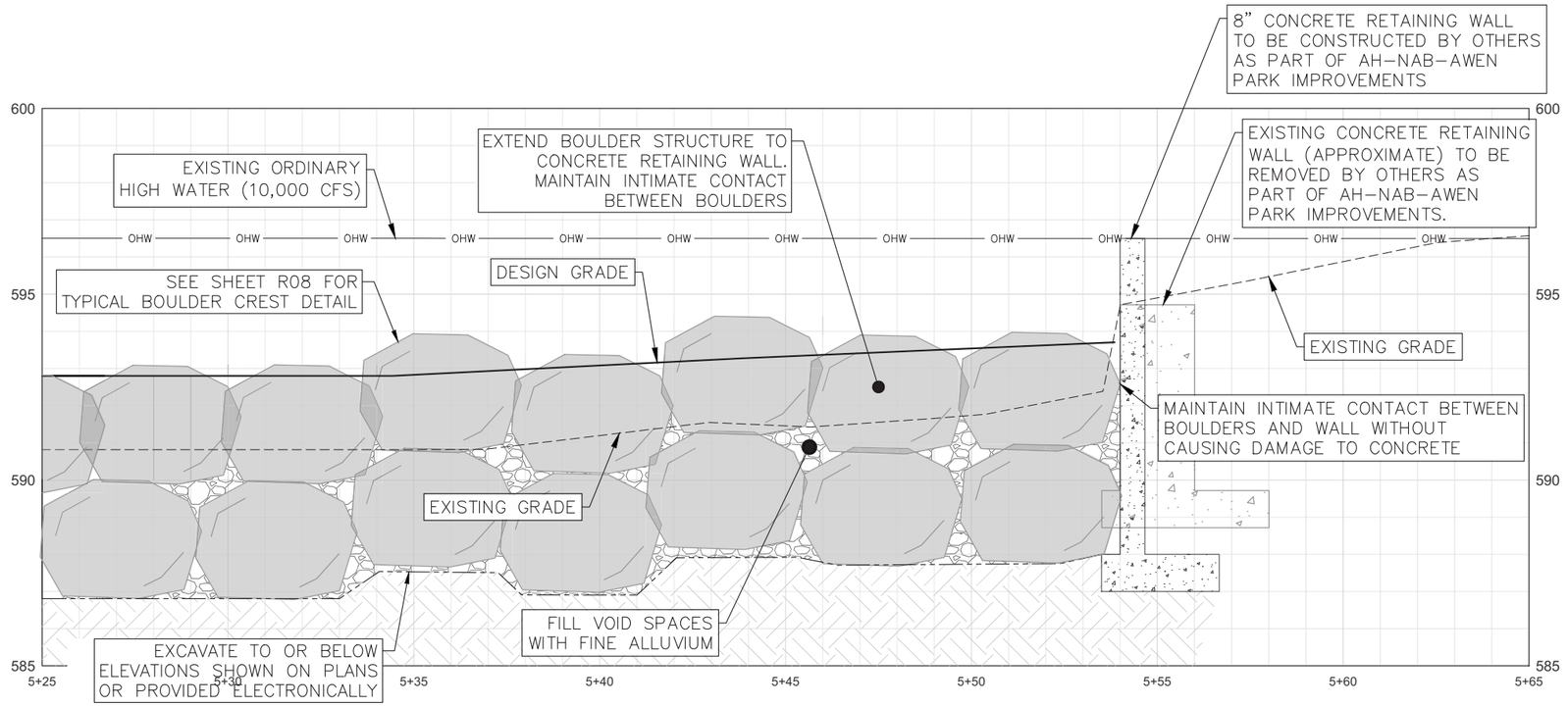
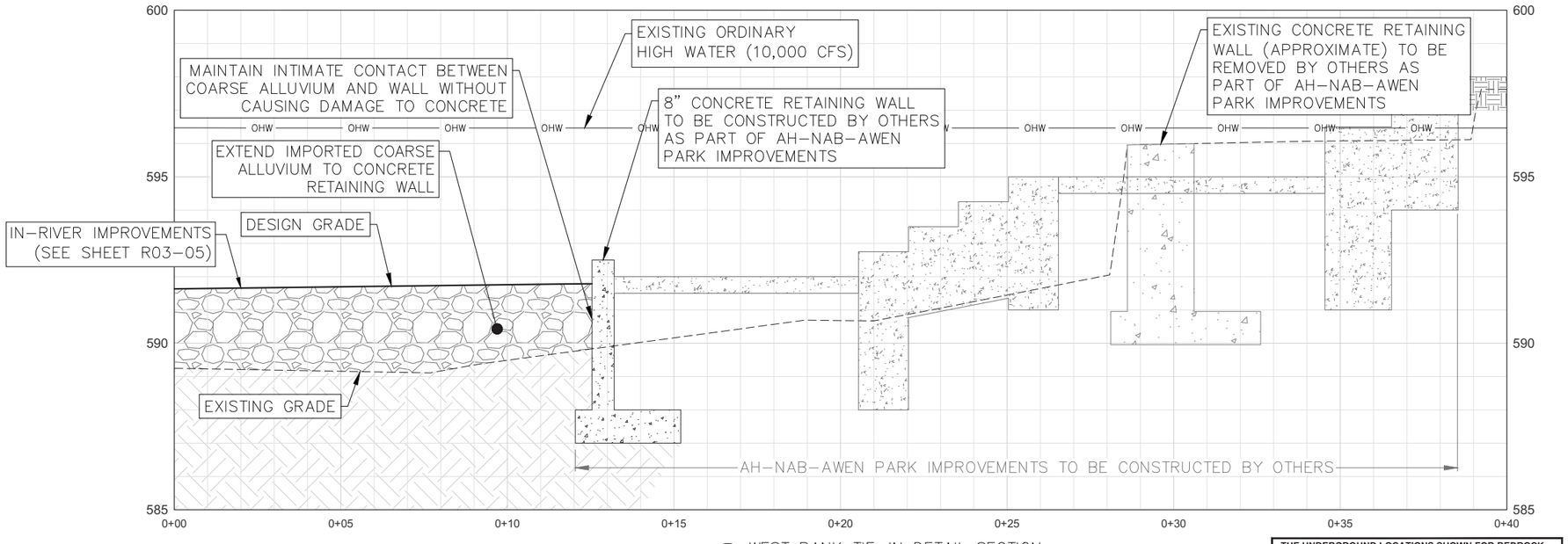
GPF No. 5315

Sheet No. 21 of 34 R06



1 / R07 WEST BANK TIE–IN DETAIL SECTION
BOULDER STRUCTURE CREST



2 / R07 WEST BANK TIE–IN DETAIL SECTION
CONSTRUCTED RIFFLE

0 2' 4'
SCALE: 1" = 2'
NO VERTICAL EXAGGERATION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH
WEST TIE-IN DETAIL SECTIONS

SURVEYED & DESIGNED BY:

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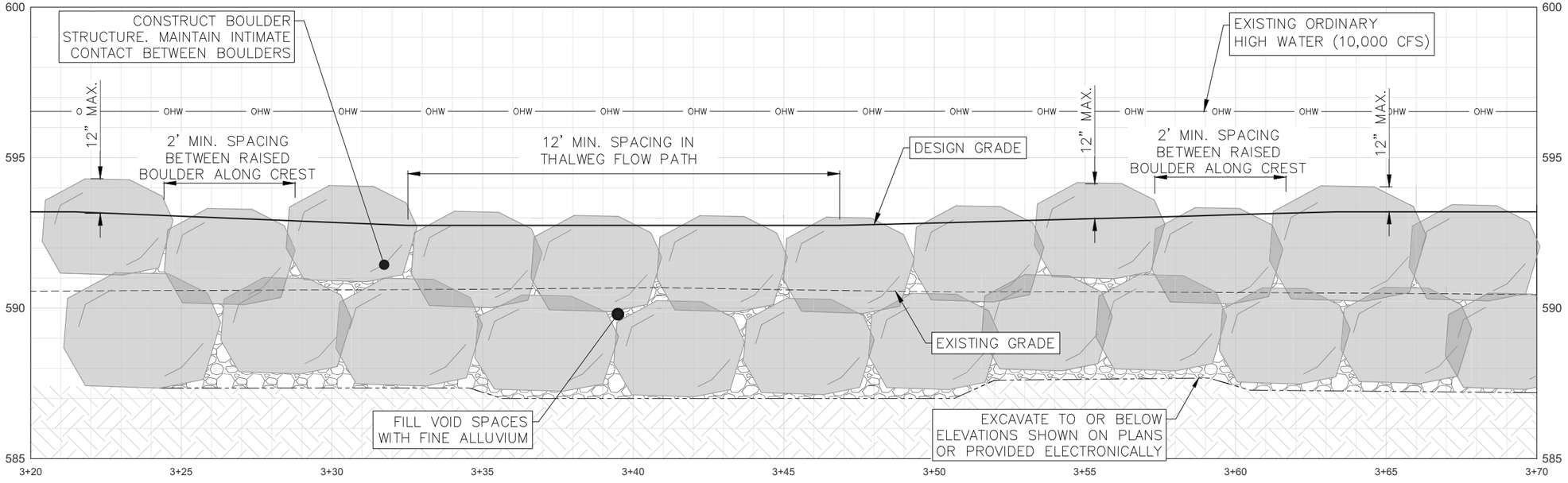
GPF No. 5315

Sheet No. 22 of 34 R07



1 / R08 BOULDER STRUCTURE TYPICAL SECTION
CREST INVERT

0 2' 4'
SCALE: 1" = 2'
NO VERTICAL EXAGGERATION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH
BOULDER STRUCTURE
TYPICAL CREST SECTION

SURVEYED & DESIGNED BY:

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Public Services
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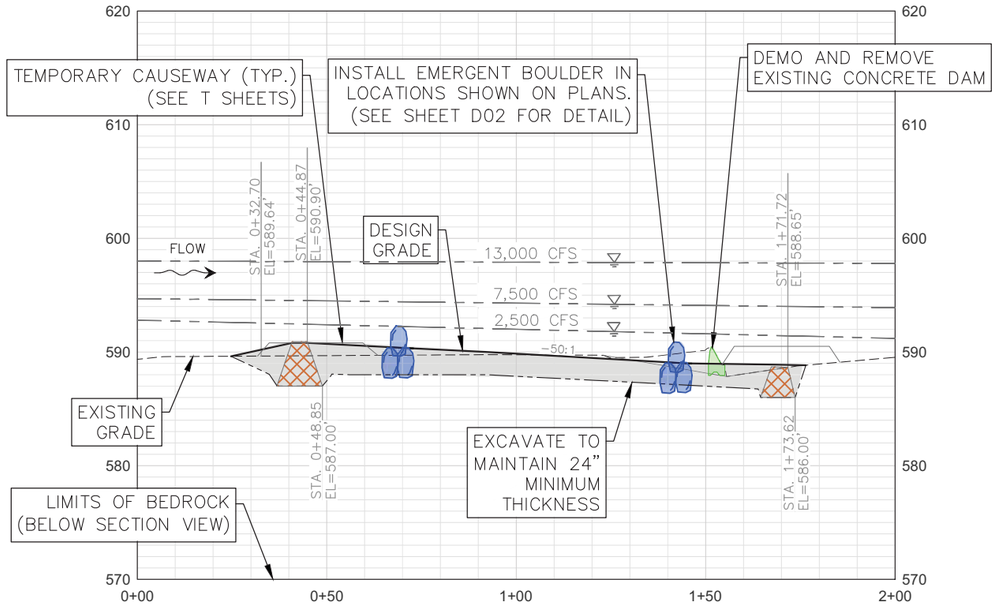
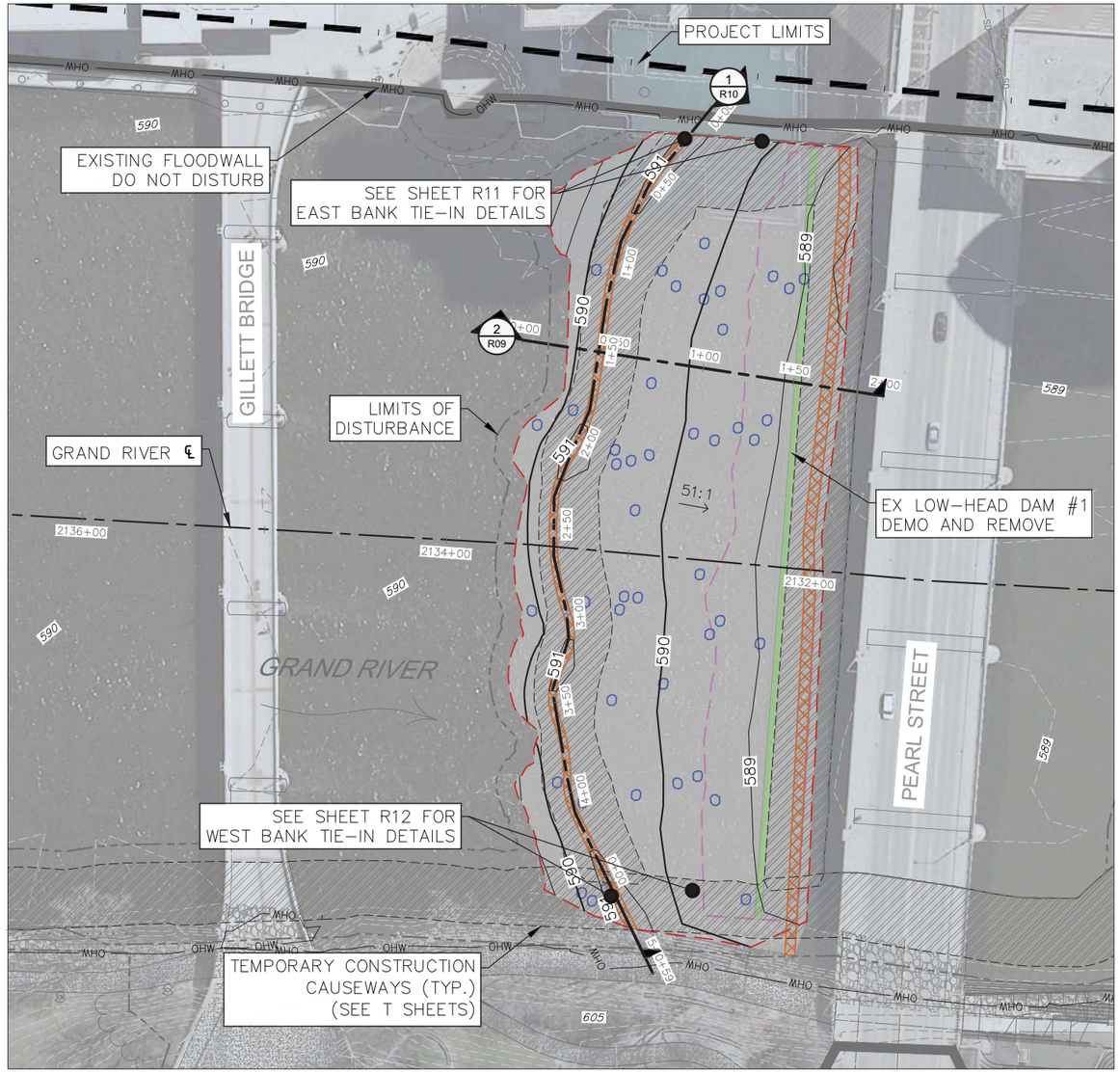
GPF No. 5315

Sheet No. 23 of 34 R08



2 R09 DESIGN PROFILE
CONSTRUCTED RIFFLE

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION



NORTH
0 40' 80'
SCALE: 1" = 40'

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
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REVISIONS

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DAM 1 REACH

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IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
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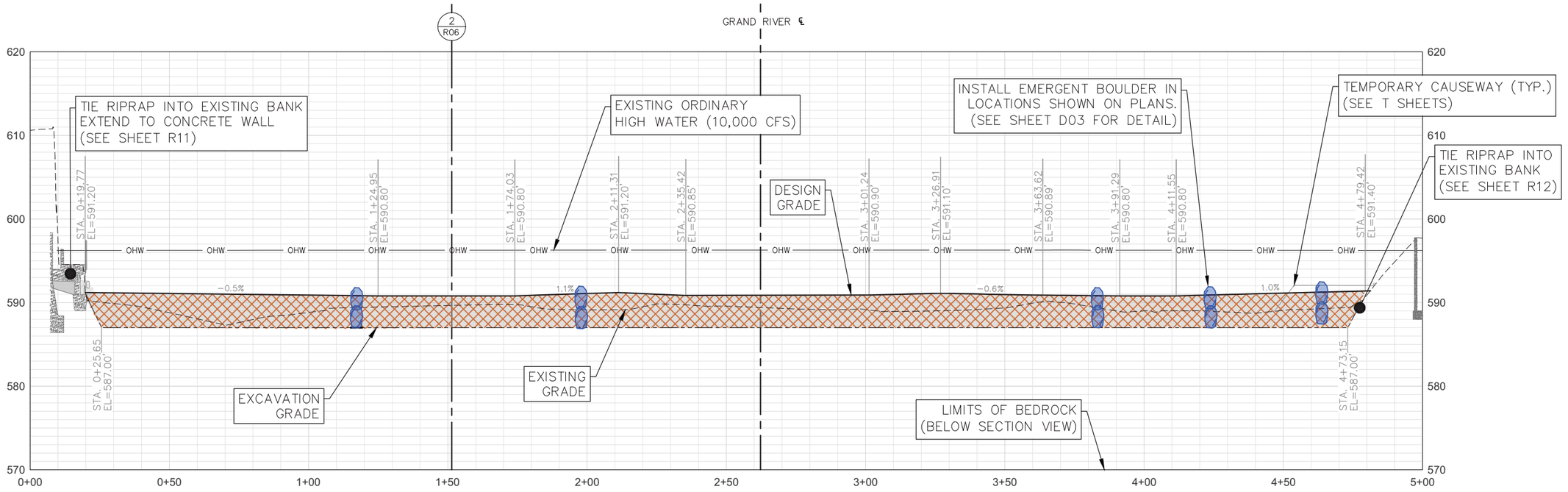
GPF No. 5315

Sheet No. 24 of 34 R09



1 R10 DESIGN SECTION
CREST INVERT

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- EMERGENT HABITAT BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION

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REVISIONS

NO.	DATE	DESCRIPTION

DAM 1 REACH
CROSS SECTION

SURVEYED & DESIGNED BY:

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IMPROVEMENTS
ALONG THE
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DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
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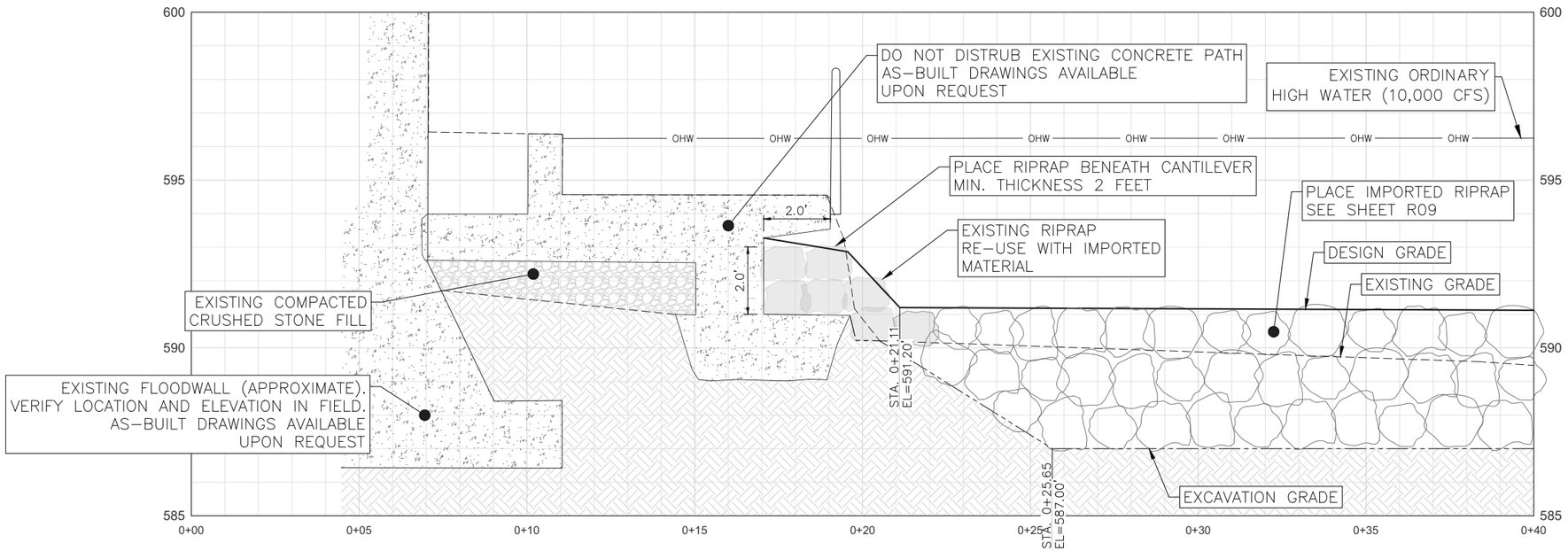
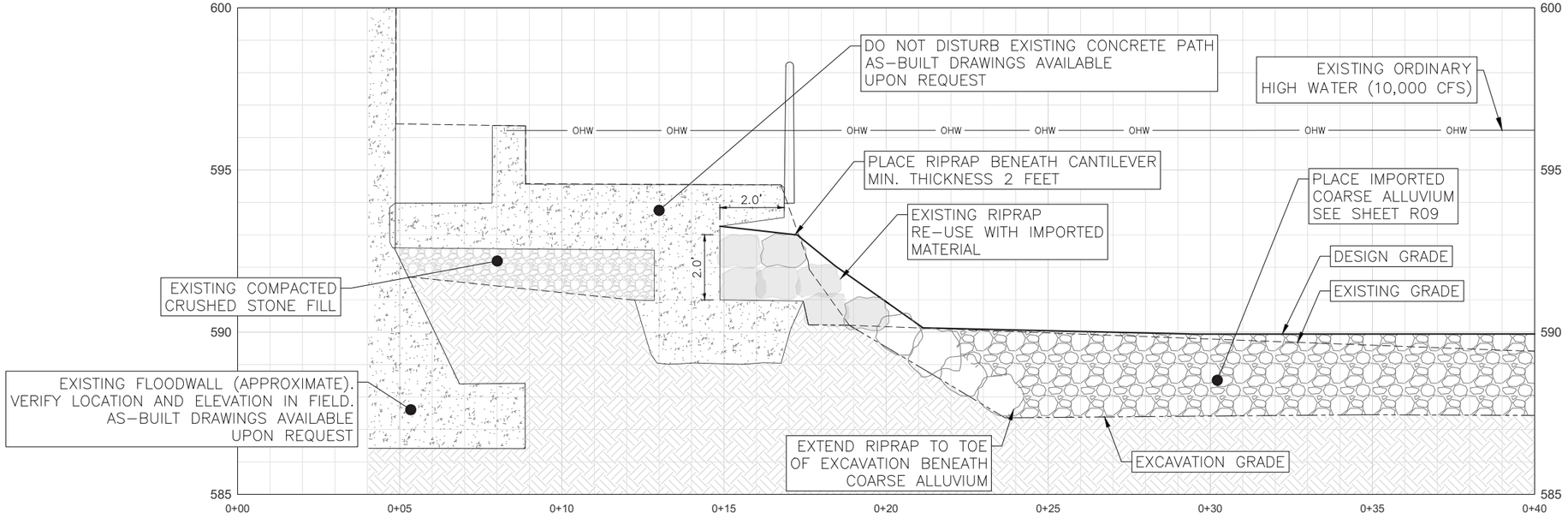
Check: Office _____

GPF No. 5315

Sheet No. 25 of 34 R10



1 / R11 EAST BANK TIE-IN DETAIL SECTION
RIPRAP SUBSTRUCTURE CREST



2 / R11 EAST BANK TIE-IN DETAIL SECTION
CONSTRUCTED RIFFLE

0 2' 4'
SCALE: 1" = 2'
NO VERTICAL EXAGGERATION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 1 REACH
EAST TIE-IN SECTIONS

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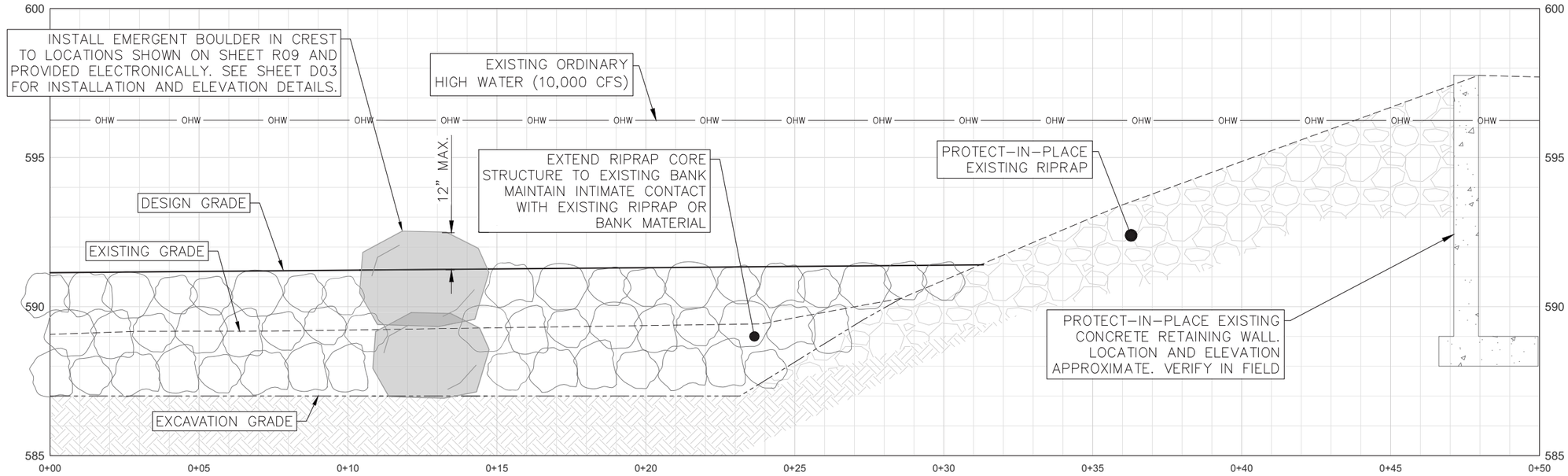
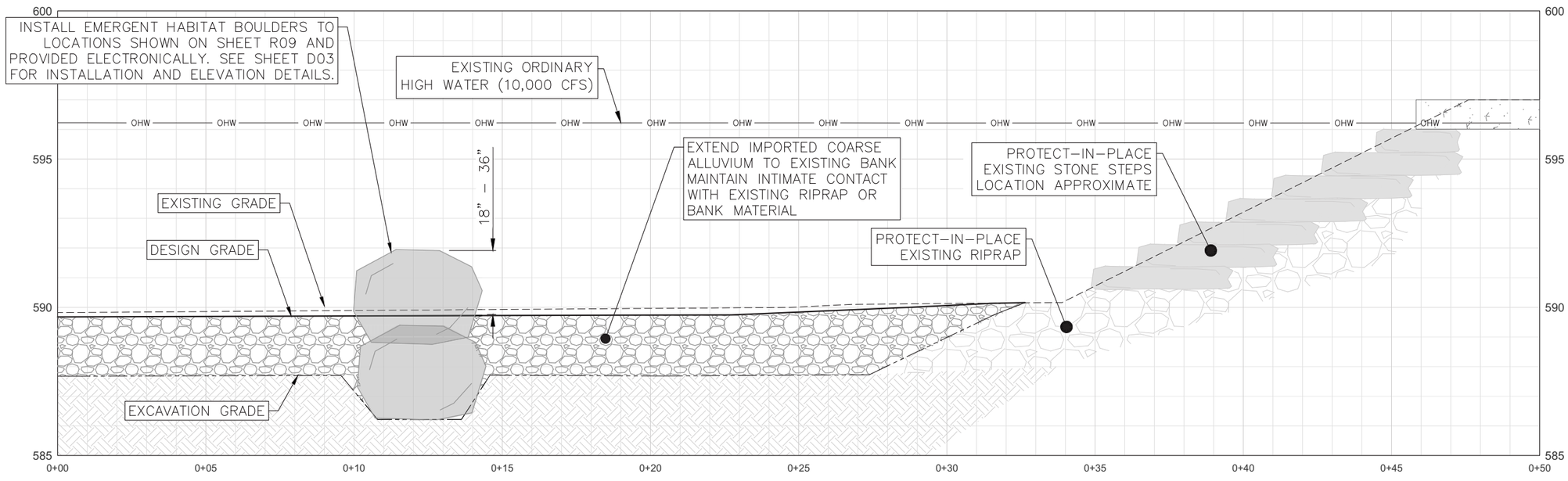
Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 26 of 34 R11



1 / R12 WEST BANK TIE-IN DETAIL SECTION
RIPRAP SUBSTRUCTURE CREST



2 / R12 WEST BANK TIE-IN DETAIL SECTION
CONSTRUCTED RIFFLE

0 2' 4'
SCALE: 1" = 2'
NO VERTICAL EXAGGERATION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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WEST TIE-IN SECTIONS

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DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

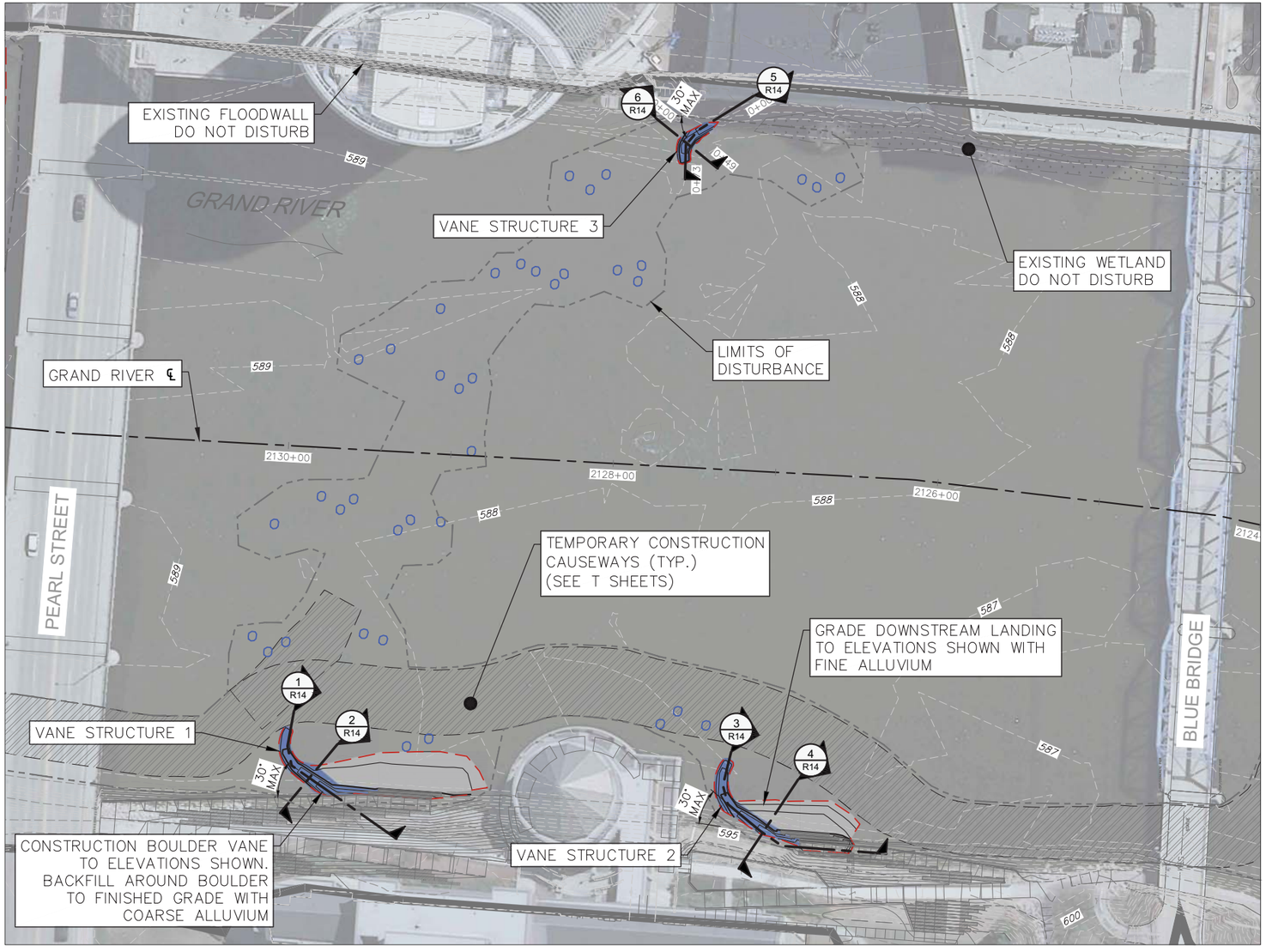
Sheet No. 27 of 34 R12

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (STABLE IMPORTED ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

SEE SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED



NORTH

0 60' 120'

SCALE: 1" = 60'

PEARL ST. TO BLUE BRIDGE REACH

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
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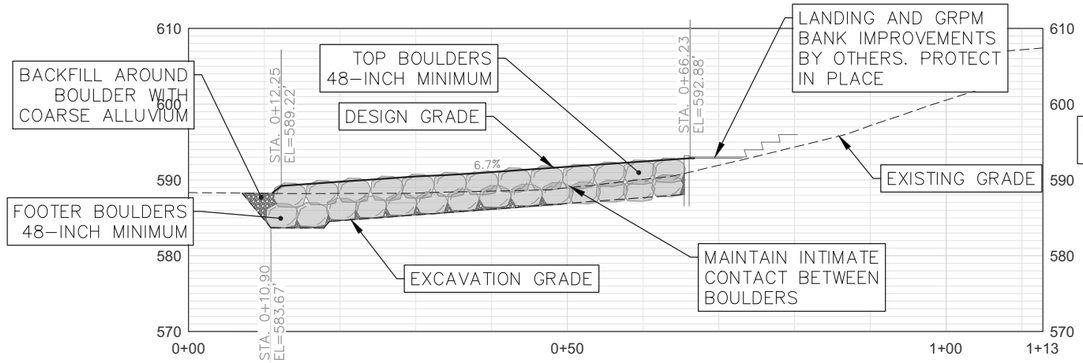
Check: Office _____

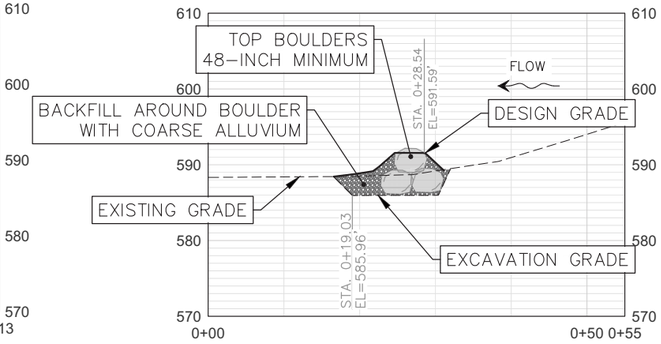
GPF No. 5315

Sheet No. 28 of 34 R13

VANE STRUCTURE 1



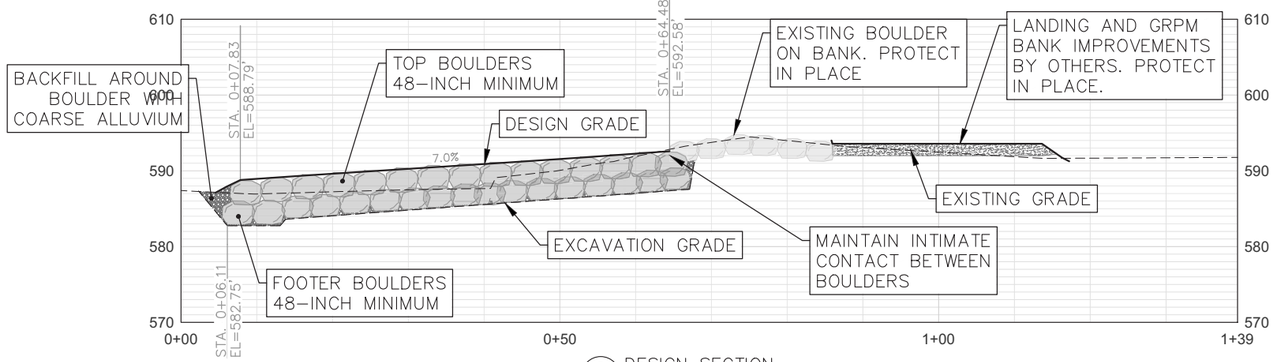
1 R14 DESIGN SECTION
VANE STRUCTURE 1



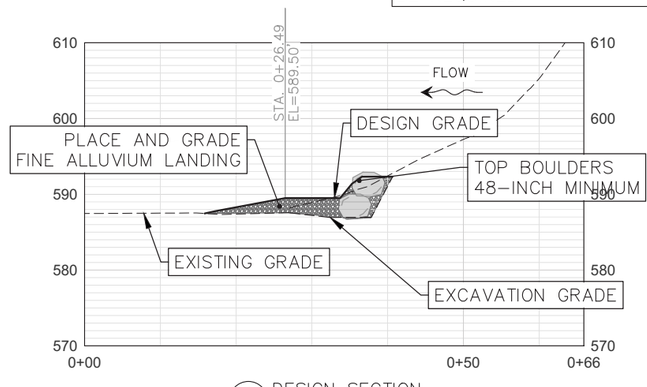
2 R14 DESIGN SECTION
VANE STRUCTURE 1

NOTE:
ALL VOID SPACES ON UPSTREAM SIDE OF BOULDER STRUCTURES GREATER THAN 3" SHALL BE FILLED WITH ALLUVIUM, HAND–CHINKING INDIVIDUAL ROCKS MAY BE REQUIRED.

VANE STRUCTURE 2

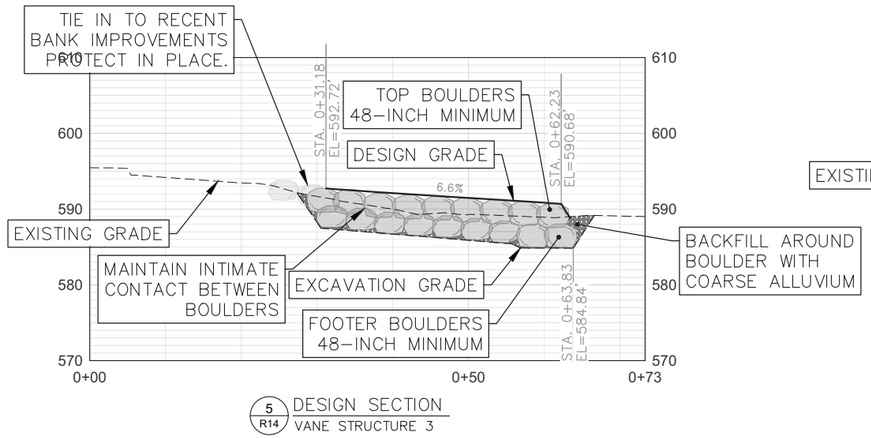


3 R14 DESIGN SECTION
VANE STRUCTURE 2

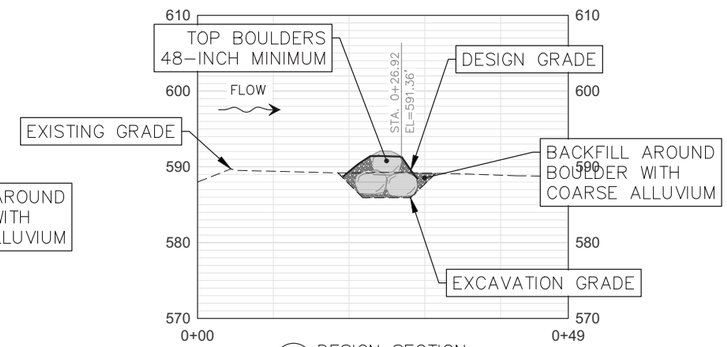


4 R14 DESIGN SECTION
VANE STRUCTURE 2

VANE STRUCTURE 3



5 R14 DESIGN SECTION
VANE STRUCTURE 3



6 R14 DESIGN SECTION
VANE STRUCTURE 3

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

PEARL ST. TO BLUE BRIDGE CROSS SECTIONS

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City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
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NOT FOR CONSTRUCTION

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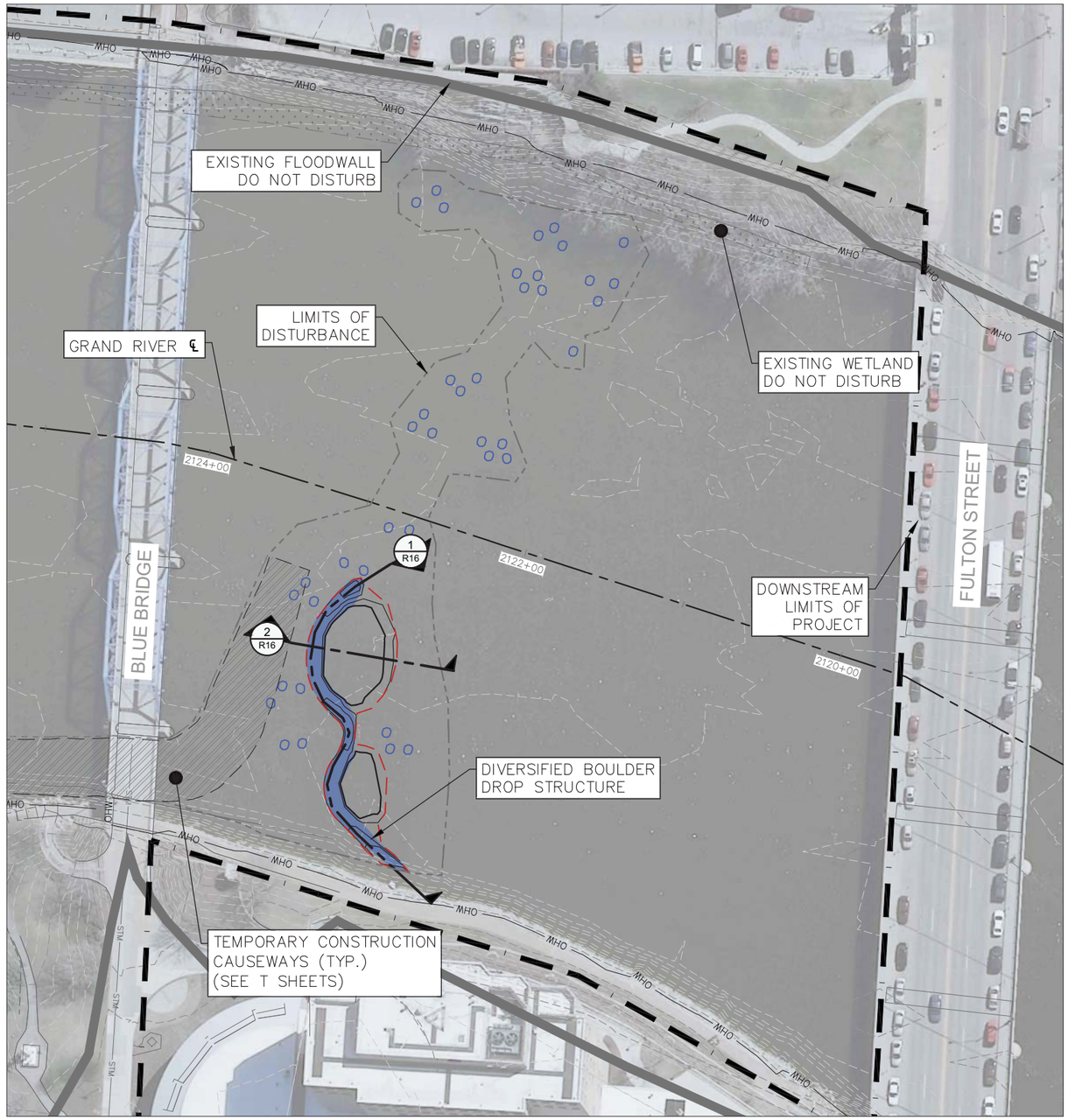
Sheet No. 29 of 34 R14



NORTH

0 60' 120'

SCALE: 1" = 60'

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

SEE SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

BLUE BRIDGE TO FULTON ST. REACH

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

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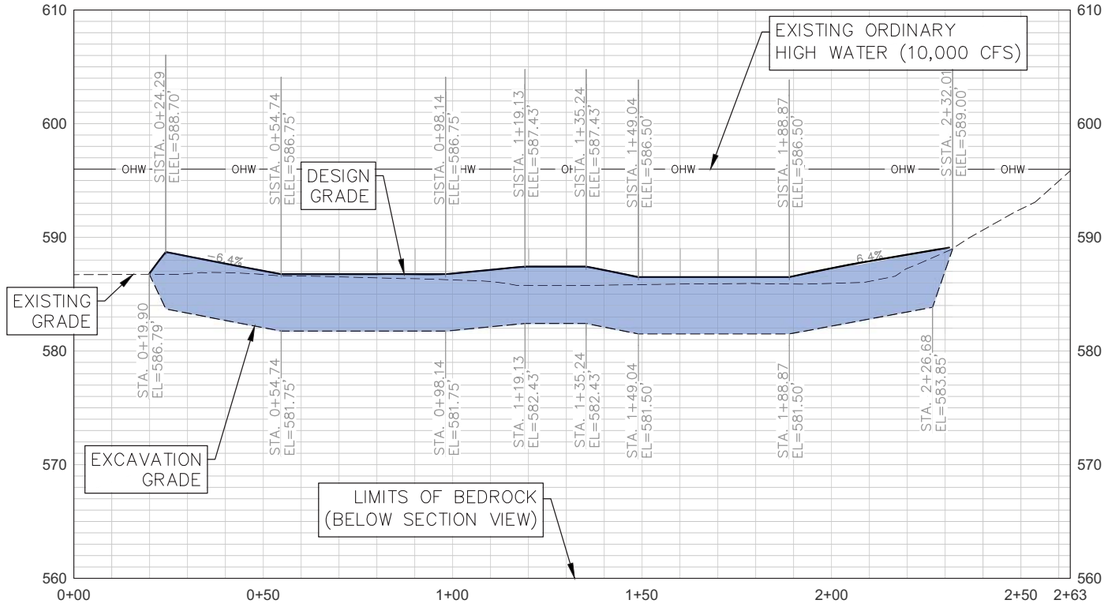
Check: Office _____

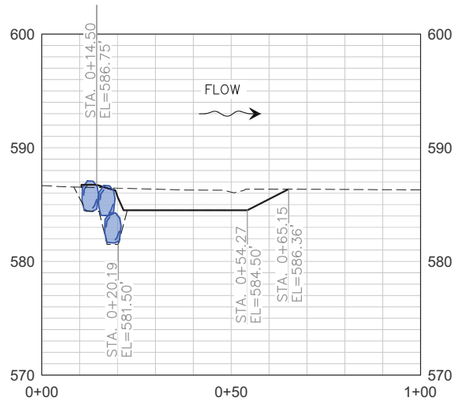
GPF No. 5315

Sheet No. 30 of 34 R15



1 / R16 DESIGN SECTION
CREST INVERT

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION



2 / R16 DESIGN PROFILE
DIVERSIFIED BOULDER DROP STRUCTURE

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- EMERGENT HABITAT BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (STABLE IMPORTED ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

BLUE BRIDGE TO FULTON
CROSS SECTIONS

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GRAND RIVER
FROM FULTON ST. TO I-196

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DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

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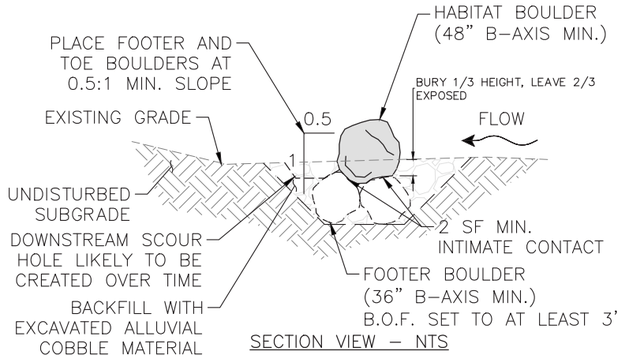
Check: Office _____

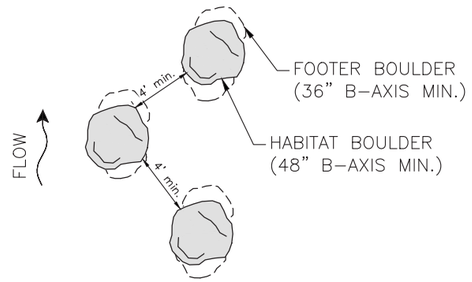
GPF No. **5315**

Sheet No. **31** of **34** **R16**



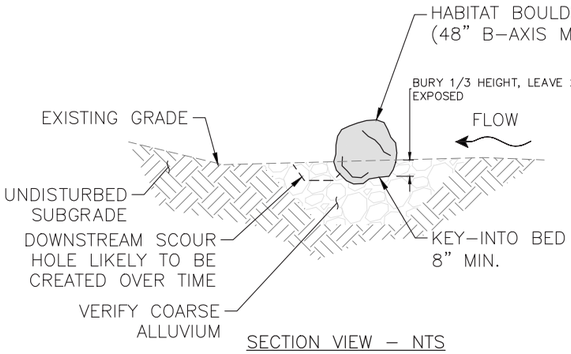
SECTION VIEW – NTS

NOTES:
1. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED.
2. FOOTER BOULDERS ARE NOT REQUIRED IF BEDROCK IS PRESENT.



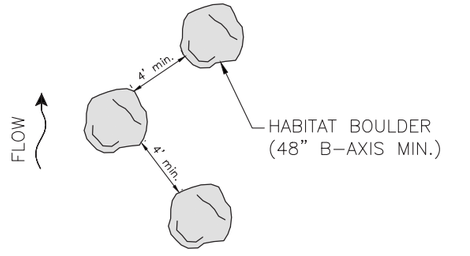
NOTES:
1. INSTALL BOULDER CLUSTERS OF 1–4 BOUILDERS
2. 4' MINIMUM SPACING BETWEEN BOULDERS
3. 12' MINIMUM SPACING BETWEEN BOULDER CLUSTERS
4. OFFSET BOULDERS FROM MAIN CURRENT.

1 / D01 EMERGENT HABITAT BOULDER CLUSTER WITH FOOTER (TYP)
PLAN VIEW – NTS



SECTION VIEW – NTS

NOTES:
1. INCREASED LIKELIHOOD FOR BOULDERS TO SHIFT OR SETTLE OVER TIME IF FOOTER BOULDERS ARE OMITTED



NOTES:
1. INSTALL BOULDER CLUSTERS OF 1–4 BOUILDERS
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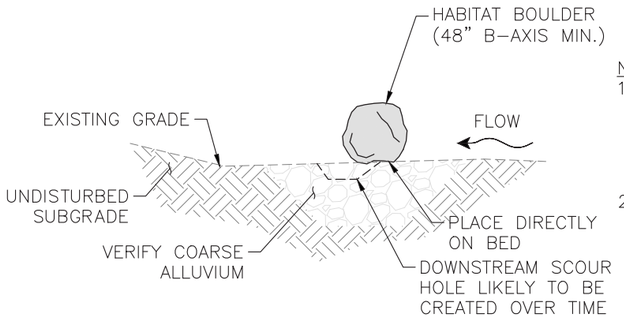
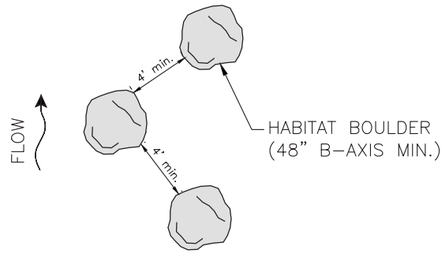
3. 12' MINIMUM SPACING BETWEEN BOULDER CLUSTERS
4. OFFSET BOULDERS FROM MAIN CURRENT.

2 / D01 EMERGENT HABITAT BOULDER CLUSTER, KEYED IN (TYP)
PLAN VIEW – NTS



SECTION VIEW – NTS

NOTES:
1. INCREASED LIKELIHOOD FOR BOULDERS TO SHIFT OR SETTLE OVER TIME IF FOOTER BOULDERS ARE OMITTED
2. INCREASED LIKELIHOOD THAT BOULDER WILL EVENTUALLY ROLL INTO SCOUR HOLE CREATED AT TOE IF NOT KEYED INTO EXISTING COARSE ALLUVIAL BED



NOTES:
1. INSTALL BOULDER CLUSTERS OF 1–4 BOUILDERS
2. 4' MINIMUM SPACING BETWEEN BOULDERS
3. 12' MINIMUM SPACING BETWEEN BOULDER CLUSTERS
4. OFFSET BOULDERS FROM MAIN CURRENT.

3 / D01 EMERGENT HABITAT BOULDER CLUSTER, PLACED (TYP)
PLAN VIEW – NTS

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

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REVISIONS

NO.	DATE	DESCRIPTION

DETAIL SHEET:
EMERGENT HABITAT BOULDER

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

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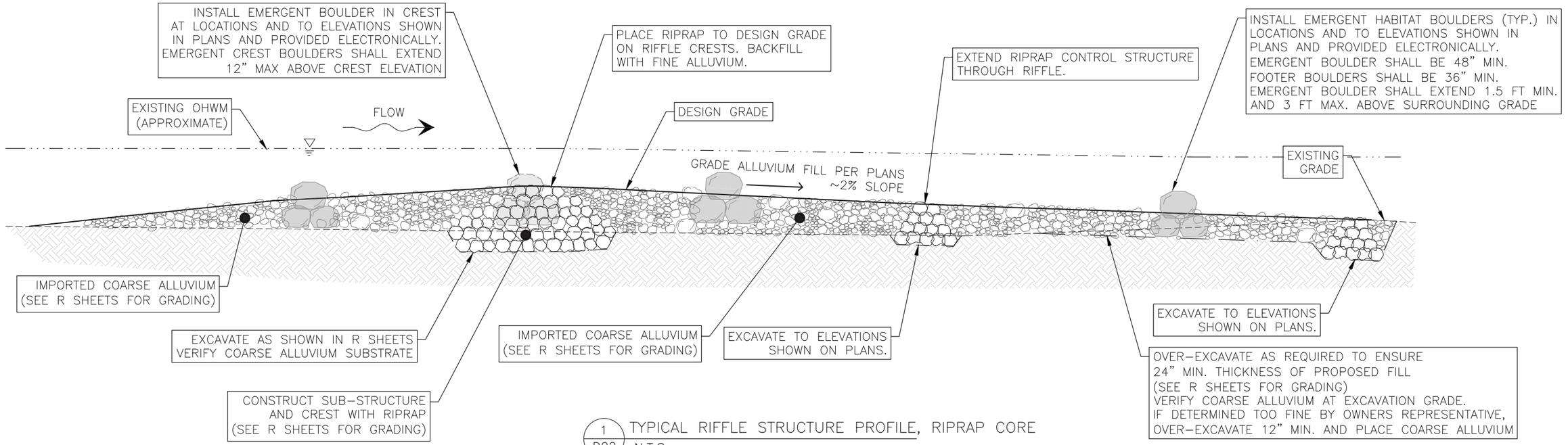
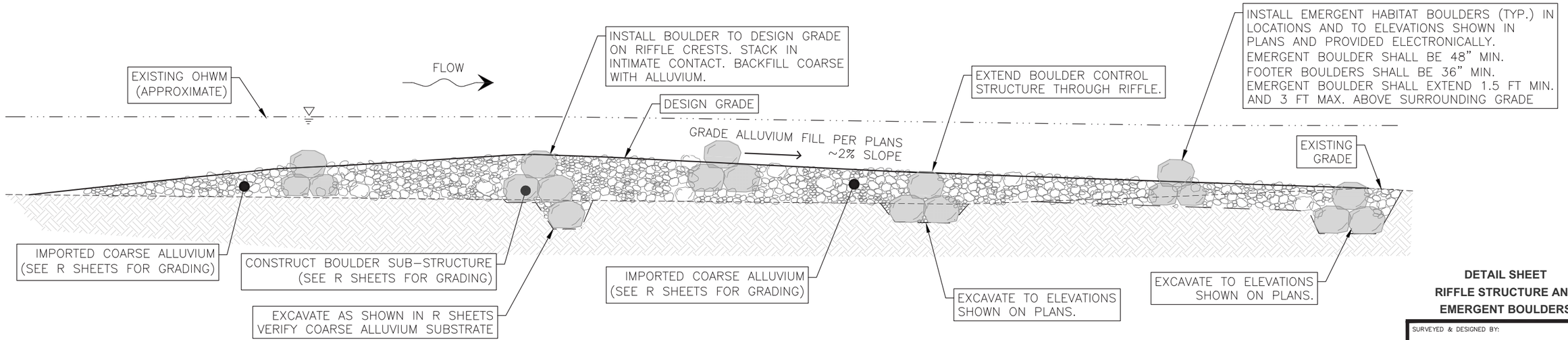
Sheet No. 32 of 34 D01



1 / D02 TYPICAL RIFFLE STRUCTURE PROFILE, RIPRAP CORE
N.T.S.



2 / D02 TYPICAL RIFFLE STRUCTURE PROFILE, BOULDER CORE
N.T.S.

DETAIL SHEET
RIFFLE STRUCTURE AND EMERGENT BOULDERS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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Sheet No. 33 of 34 D02

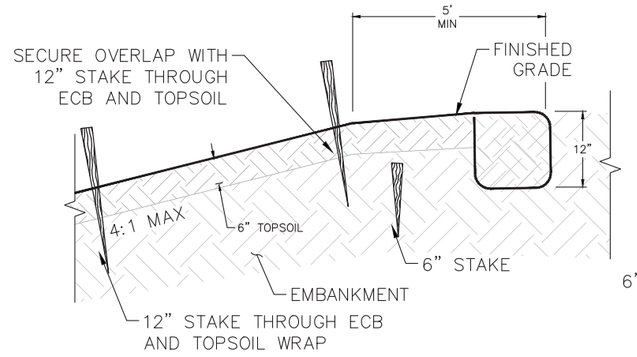


FIGURE A: SECURE ECB AT TOP OF BANK – NTS

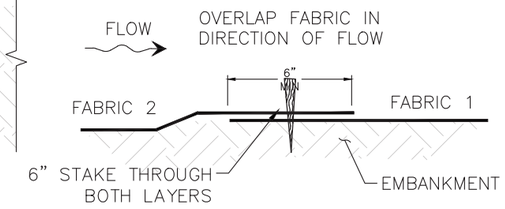


FIGURE B: CROSS SECTION VIEW OF OVERLAP – NTS

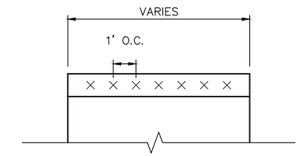
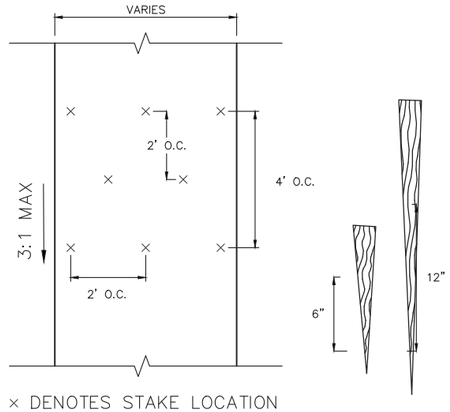


FIGURE C: TOB STAKE SPACING PLAN VIEW – NTS



× DENOTES STAKE LOCATION
(APPROXIMATELY 0.7 STAPLES PER SY)

FIGURE D: STAKE SPACING PLAN VIEW – NTS

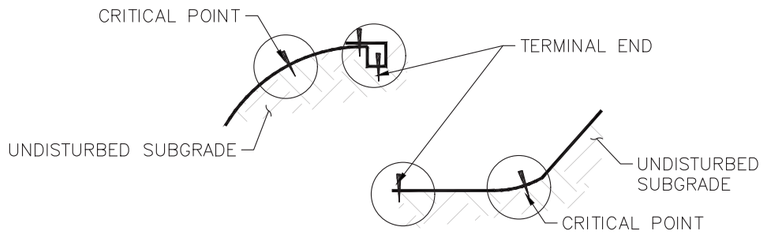
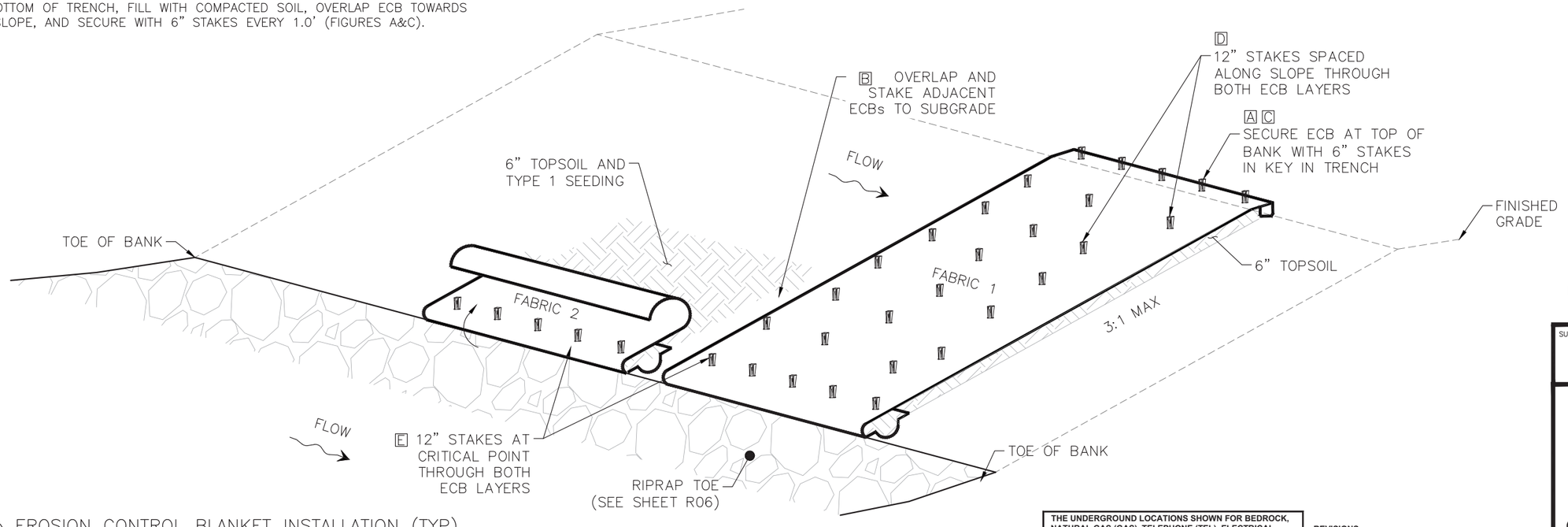


FIGURE E: CRITICAL POINT SECURING – NTS

ECB INSTALLATION NOTES:

1. CONTRACTOR SHALL USE ALL NATURAL 100% BIODEGRADABLE COIR NAG 700BN EROSION CONTROL BLANKETS (ECBs) OR APPROVED EQUIVALENT. STAKES SHALL ALSO BE 100% BIODEGRADABLE. SEE SPECIFICATIONS AND MANUFACTURER'S INSTALLATION GUIDELINES FOR ADDITIONAL INFORMATION.
2. PLACE ECB BEHIND BOULDER TOE TO A DEPTH OF 18" BELOW FINISHED GRADE AND SECURE IN PLACE PER STAKING PLAN (FIGURE D). ECB MUST BE PLACED LOOSELY OVER GROUND SURFACE. DO NOT STRETCH.
3. EDGES OF PARALLEL ECBs MUST BE STAKED WITH AN APPROXIMATE 6" OVERLAP (FIGURE B). UPSTREAM ROLL MUST BE ON TOP OF DOWNSTREAM ROLL. IF NEEDED, CONSECUTIVE ECBs SPLICED DOWNSLOPE MUST BE OVERLAPPED END–OVER–END (SHINGLED) WITH AN APPROXIMATE 3" OVERLAP.
4. IN THE FOLLOWING ORDER, APPLY TOPSOIL, SEED MIX, BONDED FIBER MATRIX, THEN WRAP ECB AT THE TOE TOWARDS THE TOP OF BANK.
5. EXCAVATE A 1.0' WIDE BY 1.0' DEEP TRENCH 5' BEHIND THE TOP OF THE SLOPE. THE TRENCH SHALL RUN ALONG THE LENGTH OF THE INSTALLATION. STAKE ECB ALONG BOTTOM OF TRENCH, FILL WITH COMPACTED SOIL, OVERLAP ECB TOWARDS TOE OF SLOPE, AND SECURE WITH 6" STAKES EVERY 1.0' (FIGURES A&C).



1 / D03 EROSION CONTROL BLANKET INSTALLATION (TYP)
NTS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DETAIL SHEET
EROSION CONTROL BLANKET INSTALLATION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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GPF No. 5315

Sheet No. 34 of 34 D03

UTILITIES - CONTACT INFORMATION

PUBLIC

CITY OF GRAND RAPIDS
DAVID MARQUARDT
PARKS & RECREATION DEPARTMENT
201 MARKET AVE. SW
GRAND RAPIDS, MI 49503

CITY OF GRAND RAPIDS STREET LIGHTING
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3281

CITY OF GRAND RAPIDS WATER SYSTEM
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 456-3141

CITY OF GRAND RAPIDS
SANITARY AND STORM SEWER MAINTENANCE
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 456-3141

CITY OF GRAND RAPIDS TRAFFIC SIGNALS
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3066

PRIVATE

CONSUMERS ENERGY (ELECTRIC)
PO BOX 201
GRAND RAPIDS, MI 49501-0201
(616) 530-4244

AT&T (TELEPHONE)
ROOM 5 (PROJECTS N. OF FRANKLIN ST.)
2ND FLOOR (PROJECTS S. OF FRANKLIN ST.)
955 36TH ST. SE
GRAND RAPIDS, MI 49508
(616) 246-7203 (PROJECTS N. OF FRANKLIN ST.)
(616) 246-7210 (PROJECTS S. OF FRANKLIN ST.)

DTE ENERGY (NATURAL GAS)
444 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(800) 947-5000

XFINITY/COMCAST (CABLE TV)
955 CENTURY AVE. SW
GRAND RAPIDS, MI 49503
(616) 245-5039

VERIZON BUSINESS (FIBER OPTICS)
2855 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 224-4944

CENTURY TEL (FIBER OPTICS)
320 N. WASHINGTON SQUARE
LANSING, MI 48933
(989) 239-8110

CHOICEONE (FIBER OPTICS)
44 GRANDVILLE AVE. SW, STE. 400
GRAND RAPIDS, MI 49503
(616) 988-7100

US SIGNAL COMPANY, LLC (FIBER OPTICS)
20 MONROE AVE. NW
GRAND RAPIDS, MI 49503
(616) 988-7031

LDMI
3355 EAGLE PARK DR. NE, STE. 102
GRAND RAPIDS, MI 49525
(616) 493-5364

VEOLIA ENERGY GRAND RAPIDS LLC - STEAM
50 MONROE AVE. NW, SUITE 430
GRAND RAPIDS, MI 49503
(616) 356-2535

TDS METROCOM, LLC
1575 GEZON PARKWAY SUITE B
WYOMING, MI 49509
(616) 301-3033

CITY OF GRAND RAPIDS

GRAND RAPIDS, MICHIGAN

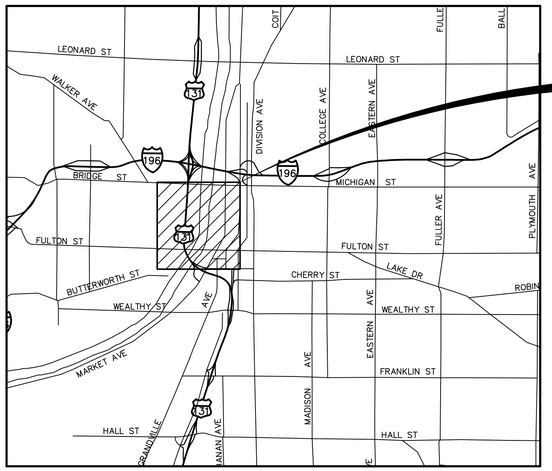
PUBLIC SERVICES

IMPROVEMENTS

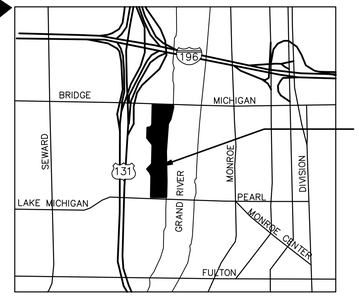
TO

CONSTRUCTION PLANS:

AH-NAB-AWEN PARK



PROJECT LOCATION



AH–NAB–AWEN PARK
220 FRONT AVE NW

JOB SITE

BID SET

BID SET NO.	DATE	BID SET NO.	DATE

REVISIONS

REV NO.	DATE	SHEET NUMBER(S)	APPROVED BY

AS-BUILT RECORD

CONTRACTOR	
FIELD ENGINEER	
INSPECTED BY	
AS-BUILT BY	
AS-BUILT DATE	
BORINGS BY	
WATER PIPE MANUFACTURER	
SANITARY PIPE MANUFACTURER	
STORM PIPE MANUFACTURER	

PERMITS

M.D.E.Q. WATER SYSTEM PERMIT NO.:	OTHER:	NO.:
M.D.E.Q. WASTEWATER SYSTEM PERMIT NO.:	OTHER:	NO.:
M.D.O.T. RIGHT-OF-WAY PERMIT NO.:	OTHER:	NO.:

CITY COMMISSION PROC. NO. _____ DATE _____

MDOT AGREEMENT ☐ CONTRACT AWARDED ☐

FINANCIAL AGREEMENT ☐ SHPO AGREEMENT ☐

GRANT AGREEMENT ☐ COST SHARING AGREEMENT ☐

PUBLIC UTILITIES EASEMENT (SEE EASEMENT DESCRIPTION SHEET)

ADDITIONAL CITY COMMISSION PROCEEDINGS

PROCEEDING NO. DATE PURPOSE

INDEX OF SHEETS

1	TITLE SHEET
2	SURVEY
3	REMOVAL - SOUTH
4	REMOVAL - NORTH
5	SITE PLAN - SOUTH
6	SITE PLAN - NORTH
7	SITE PLAN ENLARGEMENT
8	SITE PLAN ENLARGEMENT
9	GRADING & SESC - SOUTH
10	GRADING & SESC -NORTH
11	GRADING & SESC ENLARGEMENT
12	GRADING & SESC ENLARGEMENT
13	SITE ELECTRICAL PLAN - SOUTH
14	SITE ELECTRICAL PLAN - NORTH
15	LANDSCAPING - SOUTH
16	LANDSCAPING - NORTH
17	EXISTING IRRIGATION AS-BUILT
18-21	MISCELLANEOUS DETAILS

CALL 811 FOR MISS DIG

FOR PROTECTION OF UNDERGROUND UTILITIES AND IN CONFORMANCE WITH PUBLIC ACT 53, 1974, THE CONTRACTOR SHALL CALL 811 A MINIMUM OF THREE (3) FULL WORKING DAYS (EXCLUDING SATURDAYS, SUNDAYS AND HOLIDAYS) PRIOR TO EXCAVATING IN THE VICINITY OF UTILITY LINES. ALL "MISS DIG" PARTICIPATING MEMBERS WILL THUS BE ROUTINELY NOTIFIED. THIS DOES NOT RELIEVE THE CONTRACTOR OF THE RESPONSIBILITY OF NOTIFYING UTILITY OWNERS WHO MAY NOT BE A PART OF THE "MISS DIG" ALERT SYSTEM.

GENERAL NOTES

1. MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE 1993 EDITION OF THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, EXCEPT AS OTHERWISE INDICATED ON THESE PLANS OR IN THE SUPPLEMENTAL SPECIAL SPECIFICATIONS.
2. IF A WATER SERVICE (COPPER, LEAD OR OTHERWISE) IS DISTURBED, DAMAGED, RELOCATED OR REPLACED FROM THE WATER MAIN TO THE CURB STOP, WHETHER PLANNED OR UNINTENTIONAL, THE CONTRACTOR IS TO HAVE THE SERVICE MATERIAL VERIFIED FROM THE MAIN TO THE METER. IF ANY PORTION IS FOUND TO BE LEAD, THEN THE CONTRACTOR MUST HAVE THE LEAD REPLACED WITH A COPPER WATER SERVICE. ALL WATER SERVICE REPLACEMENTS MUST BE COMPLETED BY A REGISTERED UNDERGROUND CONTRACTOR. IF THE REPLACEMENT INVOLVES WORK ON PRIVATE PROPERTY, THE CONTRACTOR IS TO CONTACT THE ENGINEER IMMEDIATELY TO OBTAIN PERMISSIONS FOR THE SERVICE TO BE REPLACED BY CITY OF GRAND RAPIDS UNDERGROUND CONTRACTORS ON TERM CONTRACT FOR LEAD SERVICE REPLACEMENT. THE CONTRACTOR WILL REIMBURSE THE CITY FOR THIS COST.

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS TO AH-NAB-AWEN PARK

Drawn by SKK Notes in _____

Check: Field _____ Office _____

Approved _____ _____
Tim Burkman, P.E. City Engineer Date

APPROVAL OF SHEET(S) 1-21 ONLY

Project File No.	GPF No.	Sheet No.
		1 of 21

BENCHMARKS

BENCHMARK I — ELEV. 601.97
CHISELED SQUARE ON WEST SIDE OF CONCRETE LIGHT POLE BASE, SECOND LIGHT POLE NORTH OF GILETTE BRIDGE ON WEST SIDE OF WALK ALONG GRAND RIVER

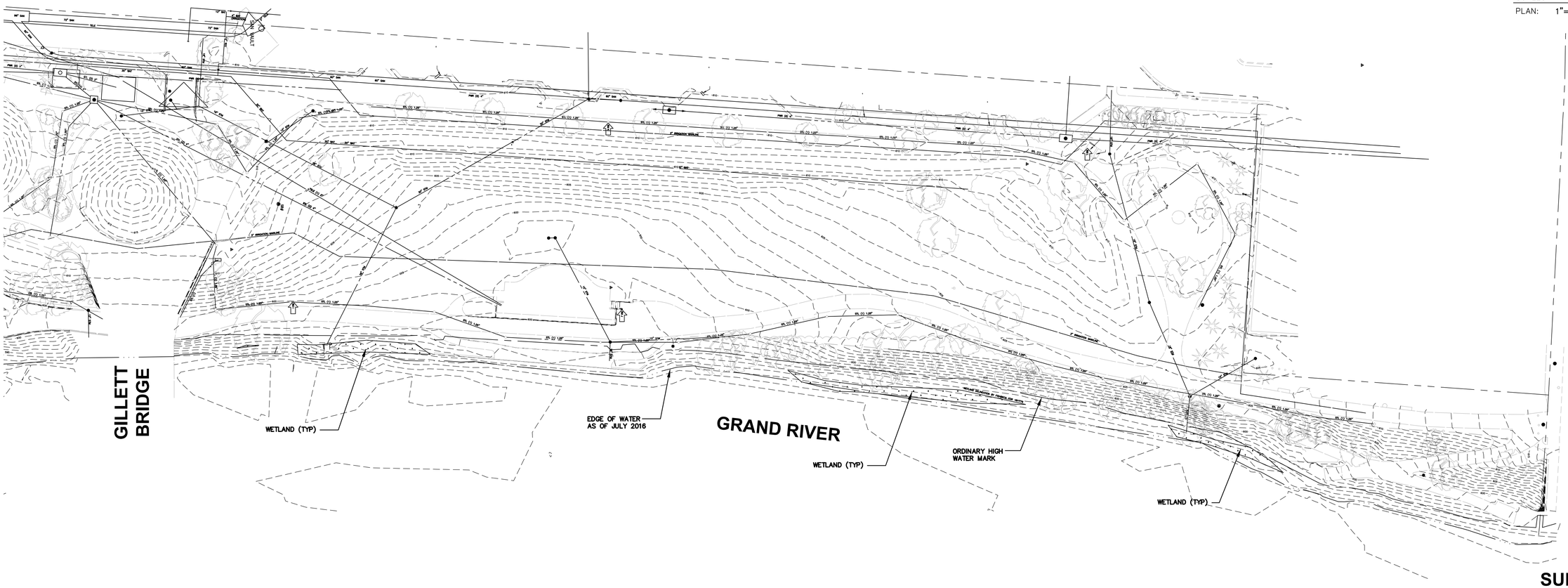
BENCHMARK J — ELEV. 600.49
CHISELED SQUARE ON NORTHEAST CORNER OF CONCRETE WALL ALONG EAST SIDE OF NORTH SET OF STEP

BENCHMARK K — ELEV. 609.86
CHISELED SQUARE ON EAST SIDE OF CONCRETE LIGHT POLE BASE, EAST OF THE FIRST "M" IN THE WORD "MUSEUM" ON THE EAST WALL OF THE GERALD R. FORD PRESIDENTIAL MUSEUM

BENCHMARK L — ELEV. 611.29
CHISELED SQUARE ON SOUTH CORNER OF CONCRETE PAD FOR ELECTRICAL EQUIPMENT, 75 FEET SW OF BUTTON SCULPTURE AND 60 FEET NORTH OF NORTH ENTRANCE TO GERALD R. FORD'S GRAVESITE

NORTH

SCALES
PLAN: 1"=40'



SURVEY

SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS TO AH-NAB-AWEN PARK

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), STEAM, TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REV. NO.	DESCRIPTION

Drawn by SKK
Check: Field
Check: Office
GPF No.
Sheet No. 2 of 21

BENCHMARKS

BENCHMARK I ELEV. 601.97
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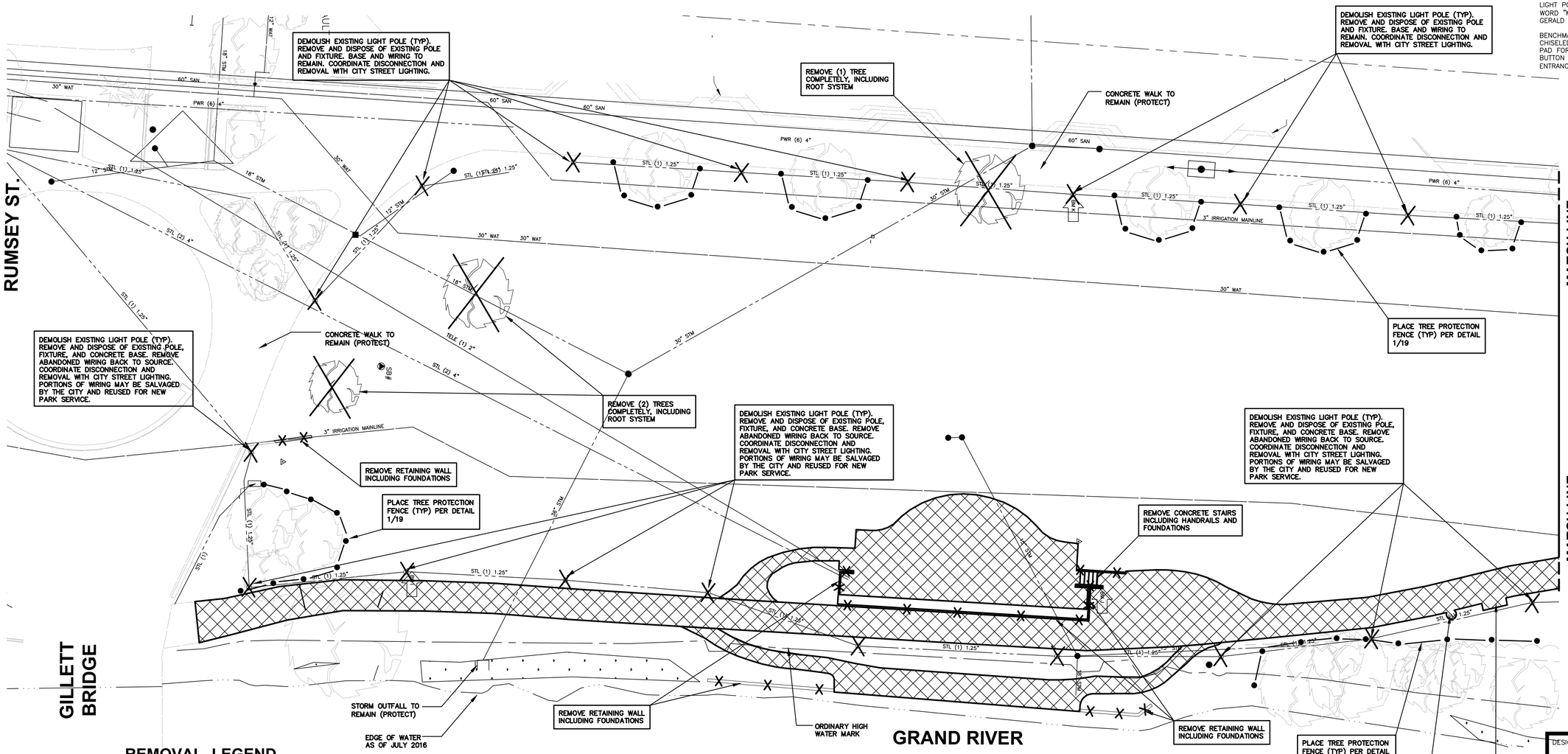
NORTH

SCALES
PLAN: 1"=20'



REMOVAL - SOUTH

REMOVAL LEGEND

- X — REMOVE ITEM AS NOTED
- SAWCUT AND REMOVE CONCRETE PAVEMENT
- REMOVE EXISTING VEGETATION, INCLUDING ROOT SYSTEMS
- REMOVE EXISTING TREE, INCLUDING ROOT SYSTEMS
- WORK LIMIT LINE

REMOVAL GENERAL NOTES

1. PAVEMENT REMOVAL LIMITS WILL BE DETERMINED BY ENGINEER. (DIMENSIONS ARE APPROXIMATE.)
2. FOR ALL ABANDONED UTILITIES THAT ARE REMOVED AS PART OF CONSTRUCTION OF A NEW UTILITY SUCH REMOVAL OF THE ABANDONED UTILITY TO LAY THE NEW UTILITY SHALL BE CONSIDERED TO BE INCLUDED IN THE ITEM FOR LAYING OF THE NEW UTILITY AND WILL NOT BE PAID FOR SEPARATELY. THIS IS ALSO THE CASE FOR THOSE UTILITIES THAT ARE DESIGNATED TO BE ABANDONED ON THE PLANS BUT END UP BEING REMOVED IN ORDER TO LAY A NEW UTILITY.
3. ALL CONSTRUCTION TO BE IN ACCORDANCE WITH THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, LATEST EDITION.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VISITING THE SITE AND BECOMING FAMILIAR WITH THE DEMOLITION AND CLEARING REQUIREMENTS.
5. NO REMOVAL, DEMOLITION, CLEARING OR TOPSOIL REMOVAL SHALL OCCUR ON SITE UNTIL THE SESC AND STORMWATER PERMITS HAVE BEEN ISSUED AND THE CONTRACTOR HAS VERIFIED AND STAKED THE LIMITS OF REMOVAL IN THE FIELD. NOTIFY SITE CONSULTANT OF THE START OF CONSTRUCTION AND DATE WHEN THE LIMITS LINE WILL BE ESTABLISHED FOR REVIEW AND APPROVAL.
6. ALL MATERIALS NOTED TO BE SALVAGED SHALL BE TURNED OVER TO THE OWNER OR REINSTALLED ON SITE AS NOTED.
7. NO BURNING OR BURYING OF CLEARED OR DEMOLITION MATERIAL SHALL BE ALLOWED ON SITE.
8. REMOVE ALL STRUCTURES, FOUNDATIONS, BITUMINOUS PAVEMENT, CONCRETE SIDEWALK STEPS AND OTHER EXISTING SITE FEATURES AS INDICATED ON THE DRAWINGS. ALSO, REMOVE ALL DEBRIS FROM WITHIN CONSTRUCTION LIMITS ON SITE. ALL DEMOLITION MATERIALS SHALL BE REMOVED FROM THE SITE AND, UNLESS OTHERWISE NOTED, DISPOSED OF IN A MANNER ACCEPTABLE TO LOCAL JURISDICTION HAVING AUTHORITY.
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REV. NO.	DESCRIPTION

DESIGNED BY: VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 438-9841 (voice) viridis@viridg.com

SURVEYED BY: fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS TO AH-NAB-AWEN PARK

Drawn by SKK
Check: Field
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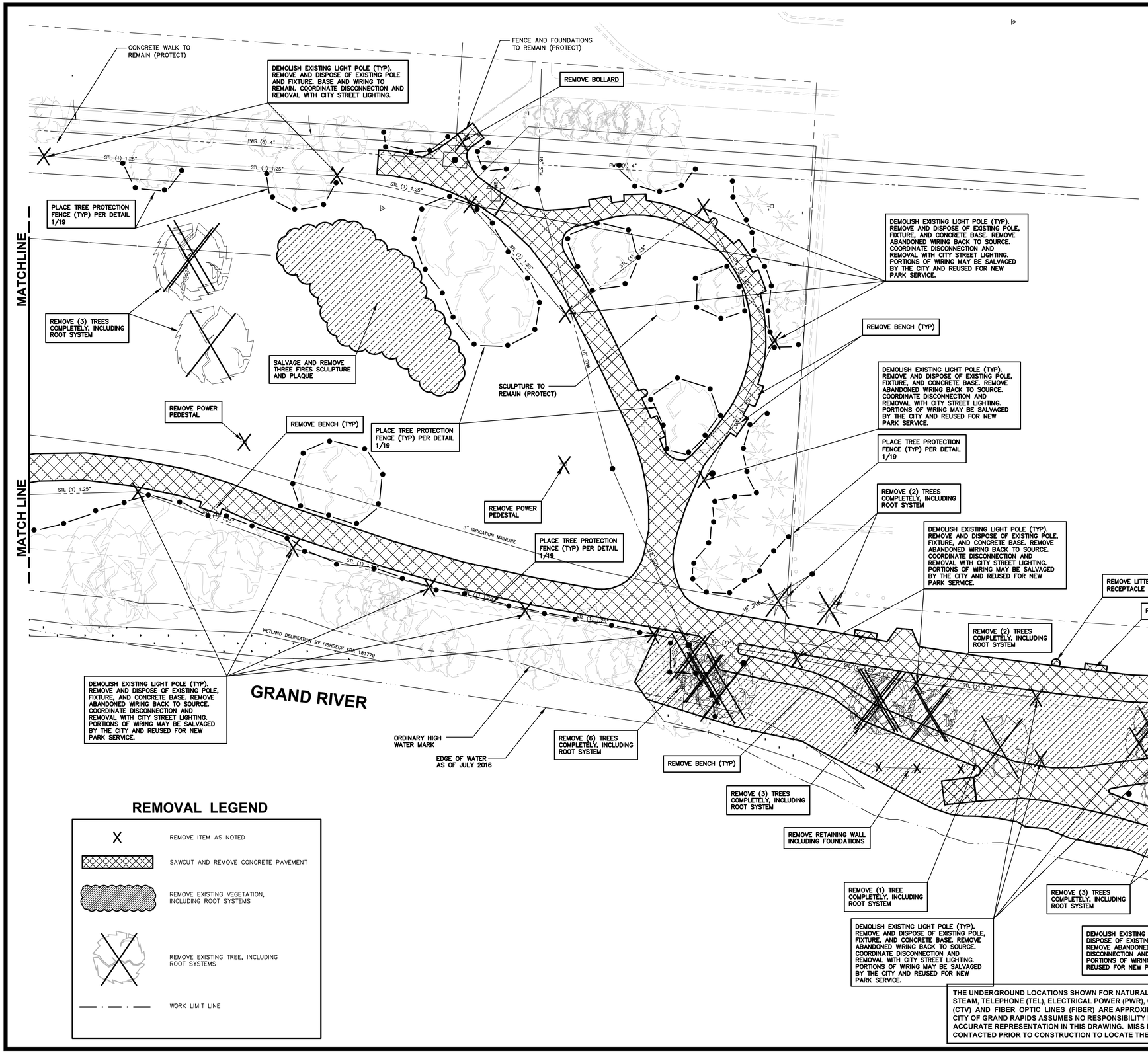

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NORTH

SCALES

PLAN: 1"=20'

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REMOVAL - NORTH

REV. NO.	DESCRIPTION

DESIGNED BY:
VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 458-9841 (voice) viridis@viridg.com

SURVEYED BY:
fish
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS TO AH-NAB-AWEN PARK

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Check: Field
Check: Office

GPF No.

Sheet No. 4 of 21

BENCHMARKS

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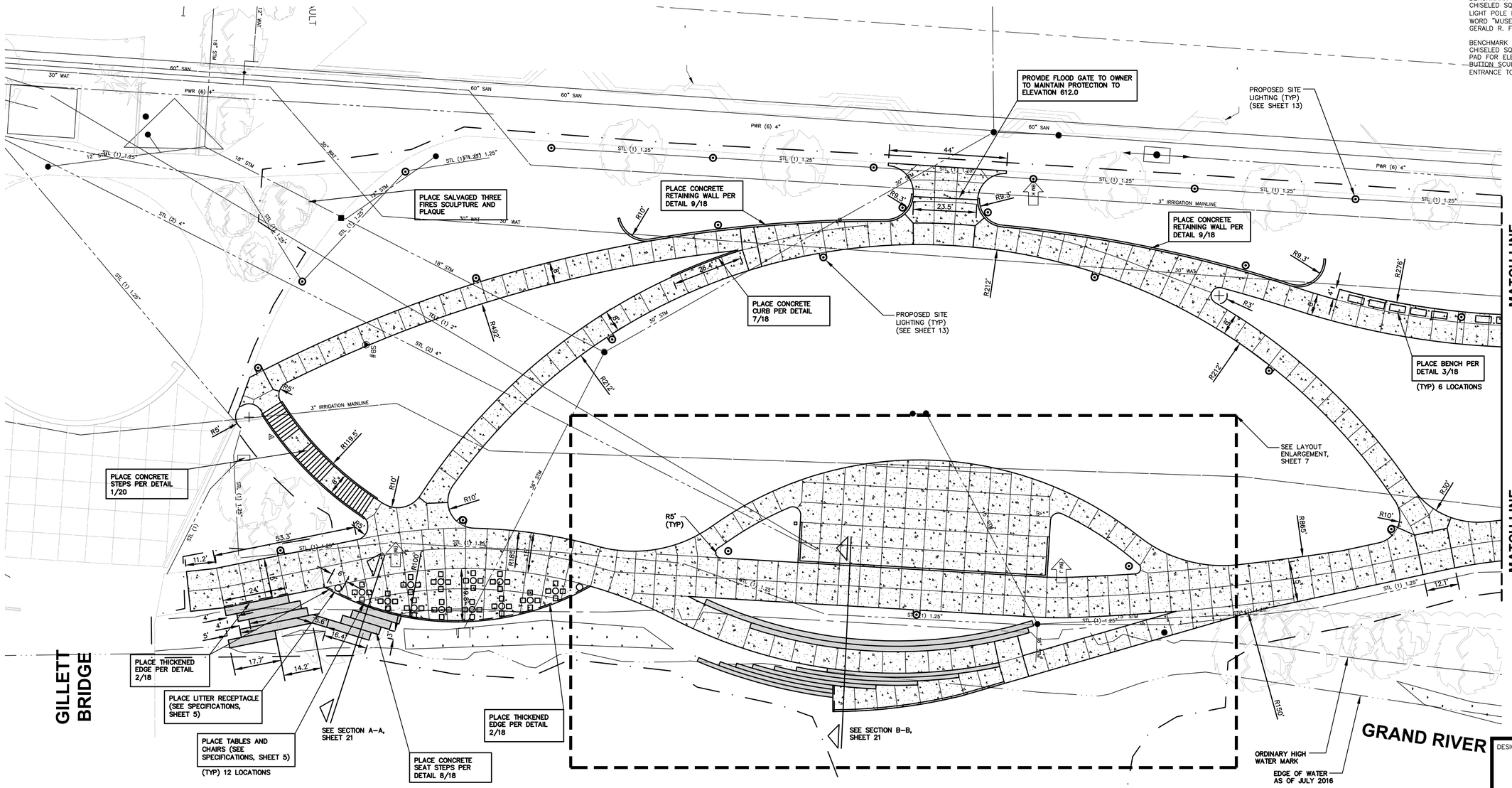
NORTH

SCALES
PLAN: 1"=20'



LEGEND

PLACE 4" CONCRETE SIDEWALK PER DETAIL 1/18

WORK LIMIT LINE

SITE PLAN GENERAL NOTES

1. CONTRACTOR TO OBTAIN ALL REQUIRED SITE WORK PERMITS.
2. ALL WORK TO BE COORDINATED WITH CITY OF GRAND RAPIDS.
3. A PRE–CONSTRUCTION MEETING SHALL BE HELD BETWEEN CITY OF GRAND RAPIDS AND THE CONTRACTOR.
4. CONTRACTOR TO CALL 811 AT LEAST 3 WORKING DAYS PRIOR TO CONSTRUCTION, TO CONFIRM LOCATION OF EXISTING UTILITIES.
5. CONTRACTOR TO COORDINATE ALL CONSTRUCTION WITH THE APPROPRIATE PUBLIC UTILITY.
6. CONTRACTOR TO COORDINATE AND MEET REQUIREMENTS OF THE CITY OF GRAND RAPIDS FOR WORK ASSOCIATED WITH THE CONNECTIONS TO UTILITIES.
7. CONTRACTOR TO PLACE SESC MEASURES PER SHEETS 9 AND 10. CONTRACTOR TO CONSTRUCT SOIL EROSION CONTROLS AND STORM WATER DETENTION BASIN AS FIRST ITEMS OF CONSTRUCTION.
8. LENGTHS OF ALL UTILITIES SHOWN ARE APPROXIMATE.
9. DIMENSIONS ARE TO FACE OF CURB UNLESS OTHERWISE NOTED.
10. EXISTING TREES TO REMAIN UNLESS NOTED OTHERWISE – CONTRACTOR TO PROTECT ROOT SYSTEMS BY MAINTAINING TREE PROTECTION FENCE. CONTRACTOR SHALL NOT STORE CONSTRUCTION MATERIALS WITHIN DRIP LINE (EDGE OF CANOPY) OF TREES TO REMAIN. DO NOT PERMIT VEHICLES WITHIN THE DRIP LINE. RESTRICT FOOT TRAFFIC TO PREVENT EXCESSIVE COMPACTION OF SOIL OVER ROOT SYSTEMS WITHIN DRIP LINE.
11. CONTRACTOR MUST RESTORE AND REPAIR ANY EXISTING CONDITIONS DISTURBED BY CONSTRUCTION, THIS IS TO INCLUDE BURIED UTILITIES, LIGHTING, LANDSCAPING, SPRINKLING, ETC.
12. ANY AREA DISTURBED BY CONSTRUCTION TO BE RESTORED TO CONDITION EQUAL TO OR BETTER THAN BEFORE CONSTRUCTION BEGAN.
13. SIDEWALK TO BE STAKED IN FIELD FOR ENGINEER'S REVIEW PRIOR TO CONSTRUCTION.

SITE FURNISHINGS

1. BENCHES TO BE FGP, BACKED 70" BENCH WITH IPE WOOD AND ANODIZED CAST ALUMINUM FRAME AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430–6206 X 1320.
2. LITTER RECEPTACLES TO BE POE, SIDE OPENING, COLOR METALLIC SILVER, AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430–6206 X 1320.
3. BIKE LOOPS TO BE CLASSIC BIKE U RACK WITH CROSSBAR IN STAINLESS STEEL, AS MANUFACTURED BY CYCLESAFE, INC. (616) 954–9977.
4. TABLES TO BE MARNEAUX 42" DIAMETER TABLE TOP WITH CATENA FREESTANDING BASE AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430–6206 X 1320.
5. TABLES TO HAVE SHADE; SHADE TO BE STRETCH ALUMINUM SHADE AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430–6206 X 1320.
6. CHAIRS TO BE VERONA CHAIR WITH ARMS AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430–6206 X 1320.

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), STEAM, TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REV. NO.	DESCRIPTION

SITE PLAN - SOUTH

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1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
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AH-NAB-AWEN PARK

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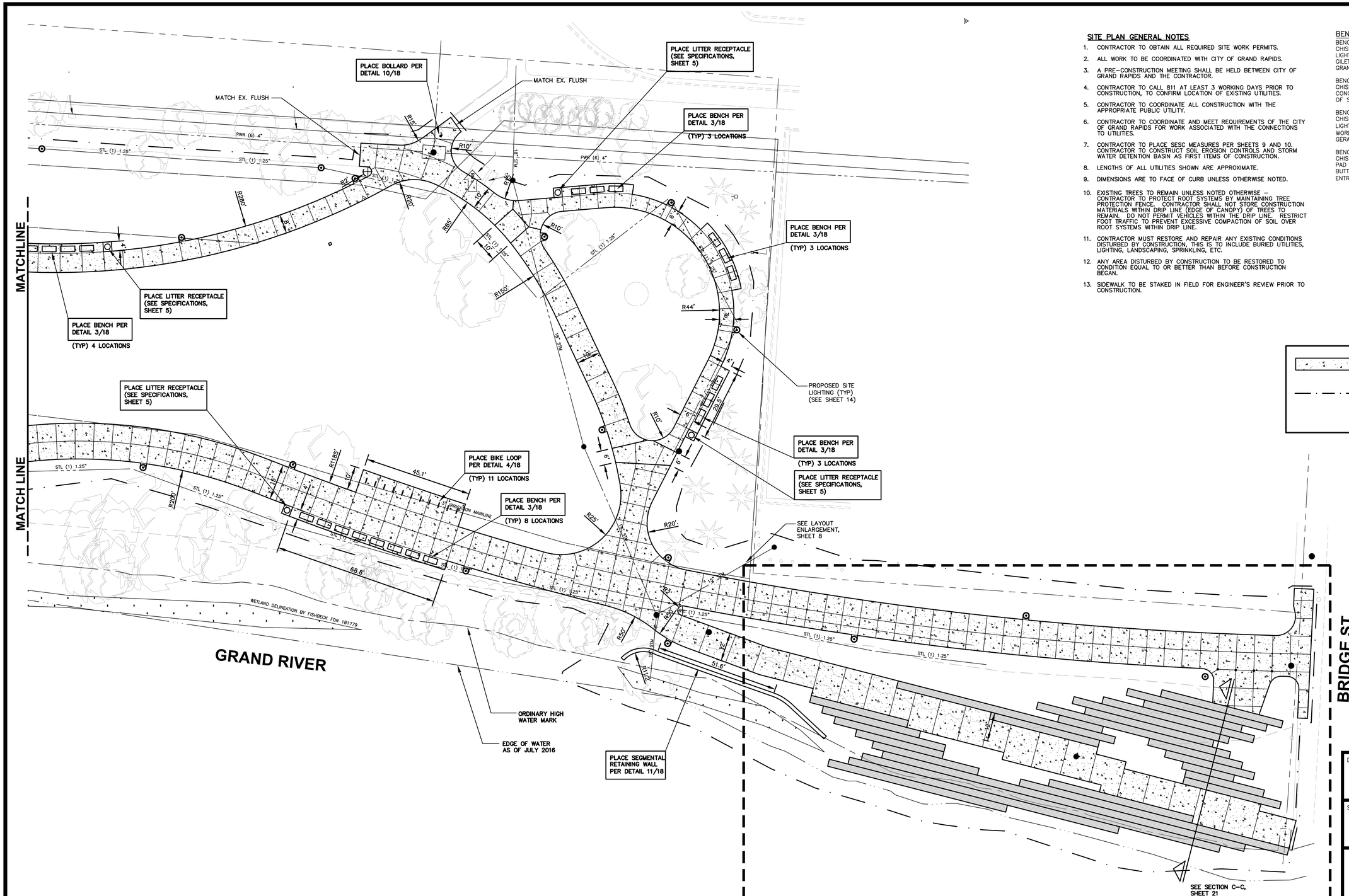
Sheet No. 5 of 21



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8. LENGTHS OF ALL UTILITIES SHOWN ARE APPROXIMATE.
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BENCHMARKS

BENCHMARK I ELEV. 601.97
CHISELED SQUARE ON WEST SIDE OF CONCRETE LIGHT POLE BASE, SECOND LIGHT POLE NORTH OF GILETTE BRIDGE ON WEST SIDE OF WALK ALONG GRAND RIVER

BENCHMARK J ELEV. 600.49
CHISELED SQUARE ON NORTHEAST CORNER OF CONCRETE WALL ALONG EAST SIDE OF NORTH SET OF STEP

BENCHMARK K ELEV. 609.86
CHISELED SQUARE ON EAST SIDE OF CONCRETE LIGHT POLE BASE, EAST OF THE FIRST "M" IN THE WORD "MUSEUM" ON THE EAST WALL OF THE GERALD R. FORD PRESIDENTIAL MUSEUM

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CHISELED SQUARE ON SOUTH CORNER OF CONCRETE PAD FOR ELECTRICAL EQUIPMENT, 75 FEET SW OF BUTTON SCULPTURE AND 60 FEET NORTH OF NORTH ENTRANCE TO GERALD R. FORD'S GRAVESITE

NORTH

SCALES
PLAN: 1"=20'

LEGEND

PLACE 4" CONCRETE SIDEWALK PER DETAIL 1/18

WORK LIMIT LINE

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), STEAM, TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REV. NO.	DESCRIPTION

SITE PLAN - NORTH

DESIGNED BY: VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 438-9841 (voice) viridis@virdg.com

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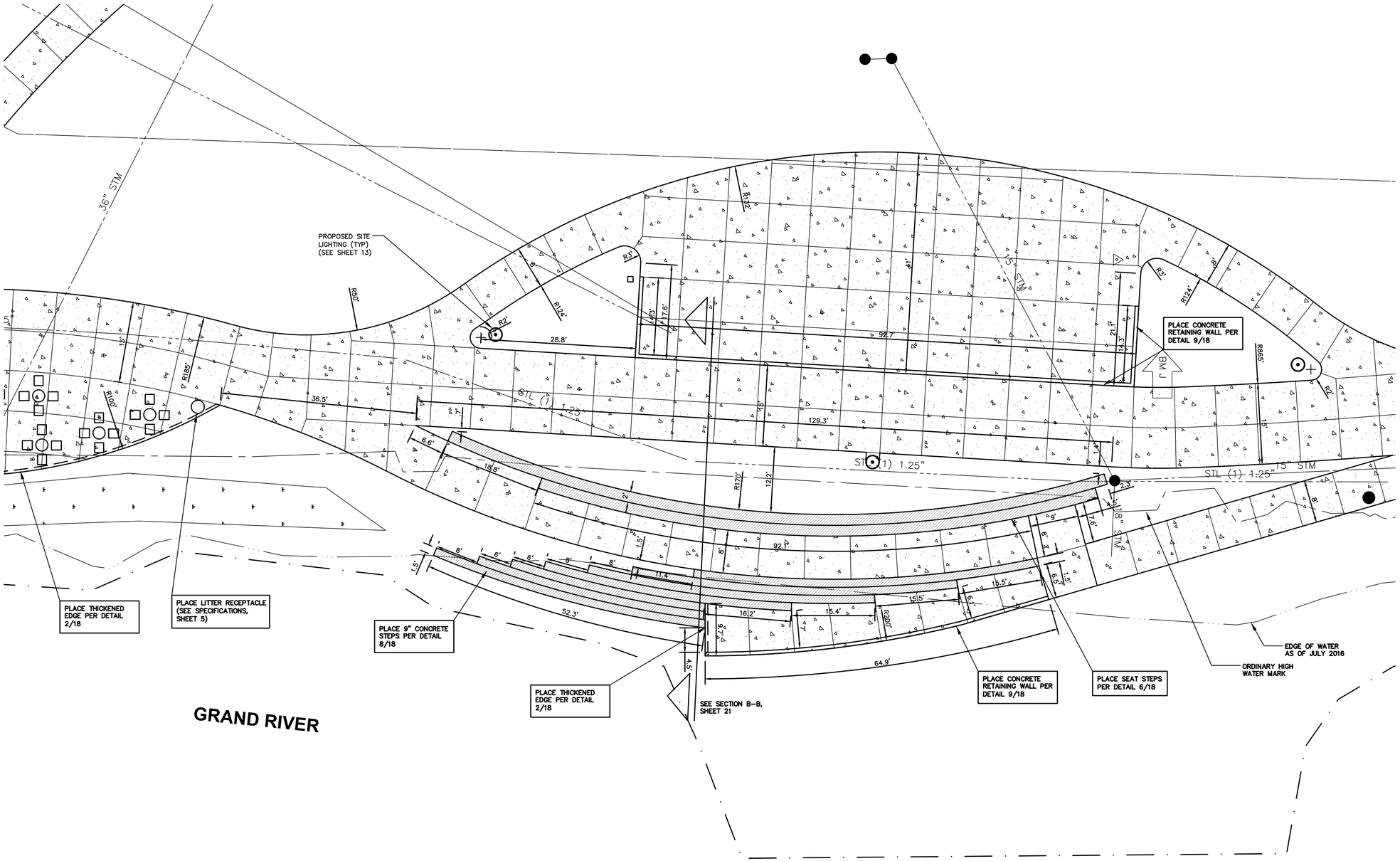
IMPROVEMENTS TO AH-NAB-AWEN PARK

Drawn by SKK
Check: Field
Check: Office

GPF No.

Sheet No. 6 of 21



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IMPROVEMENTS TO AH-NAB-AWEN PARK

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Check: Office

GPF No.

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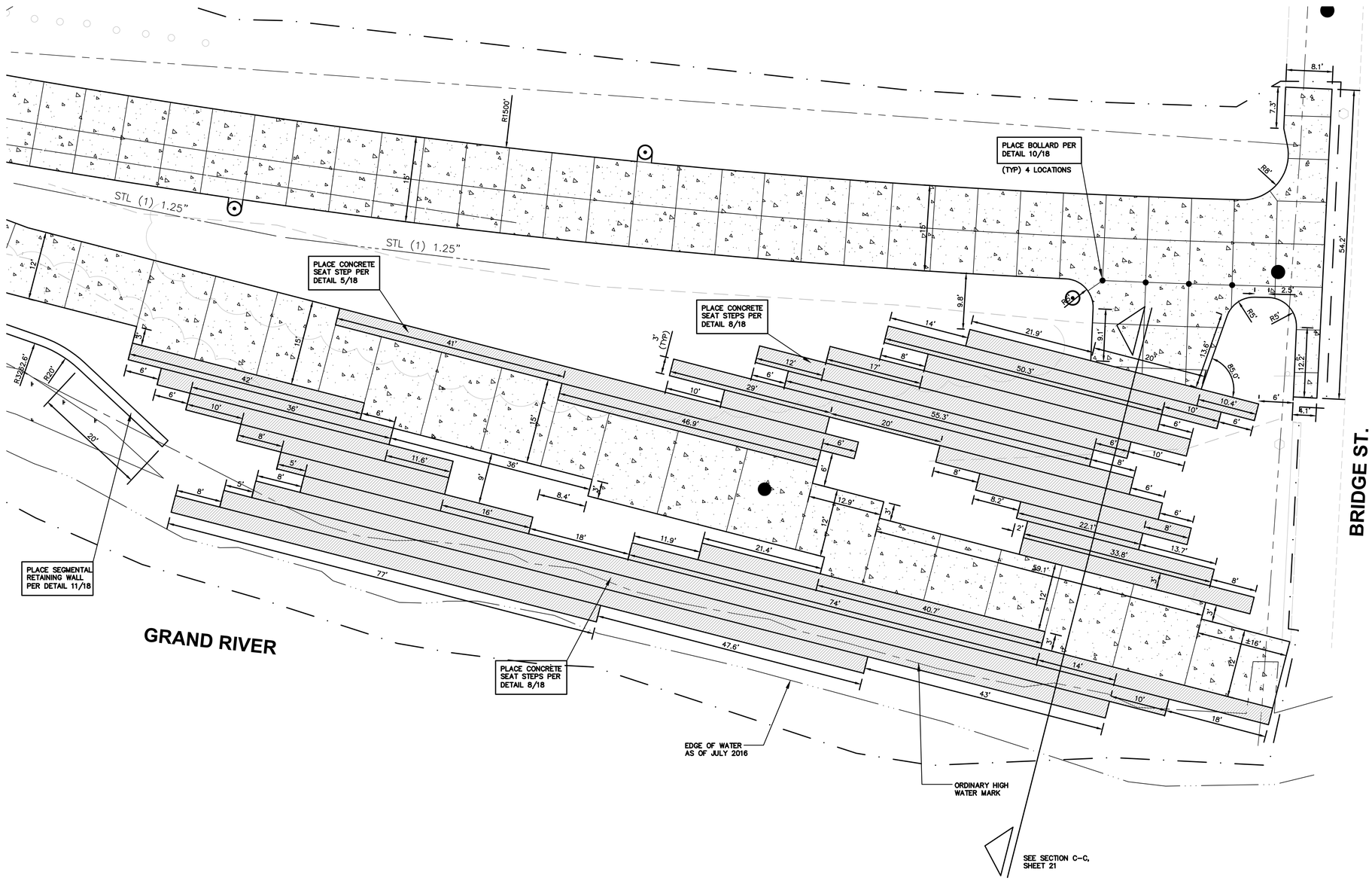

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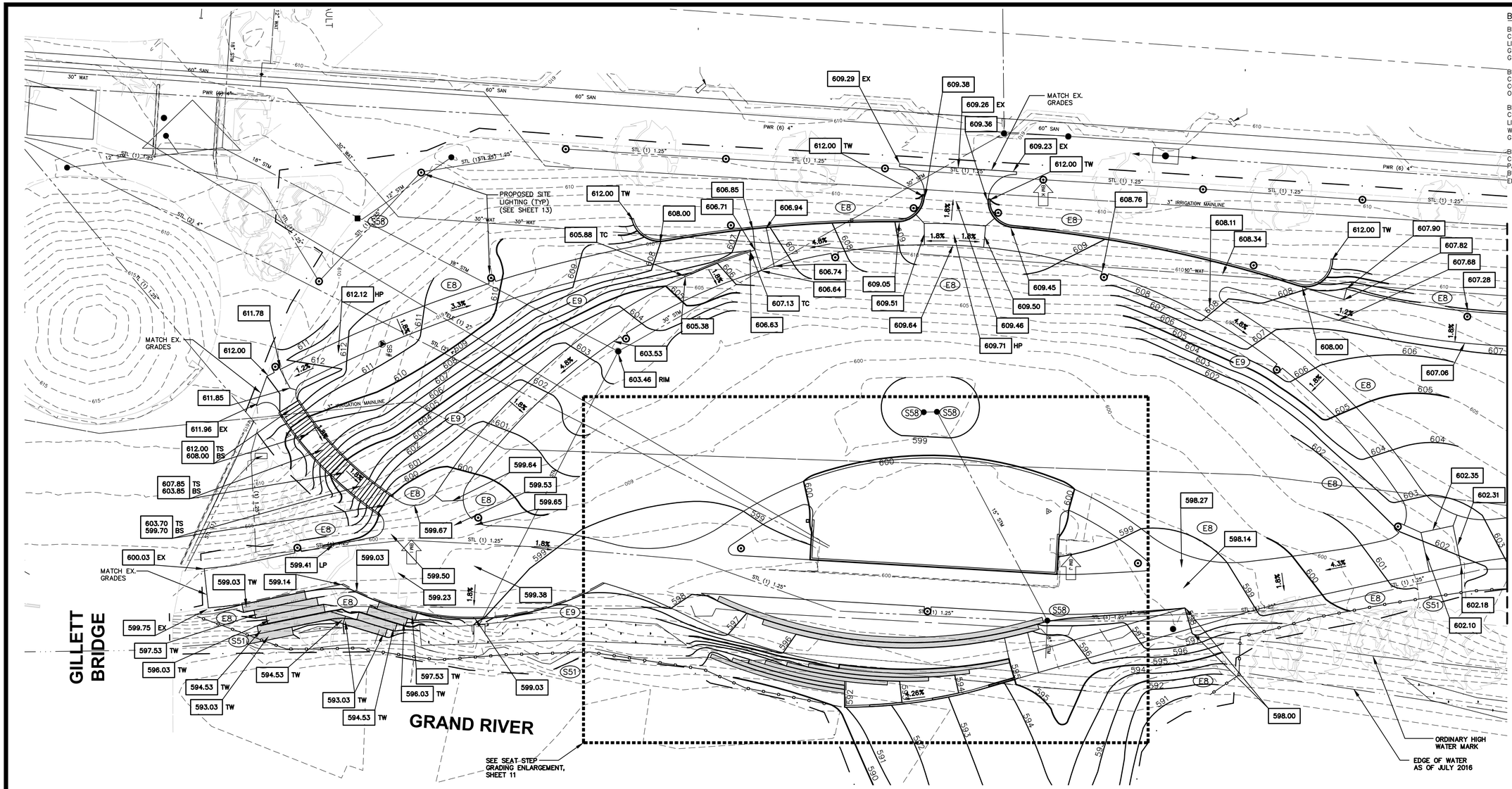

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— · — · — LIMITS OF EARTH CHANGE

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MICHIGAN DEPARTMENT OF MANAGEMENT AND BUDGET S-E-S-C KEYING SYSTEM

KEY	BEST MANAGEMENT PRACTICES	SYMBOL	WHERE USED
EROSION CONTROLS			
E8	PERMANENT SEEDING		Stabilization method utilized on sites where earth change has been completed (final grading attained).
E9	MULCH BLANKETS		On exposed slopes, newly seeded areas, new ditch bottoms, or areas subject to erosion.
S51	SILT FENCE		Use adjacent to critical areas, to prevent sediment laden sheet flow from entering these areas.
S53	STABILIZED CONSTRUCTION ACCESS		Used at every point where construction traffic enters or leaves a construction site.
S58	INLET PROTECTION FABRIC DROP		Use at stormwater inlets, especially at construction sites.

SESC SCHEDULE & SEQUENCE

	APRIL '23	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY '24	FEBRUARY	MARCH	APRIL	MAY	JUNE
INSTALL AND MAINTAIN TEMPORARY EROSION CONTROLS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
TOPSOIL STRIPPING & STOCKPILING		■	■	■											
SITE DEMOLITION & EARTHWORK		■	■												
SITE UTILITIES						■	■	■							
CONCRETE PAVING					■	■	■	■							
TOPSOIL SPREADING							■	■							
PERMANENT SEEDING														■	
REMOVE TEMPORARY EROSION CONTROLS														■	■

THIS CONSTRUCTION SCHEDULE IS PROVIDED TO INDICATE ANTICIPATED START DATES FOR SITE DISTURBANCE AND ANTICIPATED COMPLETION DATES FOR SITE STABILIZATION, AND WILL BE MODIFIED BY THE CONTRACTOR TO FIT HIS SCHEDULE, AND EXPANDED AS REQUIRED BY SITE CONDITIONS FOR SOIL EROSION AND SEDIMENTATION CONTROL PERMITTING BY CONTRACTOR WITH THE CITY OF GRAND RAPIDS FOLLOWING AWARD OF CONTRACT.

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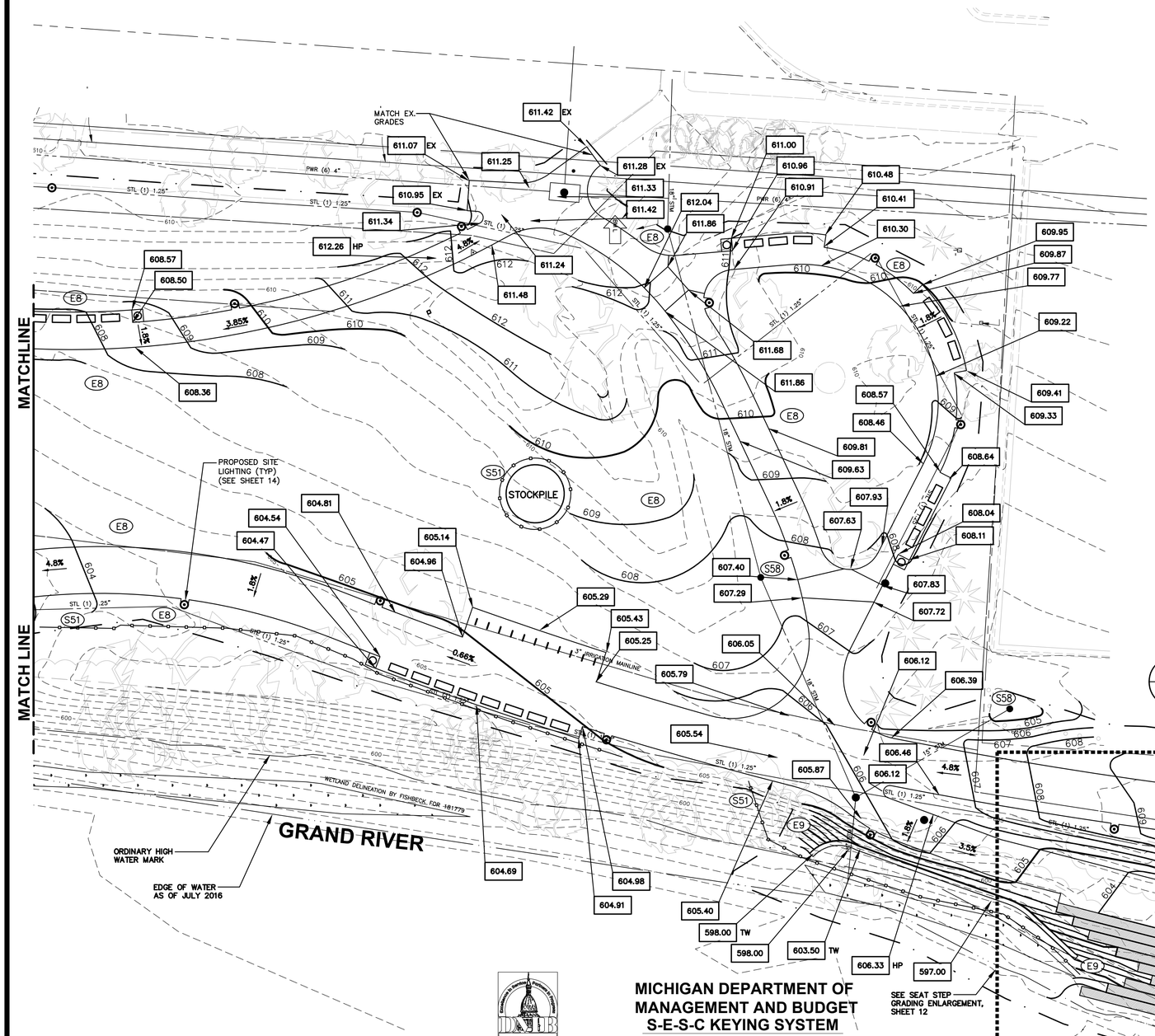

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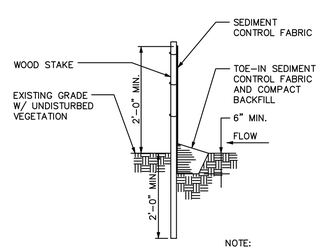
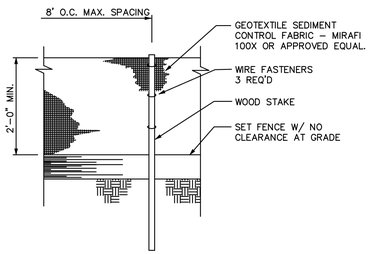
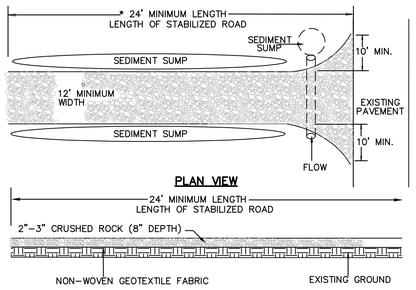




NOTE:
FACTORY PREASSEMBLED SILT FENCE SYSTEMS MAY BE INSTALLED IN PLACE OF THE FIELD ASSEMBLED SILT FENCE DETAILED AFTER APPROVAL BY ENGINEER.

S51 SILT FENCE DETAIL
NO SCALE

NOTES:
1. ESTABLISH STABILIZED CONSTRUCTION ENTRANCE PRIOR TO THE INITIATION OF SITE CONSTRUCTION ACTIVITIES.
2. CARE SHOULD BE TAKEN TO PREVENT MATERIAL MOVEMENT INTO ADJACENT WETLANDS/WATERBODIES.
3. CARE SHOULD BE TAKEN TO MAINTAIN EXISTING ROADSIDE DRAINAGE VIA CULVERT INSTALLATION, WITH SEDIMENT SUMP PLACED DOWNFLOW OF CULVERT.



S53 STABILIZED CONSTRUCTION ACCESS DETAIL
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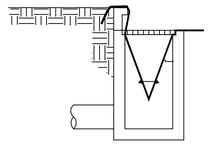
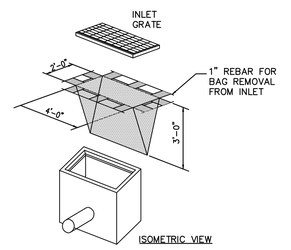


INSTALLATION DETAIL



S58 INLET PROTECTION FABRIC DROP DETAIL
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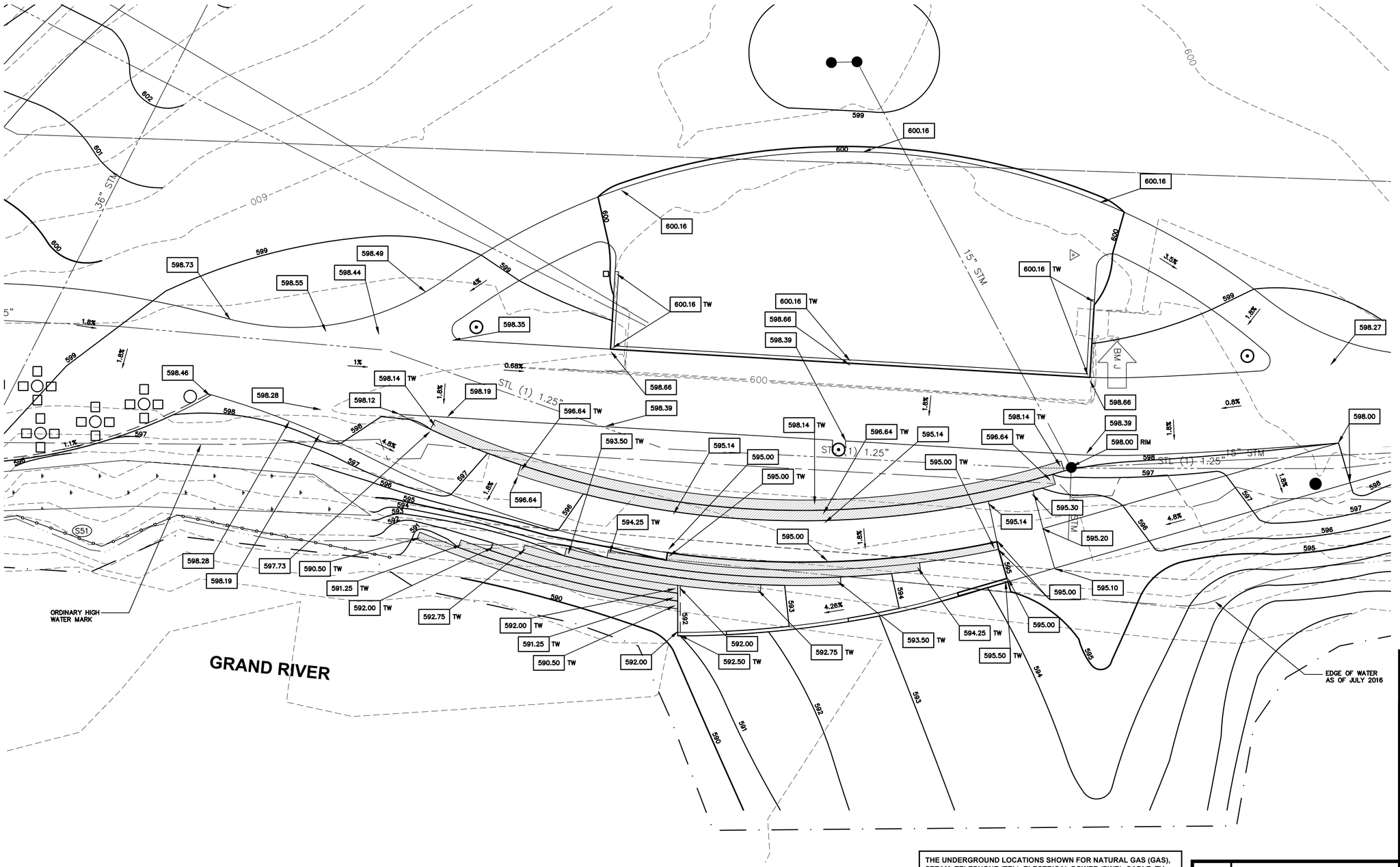

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CHISELED SQUARE ON SOUTH CORNER OF CONCRETE PAD FOR ELECTRICAL EQUIPMENT, 75 FEET SW OF BUTTON SCULPTURE AND 60 FEET NORTH OF NORTH ENTRANCE TO GERALD R. FORD'S GRAVESITE

NORTH

SCALES
PLAN: 1"=10'

GRADING LEGEND

TC = TOP OF CURB
TW = TOP OF WALL
EX = EXISTING SPOT ELEV. (APPROX.)
RIM = RIM ELEVATION
HP = HIGH POINT
LP = LOW POINT

— · — · — LIMITS OF EARTH CHANGE

GRADING GENERAL NOTES

1. PLACE EROSION CONTROL BLANKET ON ALL DISTURBED SLOPES.
2. SIDEWALK CROSS SLOPES TO BE 2% MAX. LONGITUDINAL SLOPES TO BE 5% MAX.
3. FOR WORK AT OR ABOVE SUBGRADE ELEVATION, IT IS THE CONTRACTOR'S RESPONSIBILITY TO VERIFY THE REQUIRED EARTHWORK VOLUMES BASED ON THE GRADING PLAN. IF FILL IS REQUIRED, THE CONTRACTOR SHALL INCLUDE THE REQUIRED VOLUME OF IMPORTED CLASS II FILL. IF EXCESS SOILS NEED TO BE SPOILED, THE CONTRACTOR SHALL INCLUDE HAULING AND SPOILING SOILS OFF-SITE IN THE BID. NO CONTRACT COST ADJUSTMENTS WILL BE CONSIDERED FOR EARTHWORK REQUIRED TO ACHIEVE THE FINISH GRADES SHOWN.

GRADING & SESC ENLARGEMENT

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), STEAM, TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REV. NO.	DESCRIPTION

DESIGNED BY: VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 438-9841 (voice) viridis@virdg.com

SURVEYED BY: fishbeck, thompson, carr & huber, inc.
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engineers • scientists • architects • constructors

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS TO

AH-NAB-AWEN PARK

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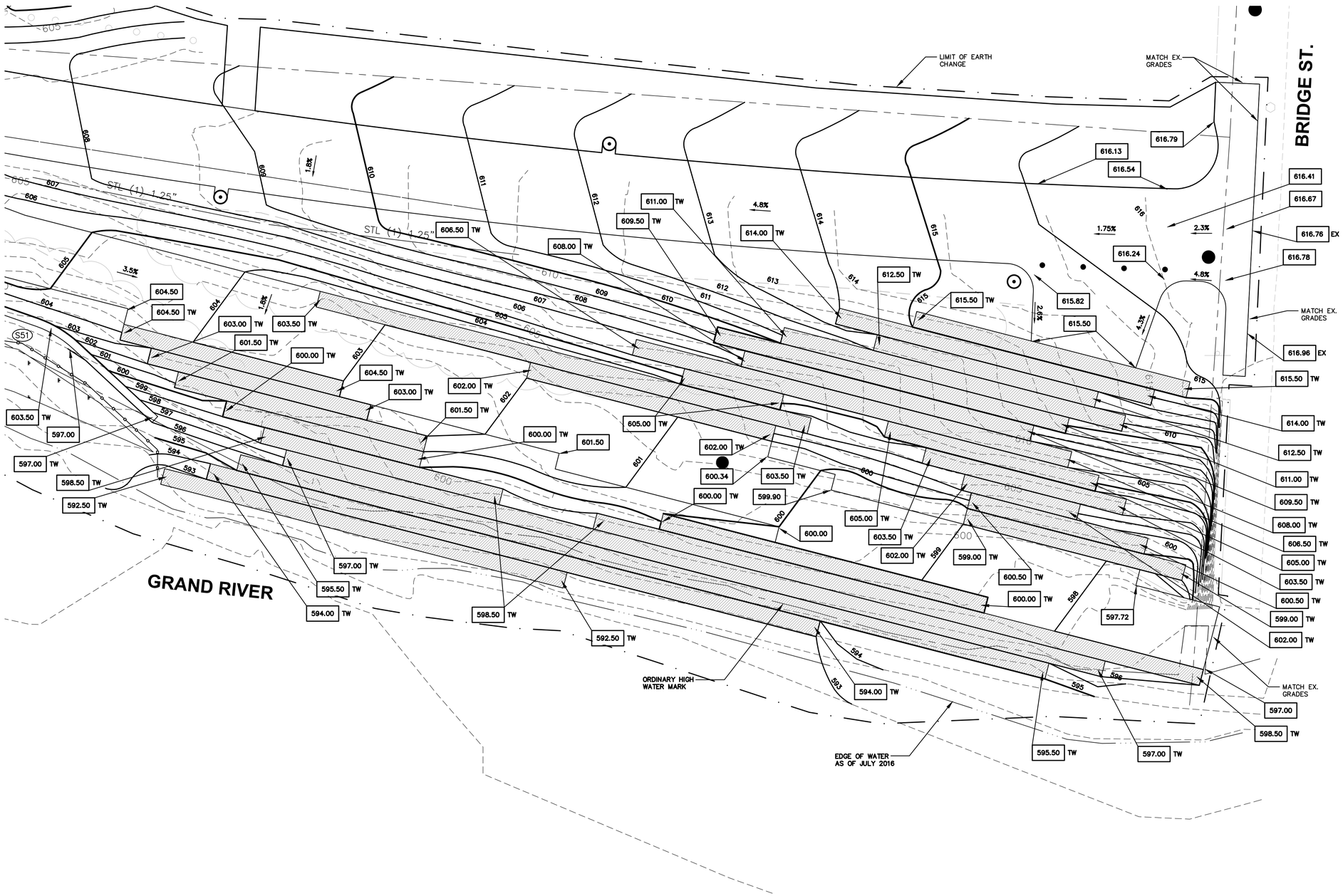

BENCHMARKS

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CHISELED SQUARE ON WEST SIDE OF CONCRETE LIGHT POLE BASE, SECOND LIGHT POLE NORTH OF GILETTE BRIDGE ON WEST SIDE OF WALK ALONG GRAND RIVER

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NORTH

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IMPROVEMENTS TO AH-NAB-AWEN PARK

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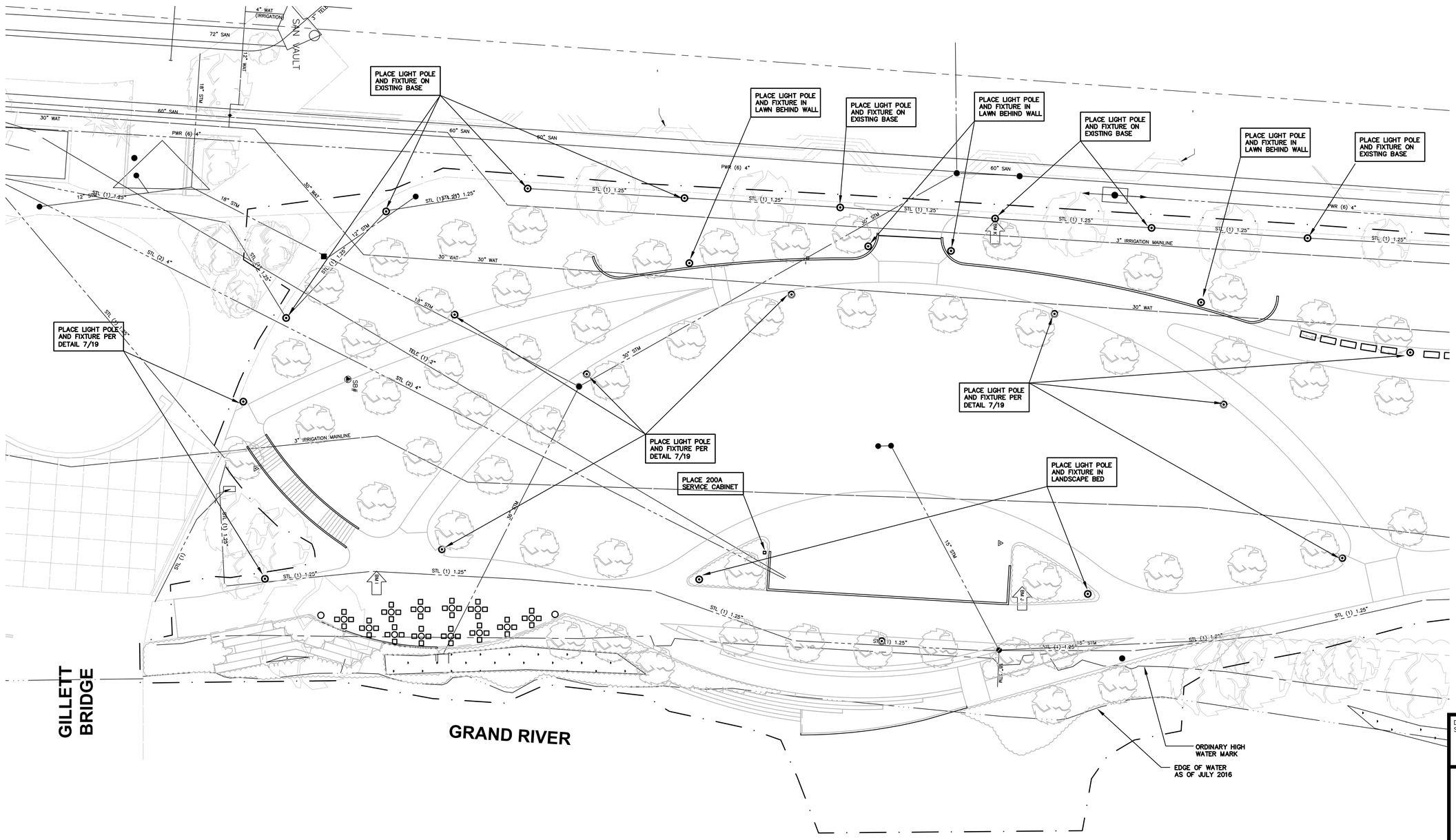

BENCHMARKS

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NORTH

SCALES
PLAN: 1"=20'

GENERAL ELECTRICAL NOTES

1. ELECTRICAL INSTALLATION SHALL COMPLY WITH THE CURRENT VERSION OF THE NATIONAL ELECTRICAL CODE (NEC) AND ALL APPLICABLE LOCAL REQUIREMENTS.
2. ALL UNDERGROUND CONDUITS SHALL BE SCHEDULE 40 PVC (UNLESS OTHERWISE NOTED) AND LOCATED A MINIMUM OF 30" BELOW GRADE, INCLUDING BIOSWALE CROSSINGS.
3. THE CONTRACTOR SHALL LOCATE AND MARK ALL UNDERGROUND UTILITIES PRIOR TO INSTALLATION. THE CONTRACTOR IS RESPONSIBLE TO REPAIR ANY DAMAGE TO EXISTING INSTALLATIONS THAT MAY RESULT FROM ELECTRICAL INSTALL.

LIGHT POLE AND FIXTURE

1. LIGHT POLE TO BE 16 FOOT LEO POLE WITH SINGLE ARM FOR (1) 22 IN. LUMINAIRE AT TOP WITH COVER PLATE AND RECEPTACLE AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430-6206 X 1320.
2. LIGHT FIXTURE TO BE LEO 22 IN. LUMINAIRE WITH 3500K COLOR TEMPERATURE AS MANUFACTURED BY LANDSCAPE FORMS, CONTACT AMANDA NAWARA, (800) 430-6206 X 1320.

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SITE ELECTRICAL PLAN - SOUTH

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phone (616)575-3824, fax (616)464-3996
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Engineering Department

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AH-NAB-AWEN PARK

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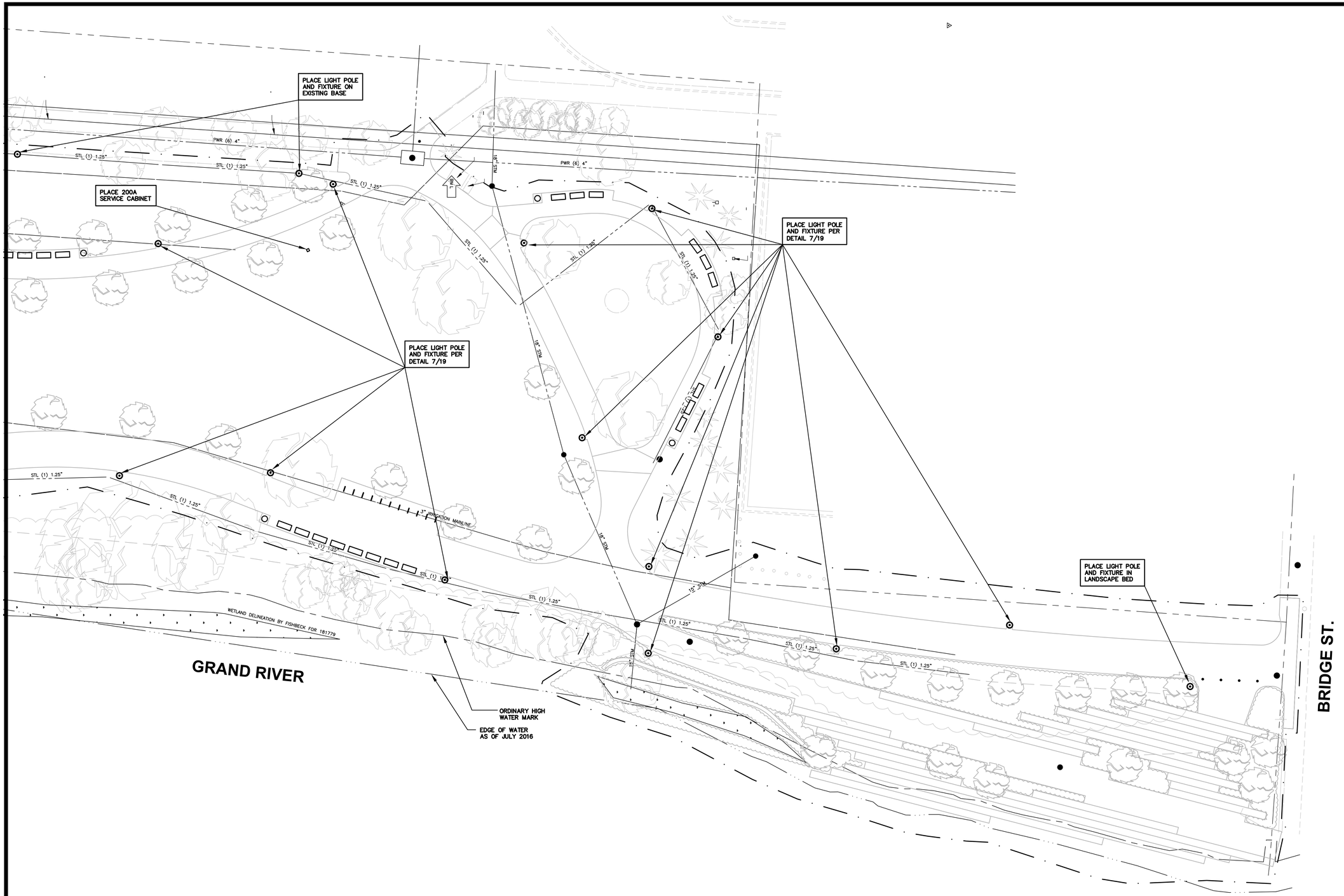

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NORTH

SCALES

PLAN: 1"=20'

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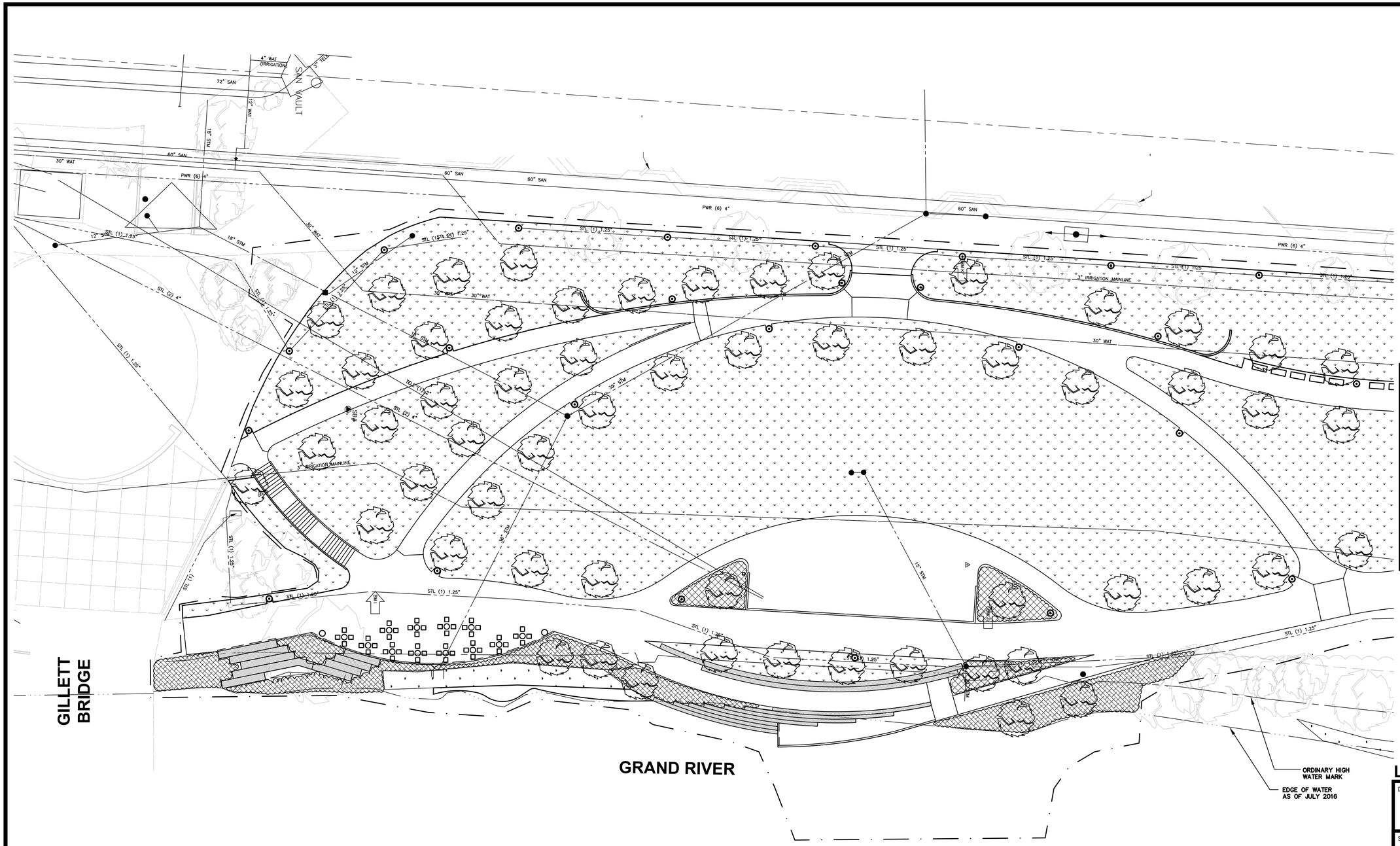

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NORTH

SCALES
PLAN: 1"=20'

LANDSCAPING LEGEND

- PROPOSED DECIDUOUS TREE, 3" CALIPER PER DETAIL 2/19
- PROPOSED PERENNIALS / ORNAMENTAL GRASSES, #1 CONTAINER MIN. WITH 8" DEPTH OF PLANTING SOIL MIX PER DETAIL 3/19
- PROPOSED LAWN ESTABLISHMENT
- PROPOSED BOULDER RIP RAP, VOIDS FILLED WITH PLANTING SOIL MIX AND PLANTED WITH NATIVE WETLAND/RIPARIAN EDGE PLUGS
- WORK LIMIT LINE

LANDSCAPING GENERAL NOTES

1. IN ADDITION TO PROPOSED LAWN AREAS, PLACE 4" OF TOPSOIL. FINISH GRADE AND SEED ALL EXISTING AREAS DISTURBED BY CONSTRUCTION ACTIVITY.

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LANDSCAPING - SOUTH

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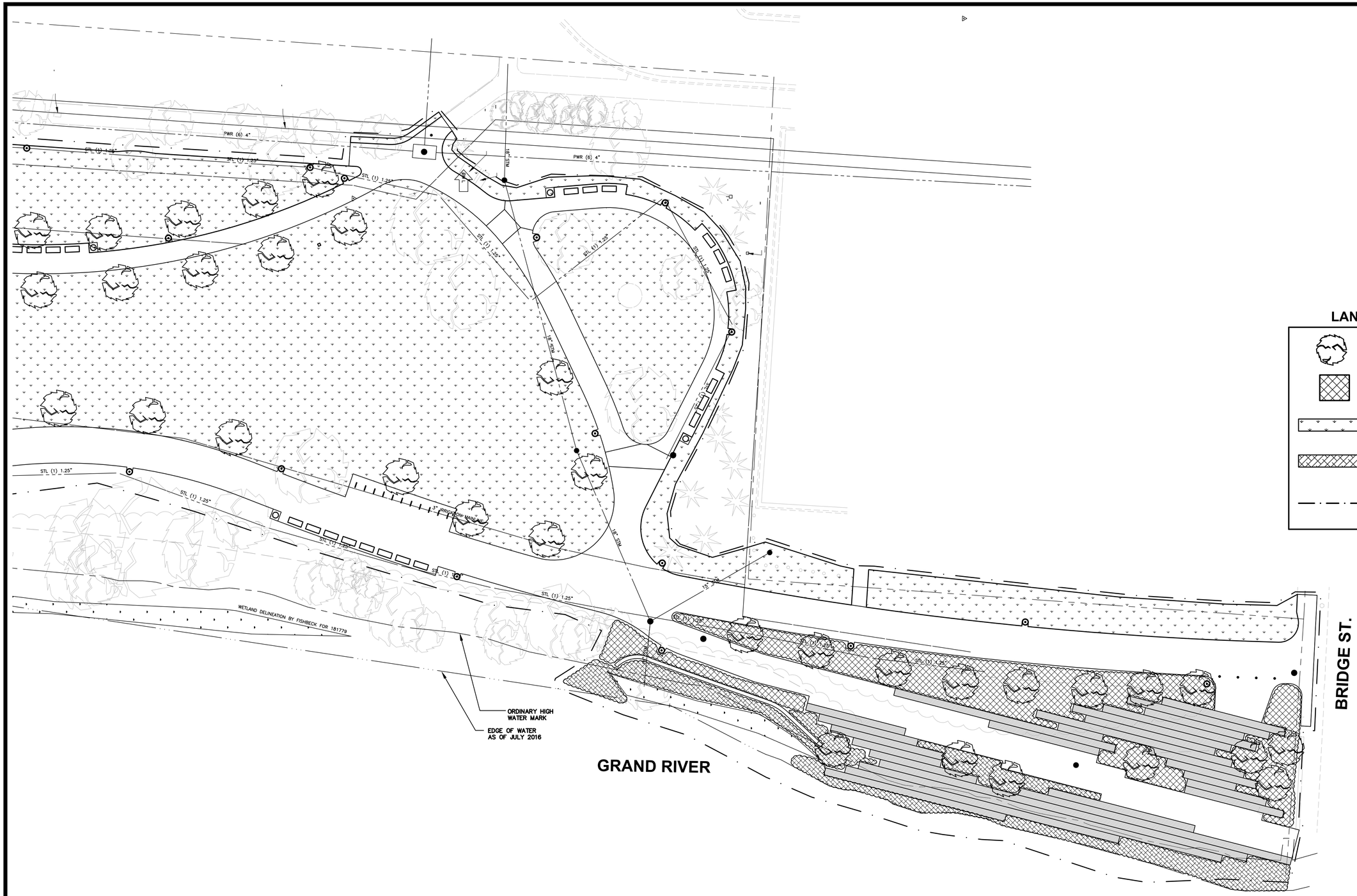
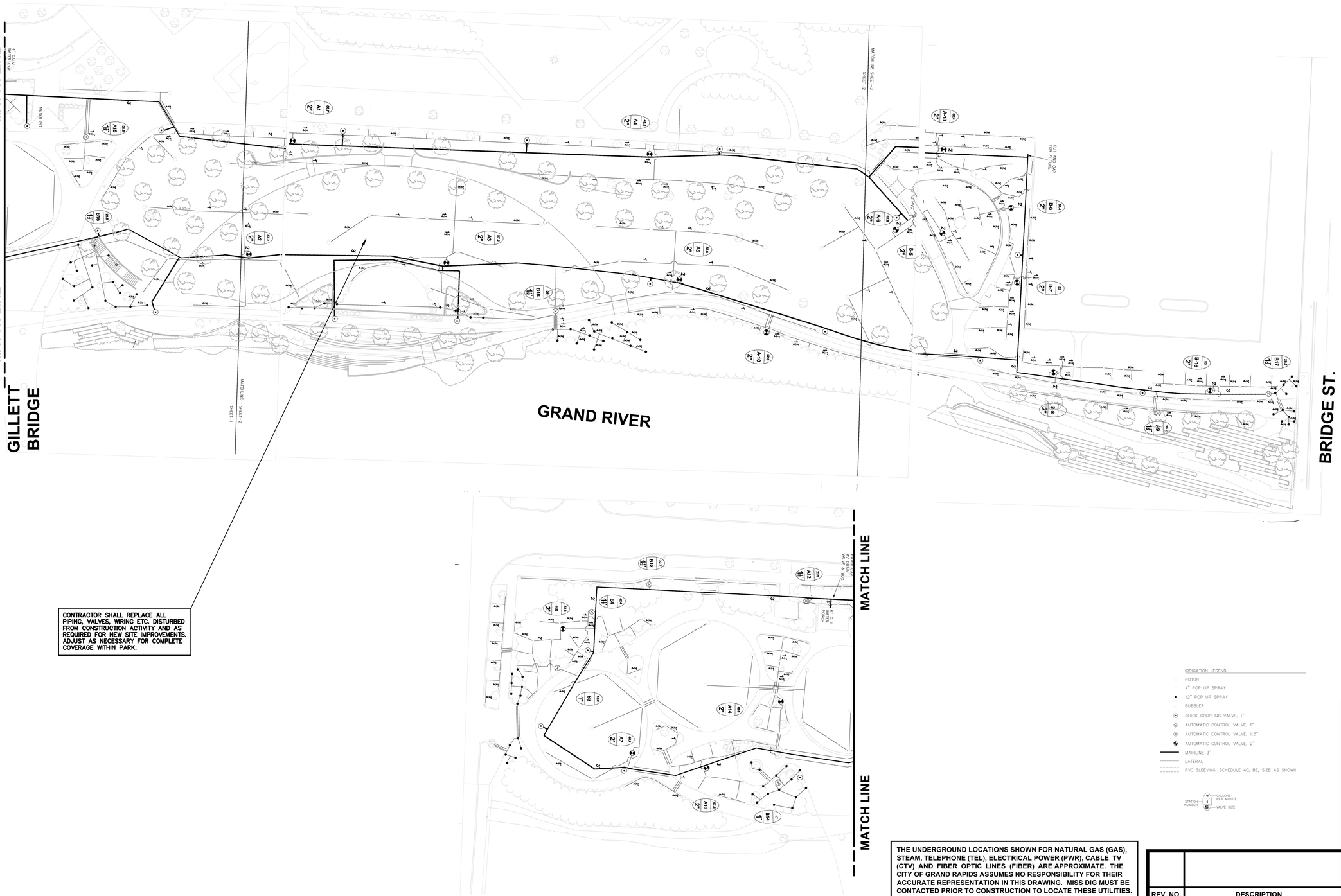

PWR (6) 4"
STL (1) 1.25"
PWR (6) 4"
STL (1) 1.25"
STL (1) 1.25"
STL (1) 1.25



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NORTH

SCALE
PLAN: 1" = 40'

IRRIGATION GENERAL NOTES

1. EXISTING IRRIGATION PLAN IS FOR REFERENCE ONLY AND IS NOT GUARANTEED. CONTRACTOR SHALL VERIFY CONDITIONS IN THE FIELD.
2. THE CONTRACTOR SHALL SUPPLY SHOP DRAIWNGS INCLUDING ALL ELEMENTS OF THE IRRIGATION SYSTEM FOR REVIEW PRIOR TO INSTALLATION.
3. THE CONTRACTOR SHALL BE LICENSED BY THE CITY OF GRAND RAPIDS AND THE STATE OF MICHIGAN FOR ALL PLUMBING.
4. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, LATEST EDITION.

IRRIGATION LEGEND
- ROTOR
- 4" POP UP SPRAY
- 12" POP UP SPRAY
- BUBBLER
- QUICK COUPLING VALVE, 1"
- AUTOMATIC CONTROL VALVE, 1"
- AUTOMATIC CONTROL VALVE, 1.5"
- AUTOMATIC CONTROL VALVE, 2"
- MAINLINE 3"
- LATERAL
- PVC SLEEVING, SCHEDULE 40, BE, SIZE AS SHOWN

STATION NUMBER — GALLONS PER MINUTE — VALVE SIZE

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EXISTING IRRIGATION AS-BUILT

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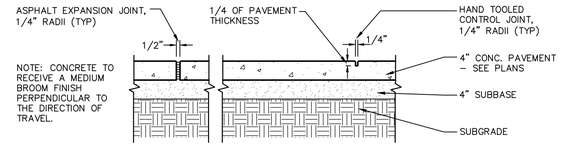
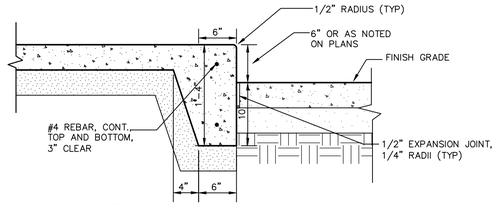
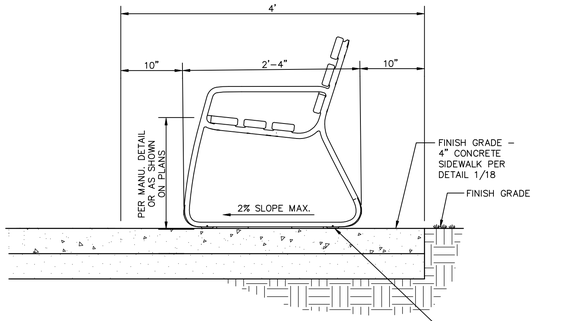


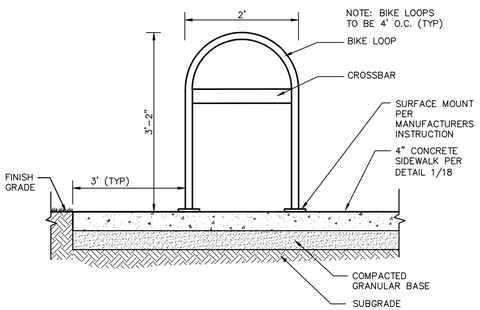
1 CONCRETE SIDEWALK
NO SCALE



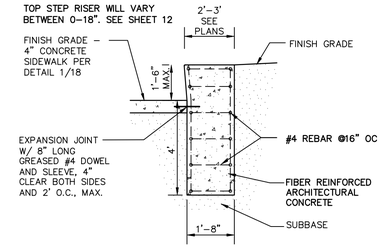
2 INTEGRAL CURB DETAIL
NO SCALE



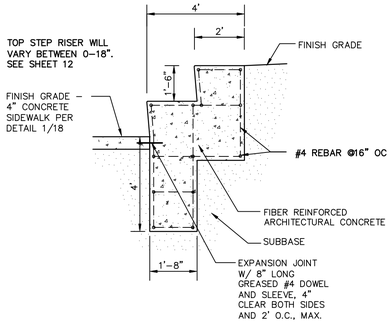
3 BENCH DETAIL
NO SCALE



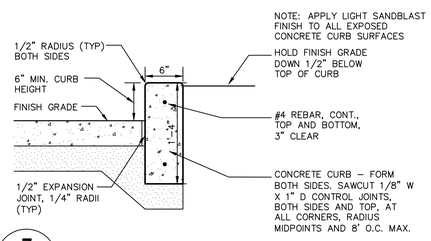
4 BIKE LOOP DETAIL
NO SCALE



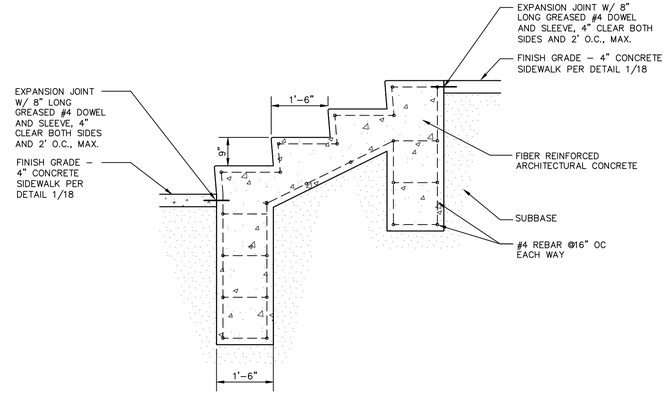
5 SINGLE CONCRETE SEAT STEP DETAIL
NO SCALE



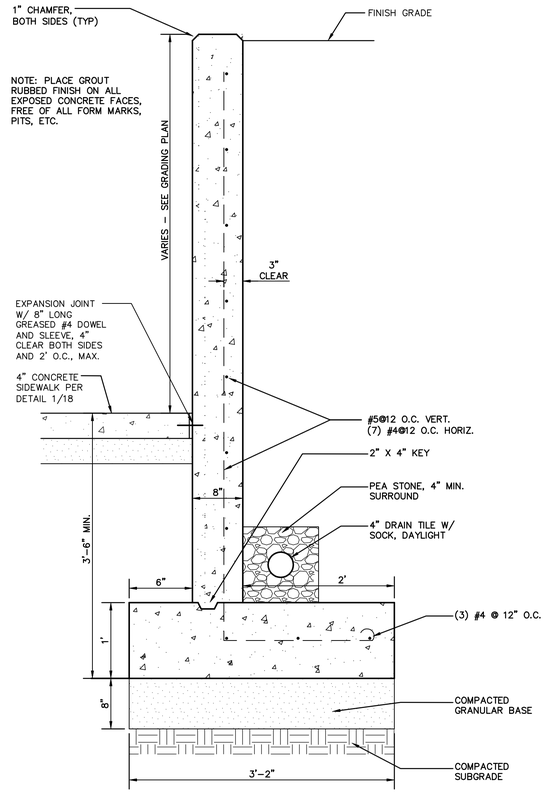
6 CONCRETE SEAT STEPS DETAIL
NO SCALE



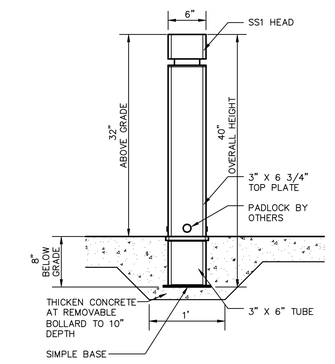
7 6" CONCRETE CURB DETAIL
NO SCALE



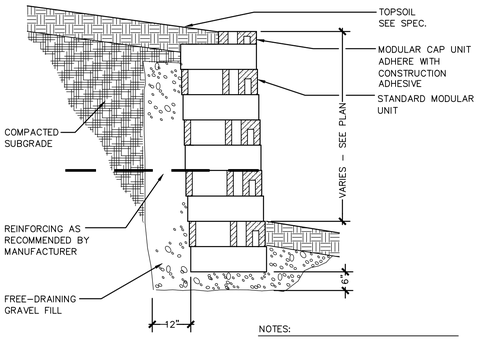
8 9" CONCRETE STEPS DETAIL
NO SCALE



9 CONCRETE RETAINING WALL
NO SCALE



10 REMOVABLE BOLLARD DETAIL
NO SCALE



NOTES:

1. PROVIDE MANUFACTURER'S SPECIFIED SETBACK FOR EACH BLOCK COURSE.

11 SEGMENTAL RETAINING WALL
NO SCALE

MISCELLANEOUS DETAILS

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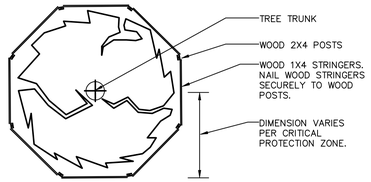
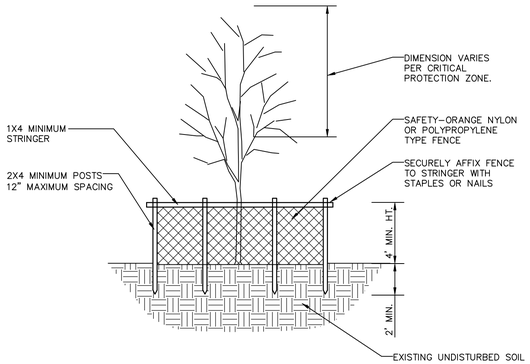
GPF No. .

Sheet No. 18 of 21



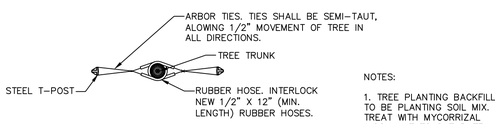
NOTE: FOR GROUPS OF TREES, PLACE BARRICADES BETWEEN TREES AND CONSTRUCTION ACTIVITY.



NOTES:
1. FOR GROUPS OF TREES: PLACE THE BARRICADES AT THE DRIPLINE AROUND THE GROUP'S PERIMETER.
2. INSTALLATION OF TREE PROTECTION BARRICADES SHALL BE PERFORMED BEFORE ANY SITE DEVELOPMENT ACTIVITY TAKES PLACE.
3. THE TREE PROTECTION BARRICADES SHALL REMAIN IN PLACE THROUGHOUT THE CONSTRUCTION PHASE AND UNTIL ALL SITE DEVELOPMENT ACTIVITIES ARE FULLY COMPLETE.
4. ANY DAMAGE THAT MAY OCCUR TO THE BARRICADES SHALL REPAIRED OR REPLACED TO THE ORIGINAL SPECIFICATIONS, WITHIN 24 HOURS OF THE DAMAGE OCCURRING.
5. THE AREA WITHIN THE TREE PROTECTION BARRICADES SHALL NOT BE USED FOR THE STORAGE OF ANY MATERIALS, SUPPLIES OR DEBRIS OR THE DISPOSAL OF ANY SOLID, LIQUID OR GASEOUS MATERIALS THAT COULD CAUSE HARM TO THE TREES.
6. ANY TREE SCHEDULED TO REMAIN IF DAMAGED DURING CONSTRUCTION SHALL BE REPLACED WITH MATERIAL AS APPROVED BY OWNER'S REPRESENTATIVE.
7. MONETARY TREE VALUE SHALL BE DETERMINED BY USING THE GUIDE FOR PLANT APPRAISAL PUBLISHED BY THE INTERNATIONAL SOCIETY OF ABORICULTURE OR OTHER SOURCES AS DETERMINED BY THE CITY FORESTER.
8. BARRICADES SHALL PROTECT ALL TREES SCHEDULED TO REMAIN, BEFORE AND DURING ALL CONSTRUCTION ACITIVITIES.
9. A PERFORMANCE BOND WILL BE REQUIRED FROM THE CONTRACTOR BY THE CITY FOR TREE PROTECTION TO INSURE TIMELY REPAIRS OR REPLACEMENT OF DAMAGED BARRICADES AND/OR RECEIPT OF MONETARY VALUE FOR ANY DAMAGED TREES.
10. THE AMOUNT OF SAID BOND SHALL BE BASED ON THE EQUIVALENT VALUE OF THE TREES SPECIFICALLY COVERED. THE BOND AMOUNT REQUIRED FOR PROTECTED TREES SHALL BE FOUR (4) TIMES THE EQUIVALENT VALUE OF THOSE TREES.
11. ANY PROPOSED UNDERGROUND UTILITIES SHALL BE ROUTED AROUND PROTECTED TREES TO THE OUTSIDE OF THE TREE'S DRIPLINE. IF THIS IS NOT FEASIBLE AS DETERMINED BY THE CITY, A SLEEVE MAY BE USED UNDER THE TREE PROVIDED THAT ALL ACCEPTABLE HORTICULTURAL/ABORICULTURAL PRACTICES ARE ADHERED TO.

*TREE PROTECTION BARRICADES SHALL BE LOCATED TO PROTECT A MINIMUM OF 75% OF THE CRITICAL PROTECTION ZONE.

1 TREE PROTECTION FENCE DETAIL
NO SCALE

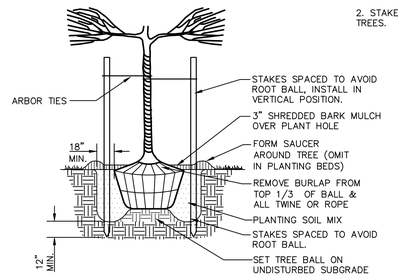


BRACING DETAIL

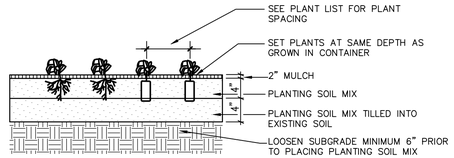
NOTES:

1. TREE PLANTING BACKFILL TO BE PLANTING SOIL MIX. TREAT WITH MYCORRIZAL INOCULANT TO SATURATE BACKFILL AND ROOT BALL DURING PLANTING.

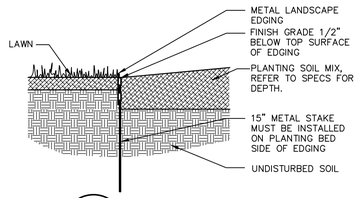
2. STAKE AND GUY ALL TREES.



2 TREE PLANTING DETAIL
NO SCALE



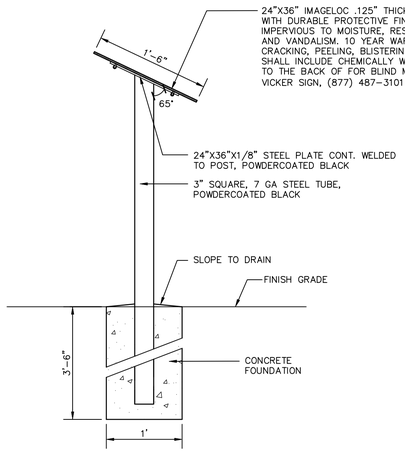
3 PERENNIAL/ GROUNDCOVER PLANTING DETAIL
NO SCALE



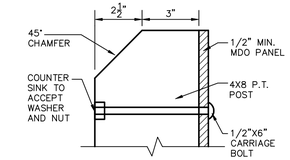
4 METAL EDGING DETAIL
NO SCALE

SIGN ENLARGEMENT

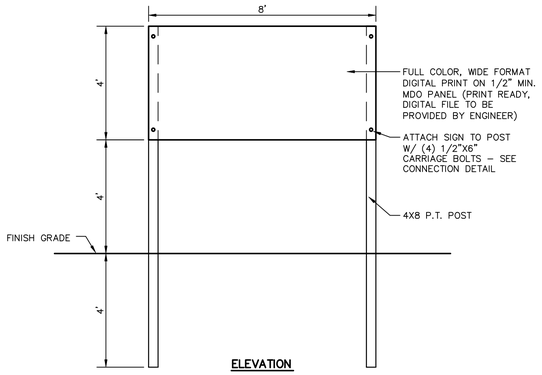
OWNER TO PROVIDE FINAL ARTWORK.



5 INTERPRETIVE SIGN DETAIL
NO SCALE

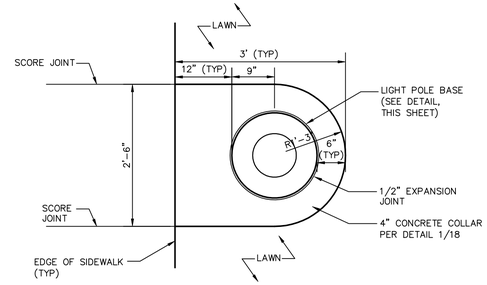


CONNECTION DETAIL

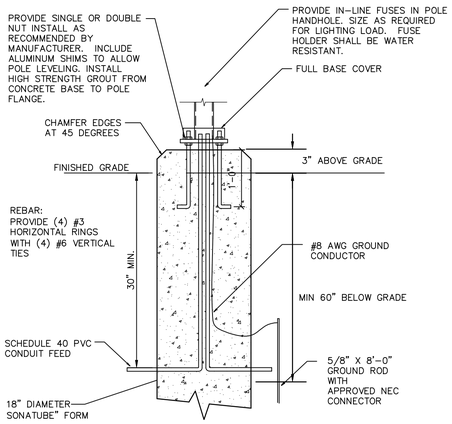


ELEVATION

6 PROJECT SIGN DETAIL
NO SCALE



TOP VIEW



7 POLE BASE DETAIL
NO SCALE

MISCELLANEOUS DETAILS

DESIGNED BY: VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 438-9841 (voice) viridis@viridg.com

SURVEYED BY: fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

City of Grand Rapids
Public Services
Engineering Department

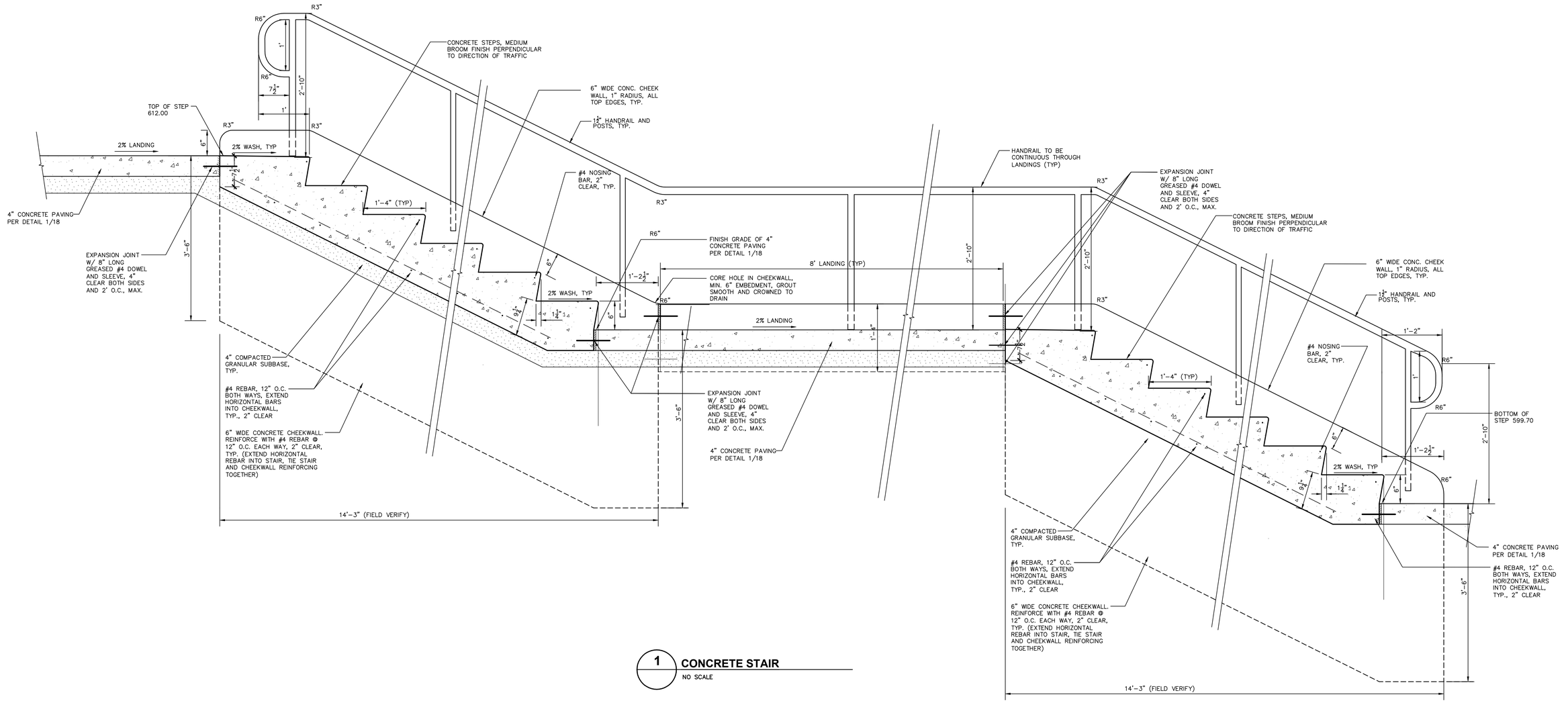
IMPROVEMENTS TO AH-NAB-AWEN PARK

REV. NO.	DESCRIPTION

Drawn by SKK
Check: Field
Check: Office

GPF No. .

Sheet No. 19 of 21



1 CONCRETE STAIR
NO SCALE

MISCELLANEOUS DETAILS

DESIGNED BY: VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 438-5841 (voice) viridis@viridg.com

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City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS TO

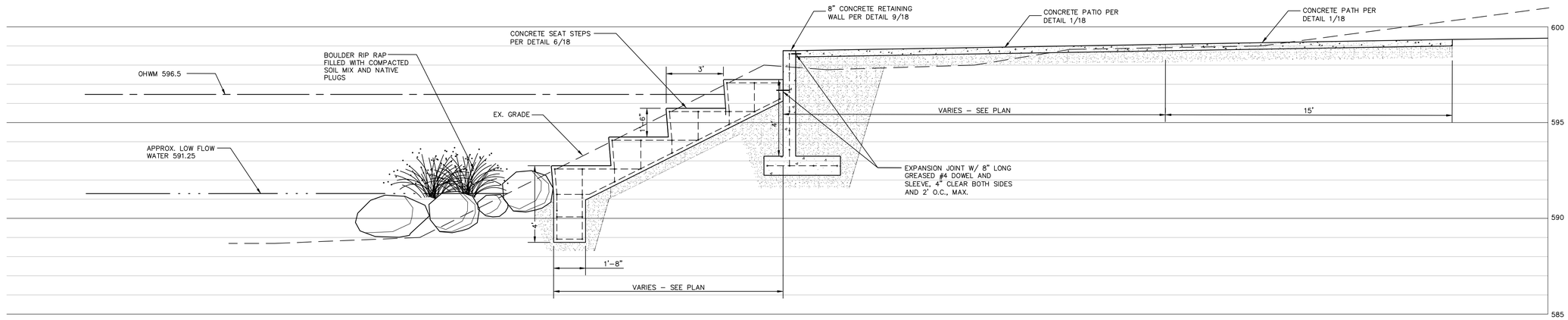
AH-NAB-AWEN PARK

REV. NO.	DESCRIPTION

Drawn by SKK
Check: Field
Check: Office

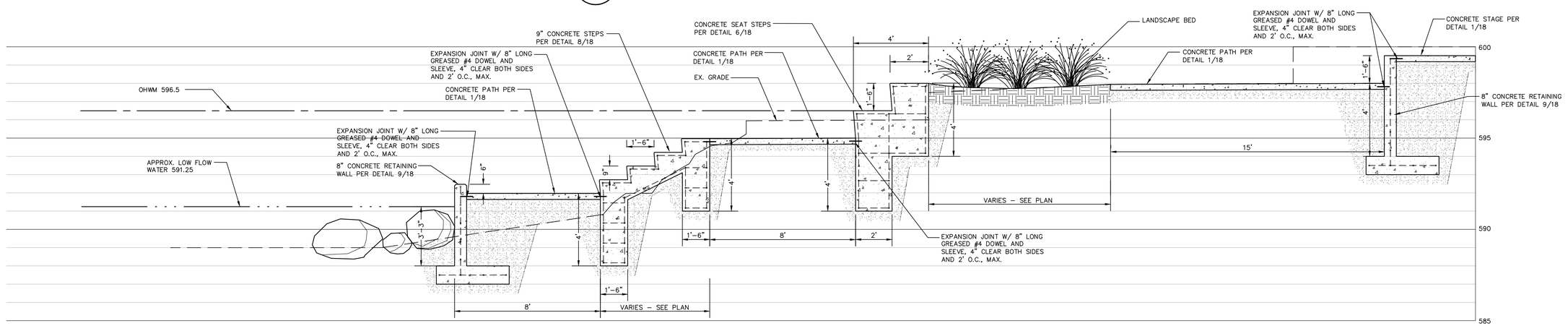
GPF No. .

Sheet No. 20 of 21



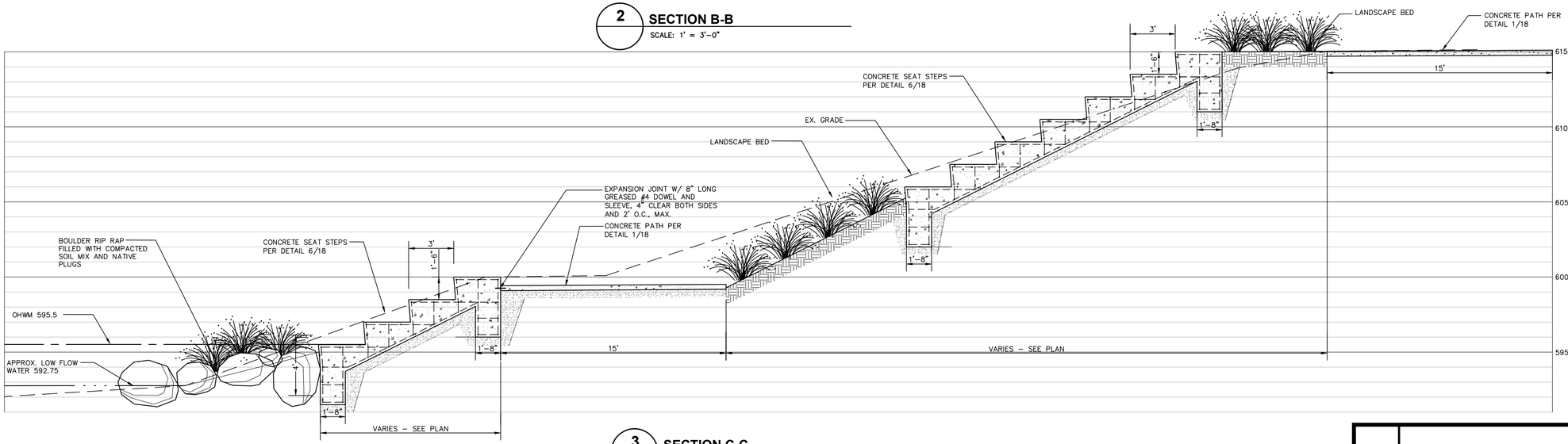
1 SECTION A-A

SCALE: 1" = 3'–0"



2 SECTION B-B

SCALE: 1" = 3'–0"



3 SECTION C-C

SCALE: 1" = 4'–0"

REV. NO.	DESCRIPTION

MISCELLANEOUS DETAILS

DESIGNED BY: VIRIDIS Design Group
1430 Monroe Ave. NW, Suite 210, Grand Rapids, MI 49505
(616) 438-9841 (voice) viridis@virdg.com

SURVEYED BY: fishbeck, thompson, carr & huber, inc.
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engineers • scientists • architects • constructors

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IMPROVEMENTS TO AH-NAB-AWEN PARK

Drawn by SKK	GPF No.	Sheet No.
Check: Field	.	21 of 21
Check: Office		

CONSTRUCTION PLANS: IMPACT SHEETS

GRAND RIVER REVITALIZATION PROJECT

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

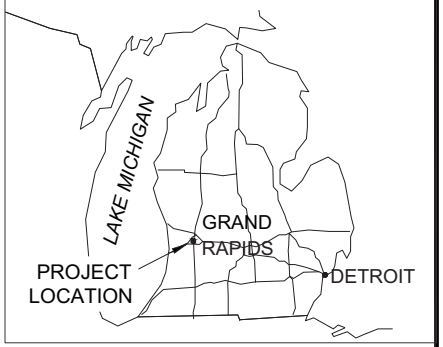
JOINT PERMIT APPLICATION

GRAND RAPIDS REVITALIZATION LOWER REACH PROJECT

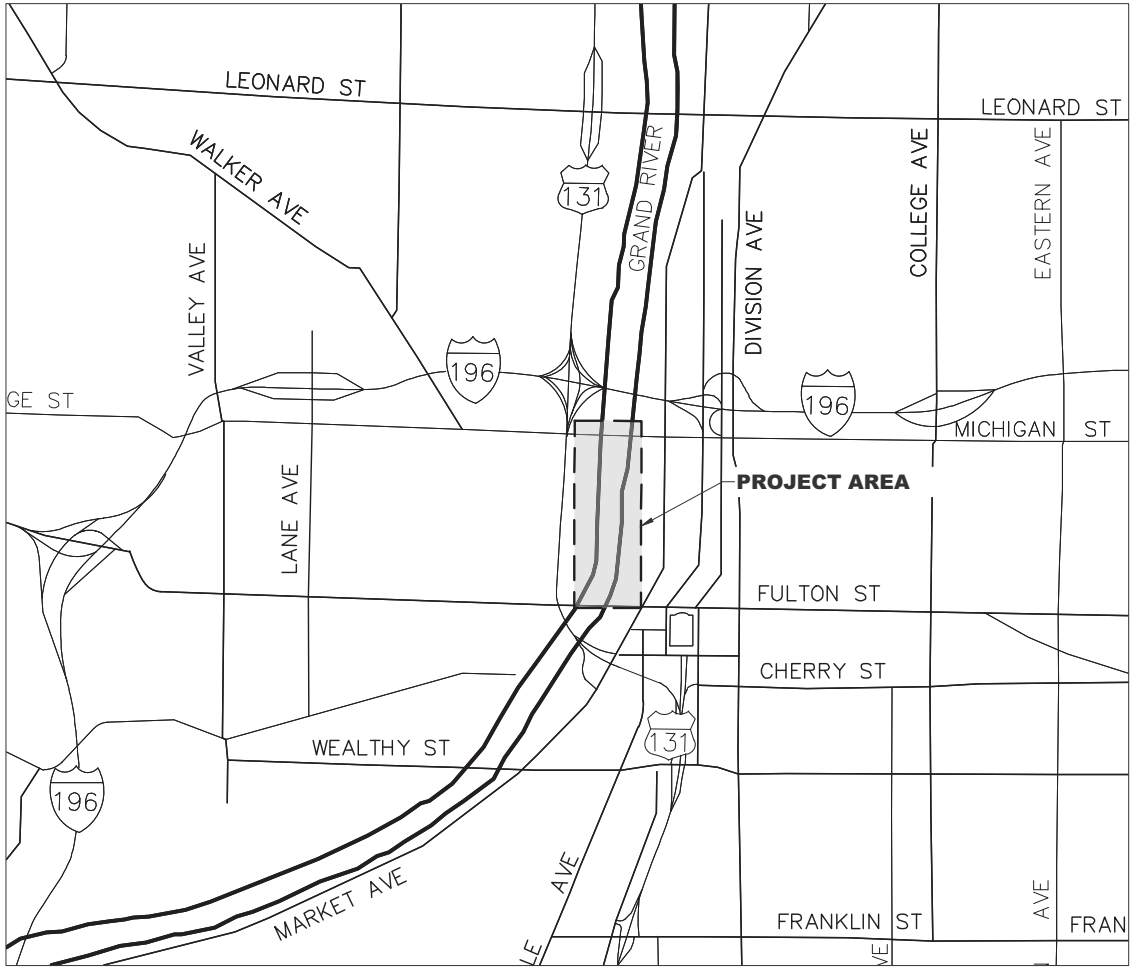
GRAND RAPIDS, MICHIGAN

MAY 2024

VICINITY MAP



LOCATION MAP



NORTH

SHEET INDEX

1	COVER SHEET
2	SHEET INDEX MAP
3	BRIDGE ST. TO GILLETT PLAN
4	BRIDGE ST. TO GILLETT CENTERLINE PROFILE
5	BRIDGE ST. TO GILLETT FEATURE PROFILES
6-7	BRIDGE ST. TO GILLETT FEATURE SECTIONS
8	GILLETT TO BLUE BRIDGE PLAN
9	GILLETT TO BLUE BRIDGE CENTERLINE PROFILE
10	GILLETT TO BLUE BRIDGE FEATURE PROFILES
11-13	GILLETT TO BLUE BRIDGE FEATURE SECTIONS
14	BLUE BRIDGE TO FULTON ST. PLAN
15-16	BLUE BRIDGE TO FULTON ST. FEATURE SECTIONS
17	AH-NAB-AWEN PARK IMPROVEMENTS PLAN
18-19	AH-NAB-AWEN PARK IMPROVEMENTS SECTIONS
20	TOTAL IMPACT TABLE

NOTE: HALF SIZE (11X17) CONSTRUCTION DESIGN DRAWINGS ARE ATTACHED FOR REFERENCE

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

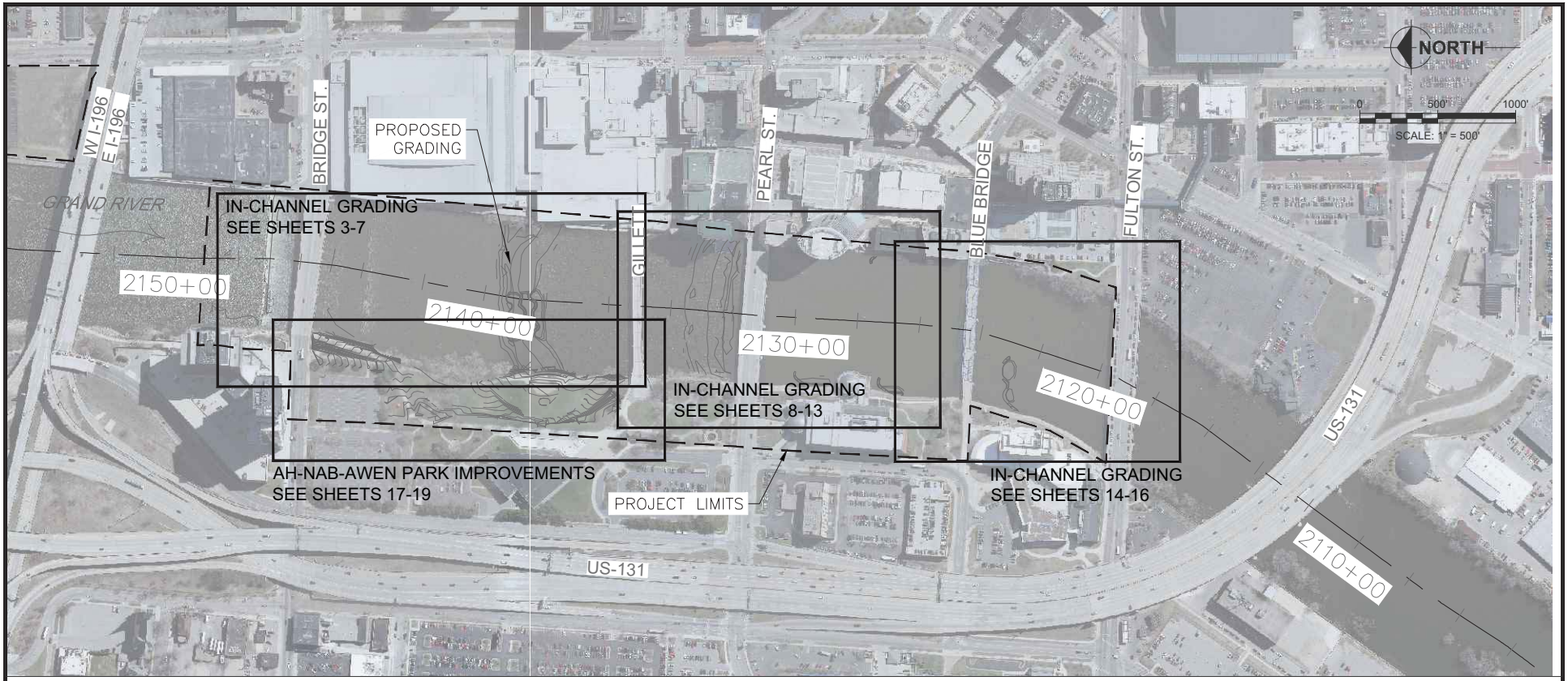
WATERWAY: GRAND RIVER

LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

COVER SHEET

SHEET: 1 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

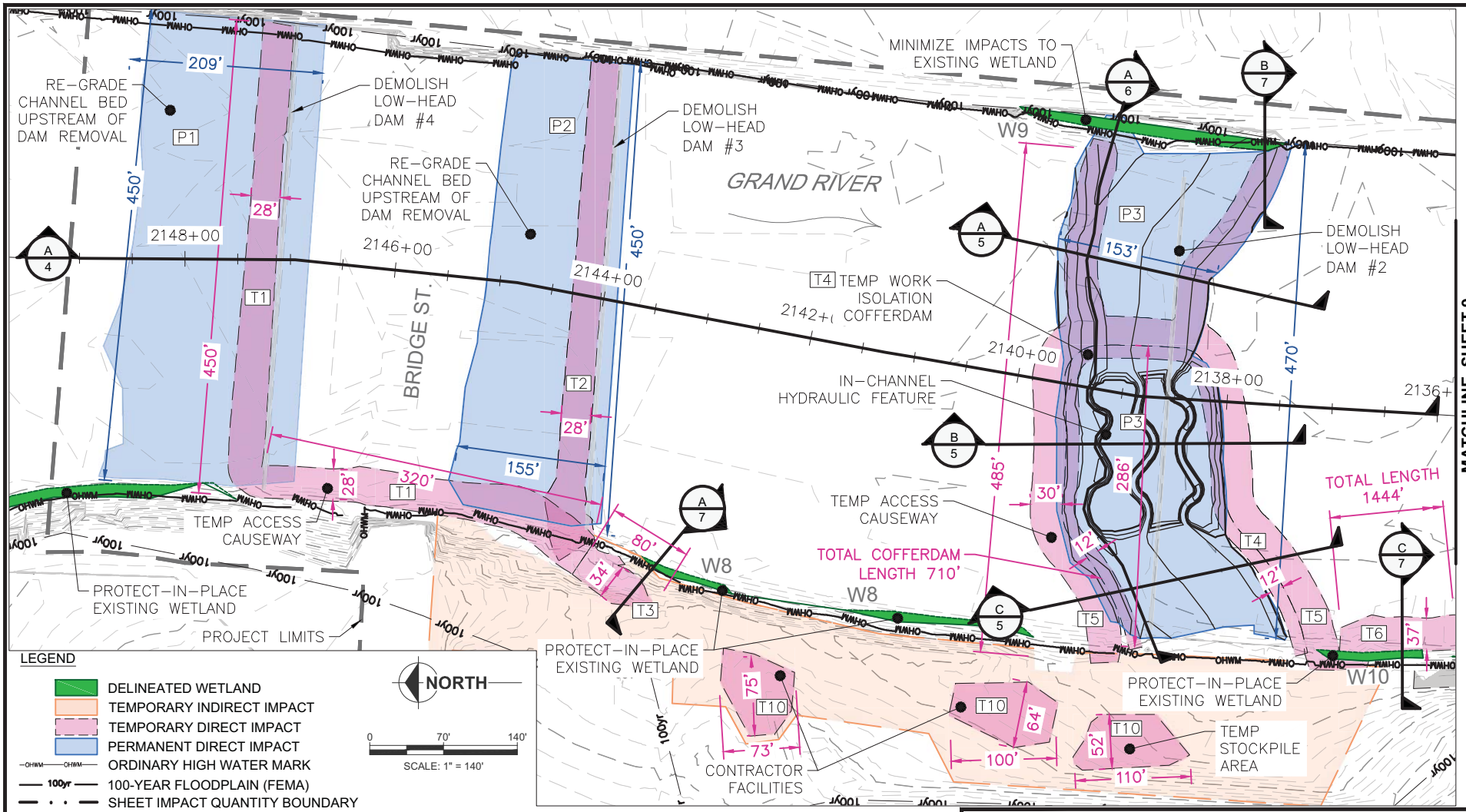
WATERWAY: GRAND RIVER

LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

SHEET INDEX MAP

SHEET: 2 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS
4. VOLUME CALCULATIONS SHOWN ON SECTION AND PROFILES SHEETS

IMPACT SUMMARY TABLE

ID	IMPACT AREA	BELOW OHWM AREA sf (ac)	BELOW OHWM VOLUME cy	WITHIN FLOODPLAIN AREA sf (ac)	WITHIN FLOODPLAIN VOLUME cy	WITHIN WETLAND AREA ac	WITHIN WETLAND VOLUME cy
T1	DAM 4 CAUSEWAY - FILL	25128 (0.6)	2100	-	-	-	-
T2	DAM 3 CAUSEWAY - FILL	2361 (0.05)	747	-	-	-	-
T3	DAM 3 & 4 HAUL ACCESS - FILL	-	-	13563 (0.3)	302	-	-
T4	DAM 2 COFFERDAM - FILL	8755 (0.2)	1500	-	-	-	-
T5	DAM 2 CAUSEWAY - FILL	34136 (0.8)	2102	-	-	-	-
T6	AH NAB AWEN CAUSEWAY - FILL	50675 (1.2)	5739	-	-	0.01	12
T10	CONSTRUCTION STAGING STOCKPILE AREA	-	-	13239 (0.3)	4717	-	-
P1	DAM 4 REMOVAL AND REGRADE - DREDGE	74663 (1.7)	2090	-	-	-	-
	DAM 4 REMOVAL AND REGRADE - FILL	74663 (1.7)	697	-	-	-	-
P2	DAM 3 REMOVAL AND REGRADE - DREDGE	51007 (1.2)	1292	-	-	-	-
	DAM 3 REMOVAL AND REGRADE - FILL	51007 (1.2)	517	-	-	-	-
P3	IN-CHANNEL FEATURE - DREDGE	73714 (1.7)	4794	-	-	0.01	61
	IN-CHANNEL FEATURE - FILL	73714 (1.7)	6658	-	-	0.01	61

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

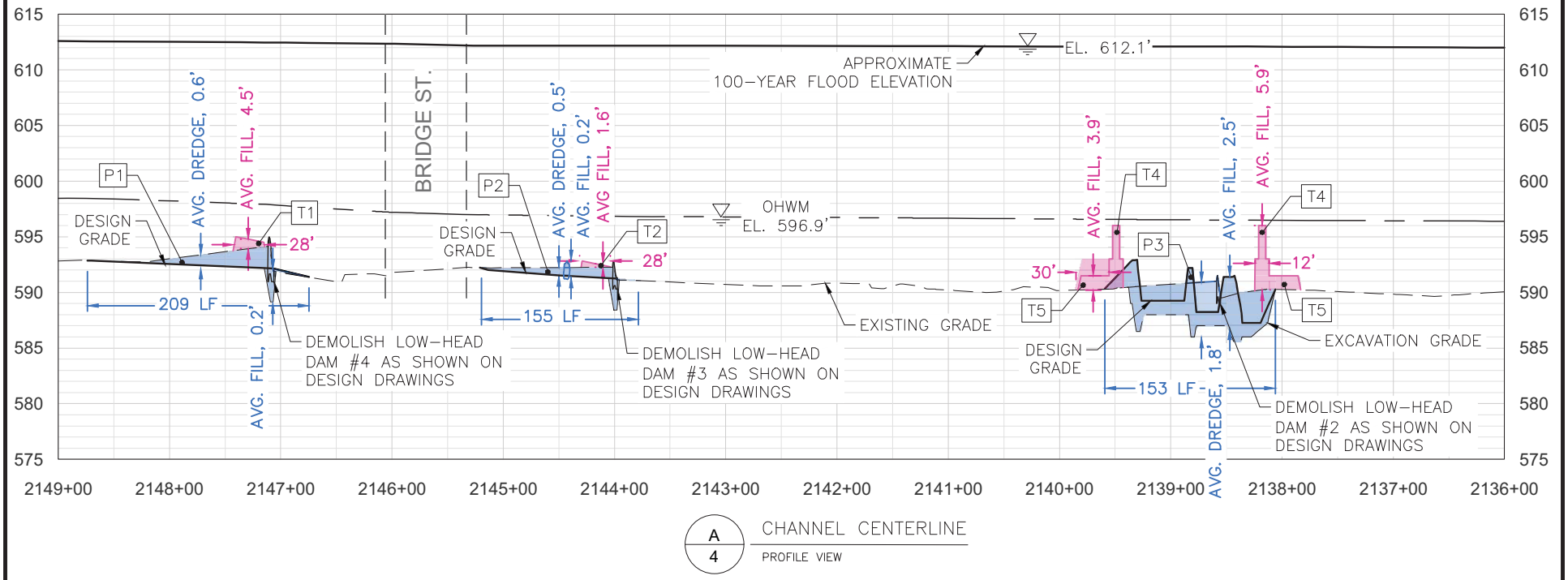
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BRIDGE STREET TO GILLETT

PLAN VIEW

SHEET: 3 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A/4 CHANNEL CENTERLINE
PROFILE VIEW

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN			WITHIN WETLAND			
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy	LENGTH ft	WIDTH ft	DEPTH ft	VOLUME cy
T1	DAM 4 CAUSEWAY - FILL	28	450	4.5	2100	-	-	-	-	-	-	-
T2	DAM 3 CAUSEWAY - FILL	28	450	1.6	747	-	-	-	-	-	-	-
T3	DAM 3 & 4 HAUL ACCESS - FILL	80	-	-	-	34	3.0	302	-	-	-	-
T4	DAM 2 COFFERDAM - FILL	24	286	5.9	1500	-	-	-	-	-	-	-
T5	DAM 2 CAUSEWAY - FILL	30	485	3.9	2102	-	-	-	-	-	-	-
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-	79	8	0.5	12
T10	CONSTRUCTION STAGING STOCKPILE AREA	283	-	-	-	75	6.0	4,717	-	-	-	-
P1	DAM 4 REMOVAL AND REGRADE - DREDGE	209	450	0.6	2090	-	-	-	-	-	-	-
	DAM 4 REMOVAL AND REGRADE - FILL	209	450	0.2	697	-	-	-	-	-	-	-
P2	DAM 3 REMOVAL AND REGRADE - DREDGE	155	450	0.5	1292	-	-	-	-	-	-	-
	DAM 3 REMOVAL AND REGRADE - FILL	155	450	0.2	517	-	-	-	-	-	-	-
P3	IN-CHANNEL FEATURE - DREDGE	153	470	1.8	4794	-	-	-	33	10	5	61
	IN-CHANNEL FEATURE - FILL	153	470	2.5	6658	-	-	-	33	10	5	61

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 3 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

0 70' 140'
SCALE: 1" = 140'

VERTICAL EXAGGERATION: 10x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

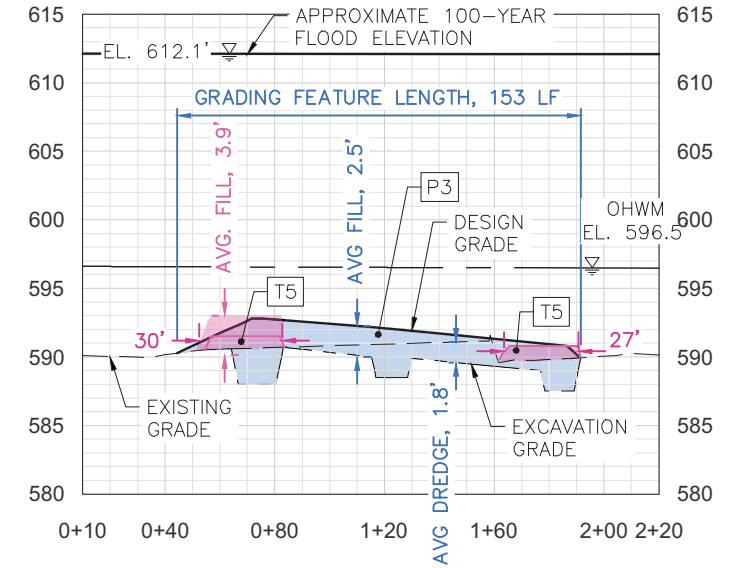
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BRIDGE STREET TO GILLETT

PROFILE VIEW - CENTERLINE

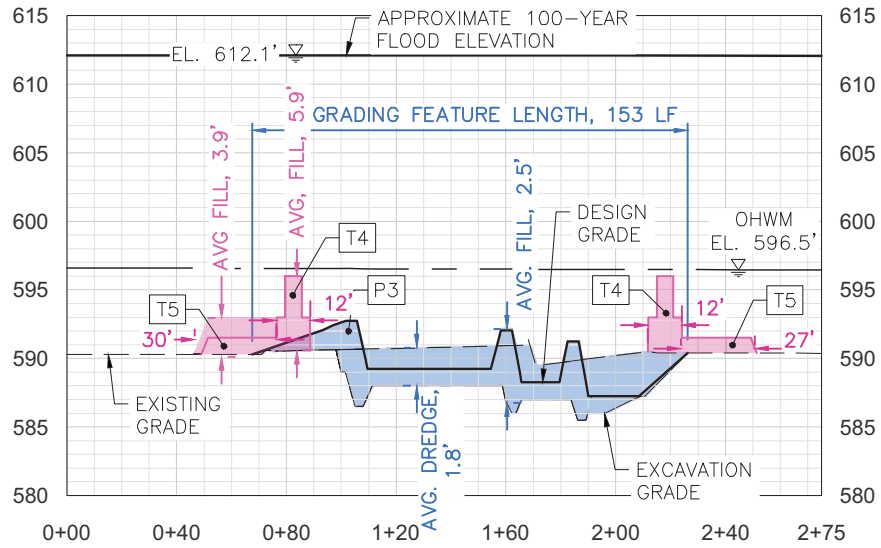
SHEET: 4 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



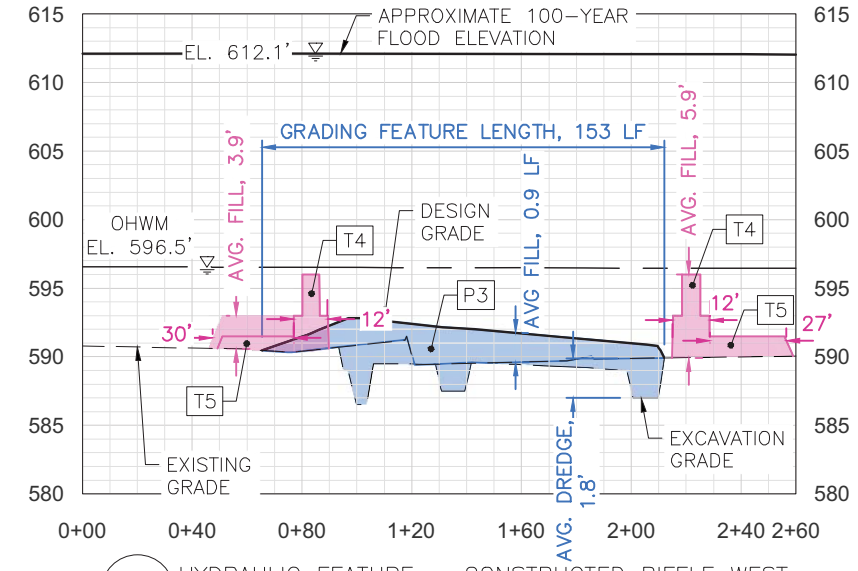
A/5 HYDRAULIC FEATURE – CONSTRUCTED RIFFLE EAST

PROFILE VIEW



B/5 HYDRAULIC FEATURE – DIVERSIFIED BOULDER DROP STRUCTURES

PROFILE VIEW



C/5 HYDRAULIC FEATURE – CONSTRUCTED RIFFLE WEST

PROFILE VIEW

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 3 FOR IMPACT AREAS.
4. SEE SHEET 4 FOR IMPACT VOLUME CALCULATIONS.
5. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS.

LEGEND

TEMPORARY IMPACT

PERMANENT IMPACT

0 35' 70'

SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

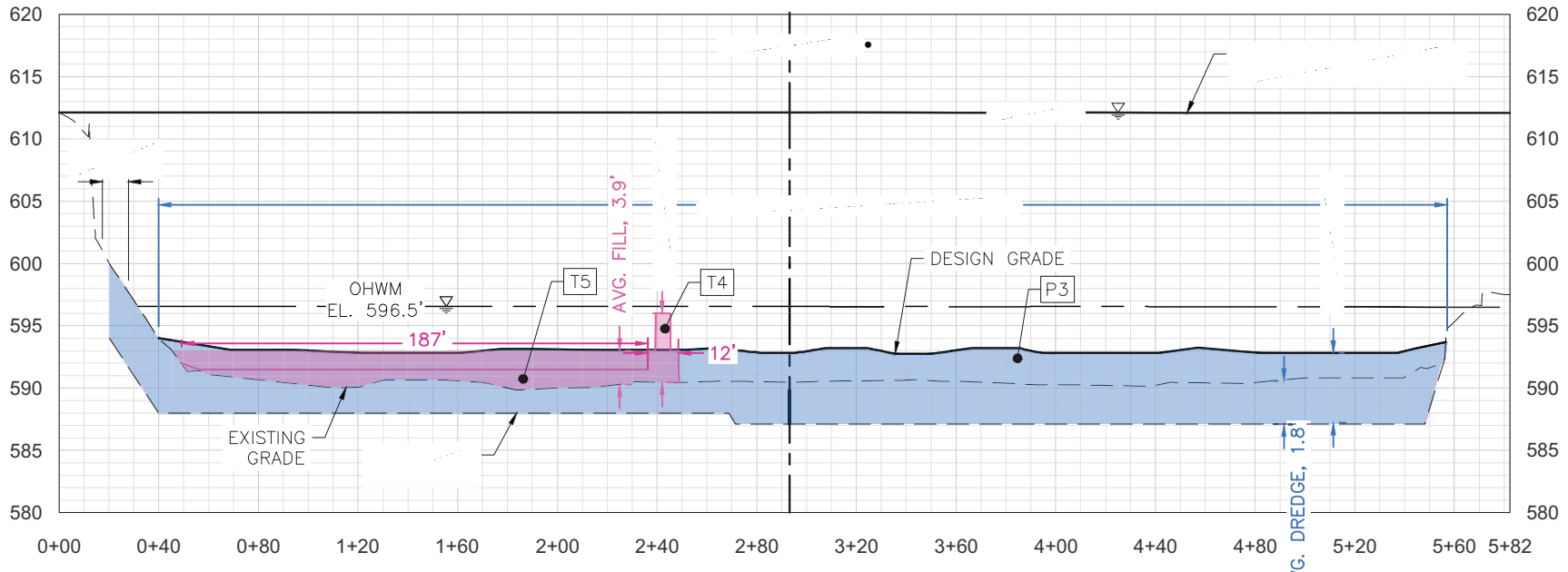
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BRIDGE STREET TO GILLETT

PROFILE VIEW - HYDRAULIC FEATURE

SHEET: 5 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A/6 STREAM IMPACT – FEATURE CREST
SECTION VIEW

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM WIDTH ft	BELOW OHWM DEPTH ft	BELOW OHWM VOLUME cy	WITHIN FLOODPLAIN WIDTH ft	WITHIN FLOODPLAIN DEPTH ft	WITHIN FLOODPLAIN VOLUME cy	WITHIN WETLAND LENGTH ft	WITHIN WETLAND WIDTH ft	WITHIN WETLAND DEPTH ft	WITHIN WETLAND VOLUME cy
T1	DAM 4 CAUSEWAY - FILL	28	450	4.5	2100	-	-	-	-	-	-	-
T2	DAM 3 CAUSEWAY - FILL	28	450	1.6	747	-	-	-	-	-	-	-
T3	DAM 3 & 4 HAUL ACCESS - FILL	80	-	-	-	34	3.0	302	-	-	-	-
T4	DAM 2 COFFERDAM - FILL	24	286	5.9	1500	-	-	-	-	-	-	-
T5	DAM 2 CAUSEWAY - FILL	30	485	3.9	2102	-	-	-	-	-	-	-
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-	79	8	0.5	12
T10	CONSTRUCTION STAGING STOCKPILE AREA	283	-	-	-	75	6.0	4,717	-	-	-	-
P1	DAM 4 REMOVAL AND REGRADE - DREDGE	209	450	0.6	2090	-	-	-	-	-	-	-
	DAM 4 REMOVAL AND REGRADE - FILL	209	450	0.2	697	-	-	-	-	-	-	-
P2	DAM 3 REMOVAL AND REGRADE - DREDGE	155	450	0.5	1292	-	-	-	-	-	-	-
	DAM 3 REMOVAL AND REGRADE - FILL	155	450	0.2	517	-	-	-	-	-	-	-
P3	IN-CHANNEL FEATURE - DREDGE	153	470	1.8	4794	-	-	-	33	10	5	61
	IN-CHANNEL FEATURE - FILL	153	470	2.5	6658	-	-	-	33	10	5	61

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 3 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

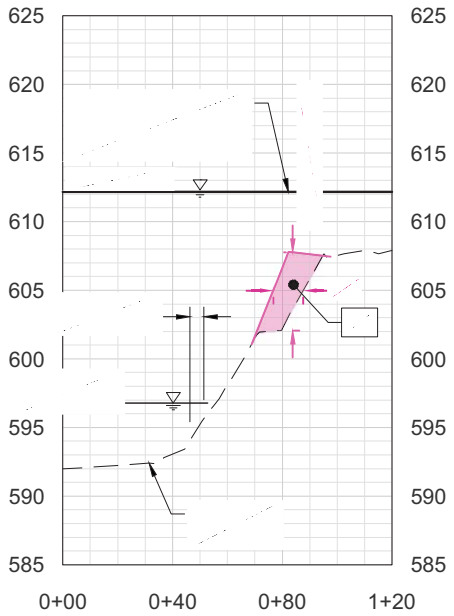
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BRIDGE STREET TO GILLETT

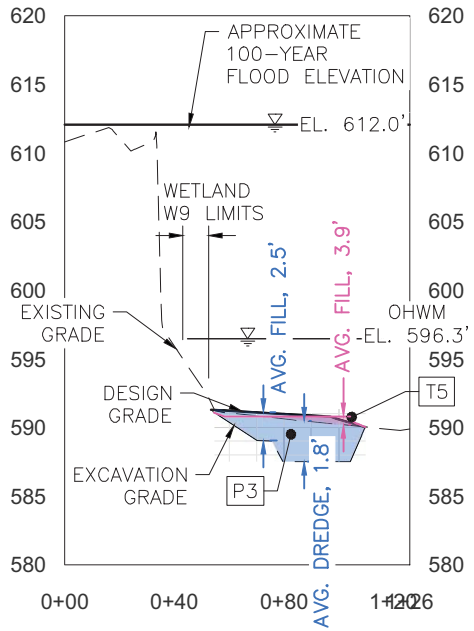
SECTION VIEW

SHEET: 6 OF 20 DATE: MAY 2024

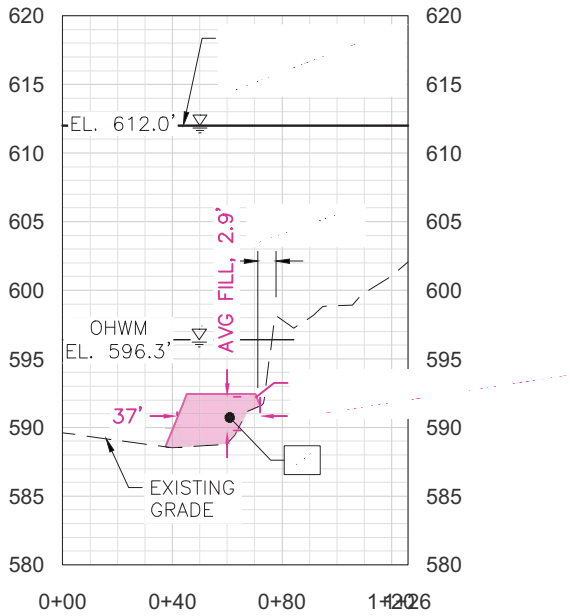
PREPARED FOR EGLE JOINT PERMIT APPLICATION



A/7 WETLAND 8 IMPACT
SECTION VIEW



B/7 WETLAND 9 IMPACT
SECTION VIEW



C/7 WETLAND 10 IMPACT
SECTION VIEW

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN			WITHIN WETLAND			
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy	LENGTH ft	WIDTH ft	DEPTH ft	VOLUME cy
T1	DAM 4 CAUSEWAY - FILL	28	450	4.5	2100	-	-	-	-	-	-	-
T2	DAM 3 CAUSEWAY - FILL	28	450	1.6	747	-	-	-	-	-	-	-
T3	DAM 3 & 4 HAUL ACCESS - FILL	80	-	-	-	34	3.0	302	-	-	-	-
T4	DAM 2 COFFERDAM - FILL	24	286	5.9	1500	-	-	-	-	-	-	-
T5	DAM 2 CAUSEWAY - FILL	30	485	3.9	2102	-	-	-	-	-	-	-
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-	79	8	0.5	12
T10	CONSTRUCTION STAGING STOCKPILE AREA	283	-	-	-	75	6.0	4,717	-	-	-	-
P1	DAM 4 REMOVAL AND REGRADE - DREDGE	209	450	0.6	2090	-	-	-	-	-	-	-
	DAM 4 REMOVAL AND REGRADE - FILL	209	450	0.2	697	-	-	-	-	-	-	-
P2	DAM 3 REMOVAL AND REGRADE - DREDGE	155	450	0.5	1292	-	-	-	-	-	-	-
	DAM 3 REMOVAL AND REGRADE - FILL	155	450	0.2	517	-	-	-	-	-	-	-
P3	IN-CHANNEL FEATURE - DREDGE	153	470	1.8	4794	-	-	-	33	10	5	61
	IN-CHANNEL FEATURE - FILL	153	470	2.5	6658	-	-	-	33	10	5	61

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 3 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS
5. THE TEMPORARY WETLAND IMPACT FROM T6 IS A POTENTIAL IMPACT ONLY. THIS AREA HAS BEEN CALCULATED BASED ON CONSERVATIVE ASSUMPTIONS FOR LIMITS OF GRADING; PROPOSED GRADING TIES INTO EXISTING GRADE OUTSIDE DELINEATED WETLAND BOUNDARY. THESE IMPACTS WILL BE AVOIDED IF SITE CONDITIONS ALLOW.

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

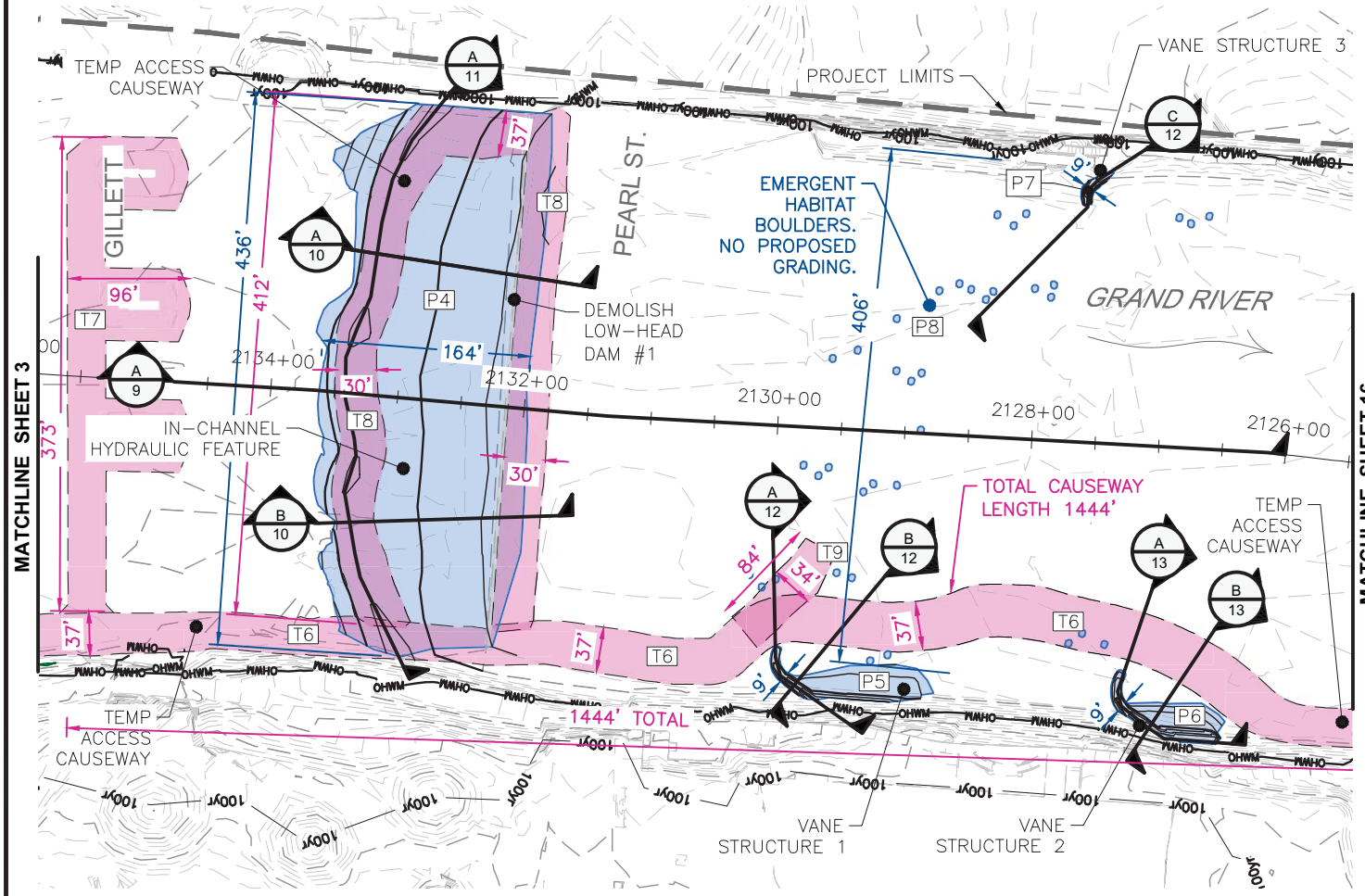
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BRIDGE STREET TO GILLETT

SECTION VIEW

SHEET: 7 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS
4. VOLUME CALCULATIONS SHOWN ON SECTION AND PROFILES SHEETS

LEGEND

- DELINEATED WETLAND
- TEMPORARY INDIRECT IMPACT
- TEMPORARY DIRECT IMPACT
- PERMANENT DIRECT IMPACT
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YEAR FLOODPLAIN (FEMA) (100yr)
- SHEET IMPACT QUANTITY BOUNDARY

NORTH

0 70' 140'

SCALE: 1" = 140'

IMPACT SUMMARY TABLE

ID	IMPACT AREA	BELOW OHWM		WITHIN FLOODPLAIN		WITHIN WETLAND	
		AREA sf (ac)	VOLUME cy	AREA sf (ac)	VOLUME cy	AREA ac	VOLUME cy
T6	AH NAB AWEN CAUSEWAY - FILL	50675 (1.2)	5739	-	-	-	-
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	21267 (0.5)	1589	-	-	-	-
T8	DAM 1 CAUSEWAY - FILL	30168 (0.7)	2197	-	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	2810 (0.06)	381	-	-	-	-
P4	IN-CHANNEL FEATURE - DREDGE	65108 (1.5)	4237	-	-	-	-
	IN-CHANNEL FEATURE - FILL	65108 (1.5)	5561	-	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	2820 (0.06)	41	-	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	2820 (0.06)	83	-	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	2100 (0.05)	45	-	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	2100 (0.05)	90	-	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	266 (0.01)	24	-	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	266 (0.01)	47	-	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	1368 (0.03)	156	-	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	1368 (0.03)	235	-	-	-	-

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

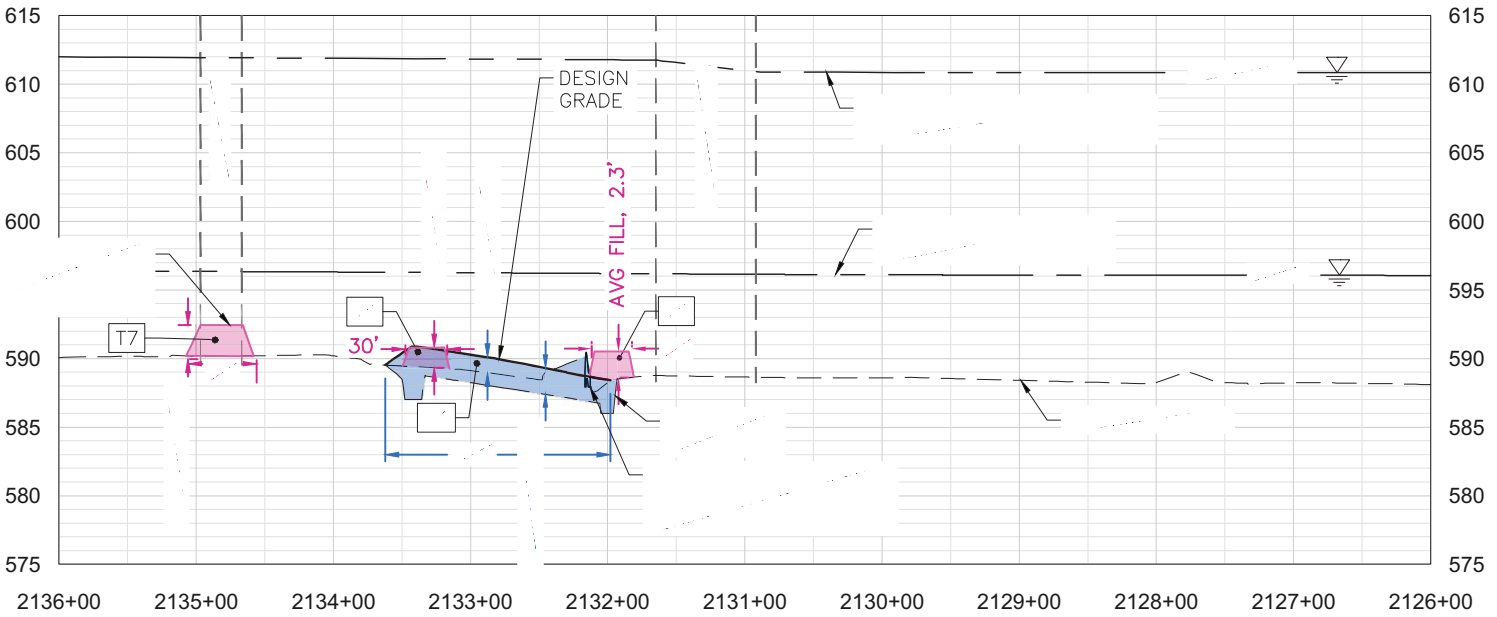
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

GILLETT TO BLUE BRIDGE

PLAN VIEW

SHEET: 8 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A/9 CHANNEL CENTERLINE
PROFILE VIEW

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	50	373	2.3	1589	-	-	-
T8	DAM 1 CAUSEWAY - FILL	60	412	2.4	2197	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	84	34	3.6	381	-	-	-
P4	IN-CHANNEL FEATURE - DREDGE	164	436	1.6	4237	-	-	-
	IN-CHANNEL FEATURE - FILL	164	436	2.1	5561	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	62	9	2.0	41	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	62	9	4.0	83	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	112	9	1.2	45	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	112	9	2.4	90	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	40	9	1.8	24	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	40	9	3.5	47	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	4	406	2.6	156	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	406	3.9	235	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 9 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

0 70' 140'
SCALE: 1" = 140'

VERTICAL EXAGGERATION: 10x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

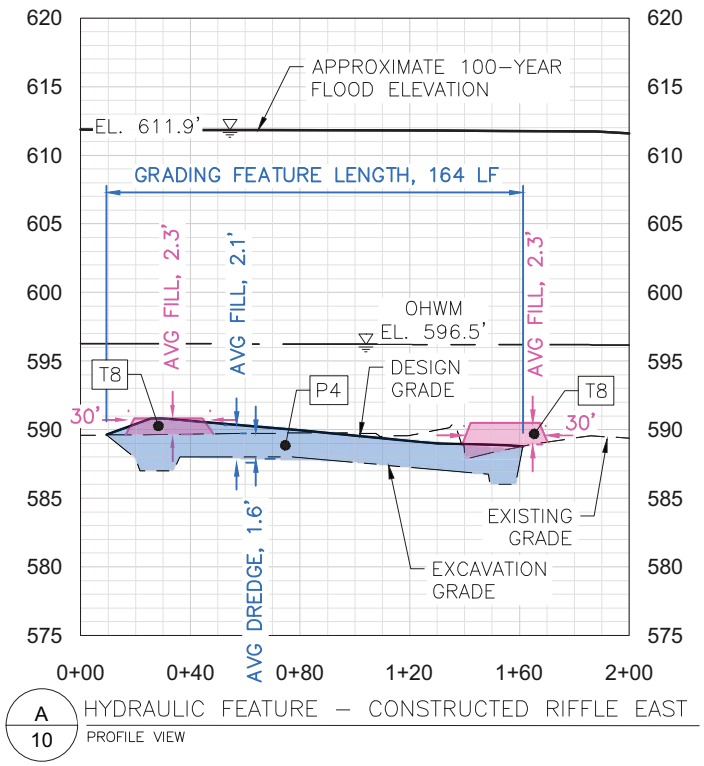
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

GILLETT TO BLUE BRIDGE

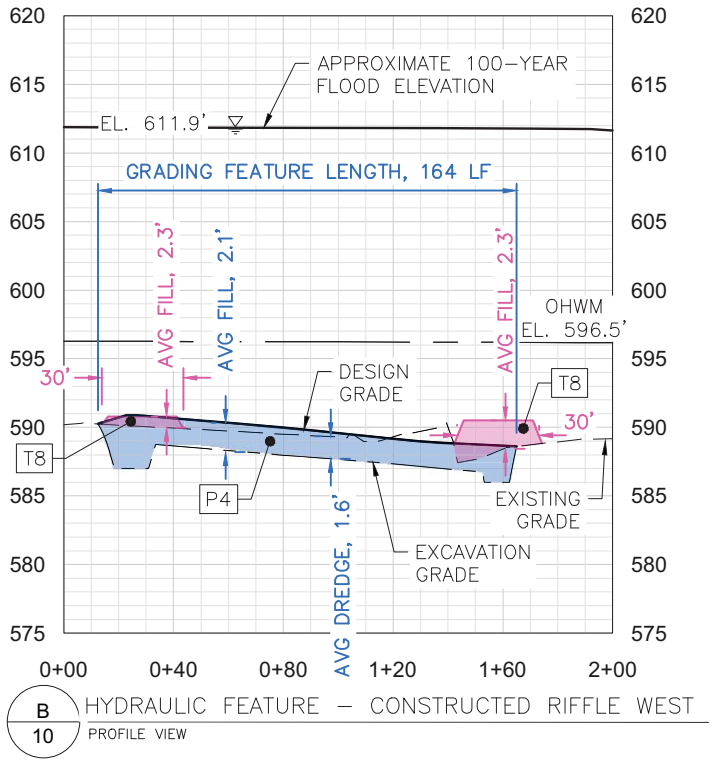
PROFILE VIEW - CENTERLINE

SHEET: 9 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A 10 HYDRAULIC FEATURE – CONSTRUCTED RIFFLE EAST
PROFILE VIEW



B 10 HYDRAULIC FEATURE – CONSTRUCTED RIFFLE WEST
PROFILE VIEW

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	50	373	2.3	1589	-	-	-
T8	DAM 1 CAUSEWAY - FILL	60	412	2.4	2197	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	84	34	3.6	381	-	-	-
P4	IN-CHANNEL FEATURE - DREDGE	164	436	1.6	4237	-	-	-
	IN-CHANNEL FEATURE - FILL	164	436	2.1	5561	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	62	9	2.0	41	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	62	9	4.0	83	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	112	9	1.2	45	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	112	9	2.4	90	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	40	9	1.8	24	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	40	9	3.5	47	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	4	406	2.6	156	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	406	3.9	235	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 9 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

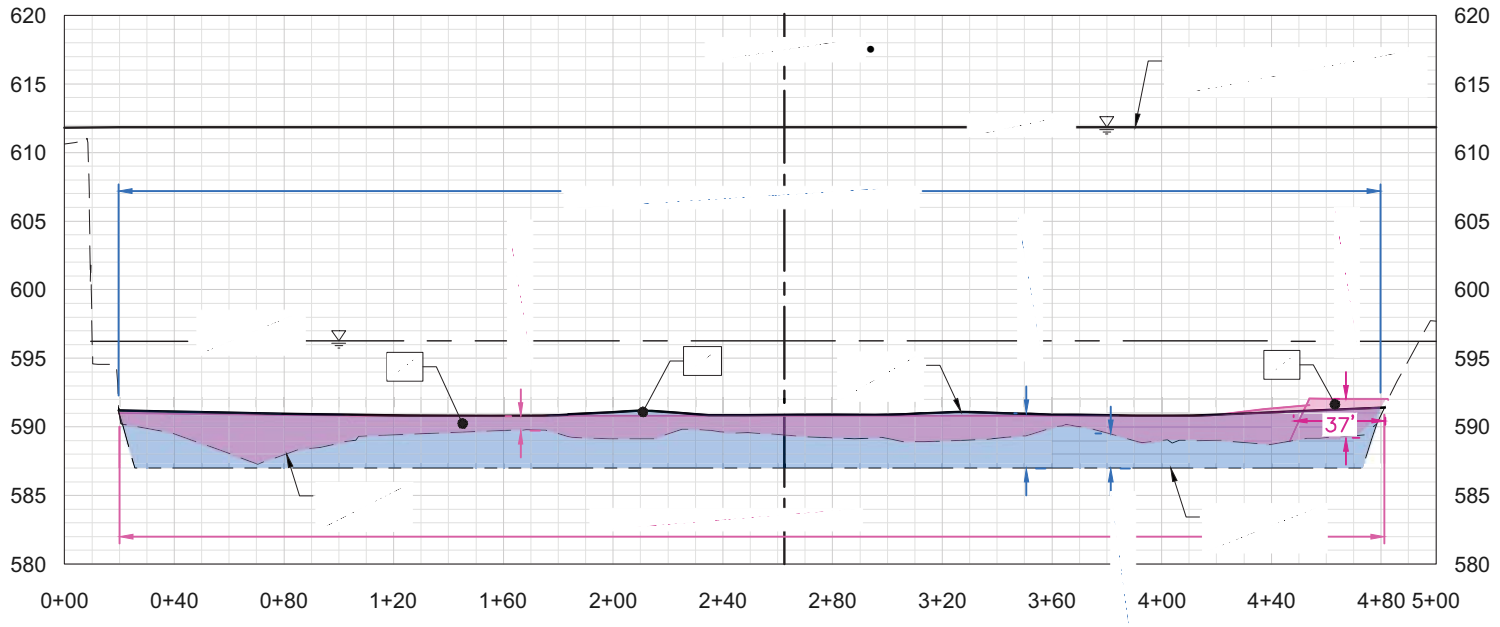
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

GILLETT TO BLUE BRIDGE

PROFILE VIEW - HYDRAULIC FEATURE

SHEET: 10 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A
11

STREAM IMPACT – DAM 1 CAUSEWAY
SECTION VIEW

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	50	373	2.3	1589	-	-	-
T8	DAM 1 CAUSEWAY - FILL	60	412	2.4	2197	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	84	34	3.6	381	-	-	-
P4	IN-CHANNEL FEATURE - DREDGE	164	436	1.6	4237	-	-	-
	IN-CHANNEL FEATURE - FILL	164	436	2.1	5561	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	62	9	2.0	41	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	62	9	4.0	83	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	112	9	1.2	45	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	112	9	2.4	90	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	40	9	1.8	24	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	40	9	3.5	47	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	4	406	2.6	156	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	406	3.9	235	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 9 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

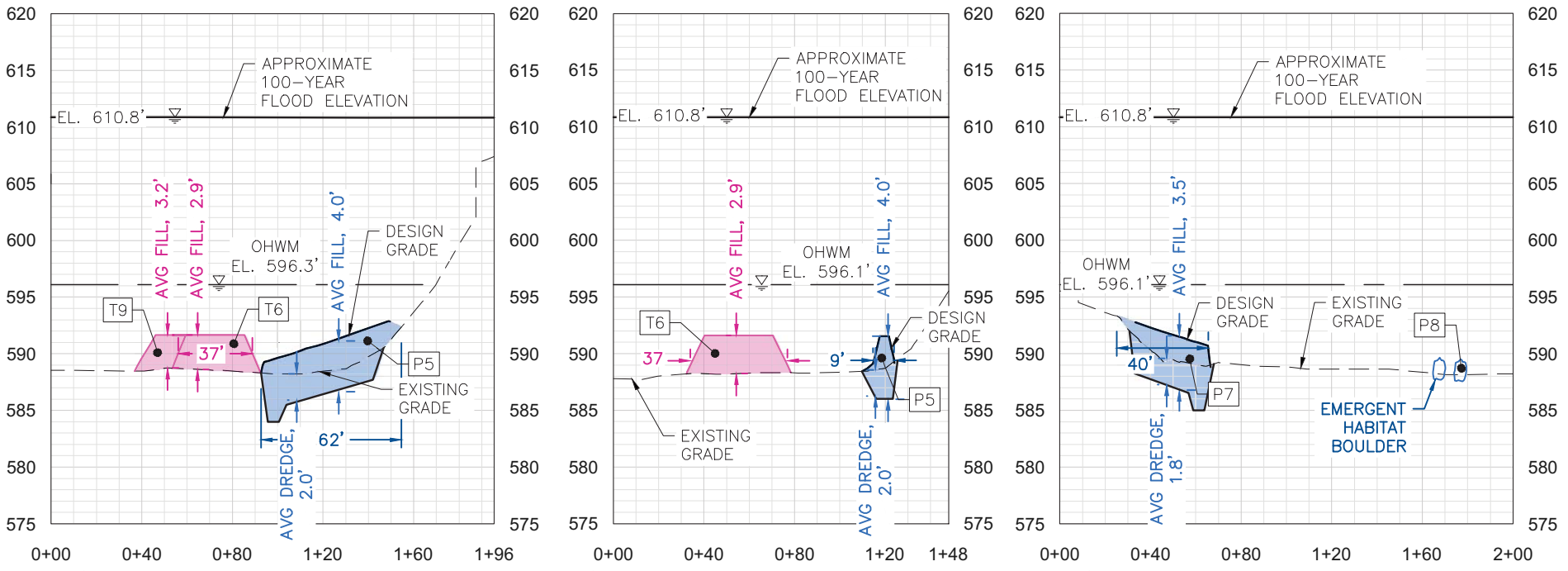
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

GILLETT TO BLUE BRIDGE

SECTION VIEW

SHEET: 11 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	50	373	2.3	1589	-	-	-
T8	DAM 1 CAUSEWAY - FILL	60	412	2.4	2197	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	84	34	3.6	381	-	-	-
P4	IN-CHANNEL FEATURE - DREDGE	164	436	1.6	4237	-	-	-
	IN-CHANNEL FEATURE - FILL	164	436	2.1	5561	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	62	9	2.0	41	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	62	9	4.0	83	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	112	9	1.2	45	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	112	9	2.4	90	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	40	9	1.8	24	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	40	9	3.5	47	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	4	406	2.6	156	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	406	3.9	235	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 9 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS.
5. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS.

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

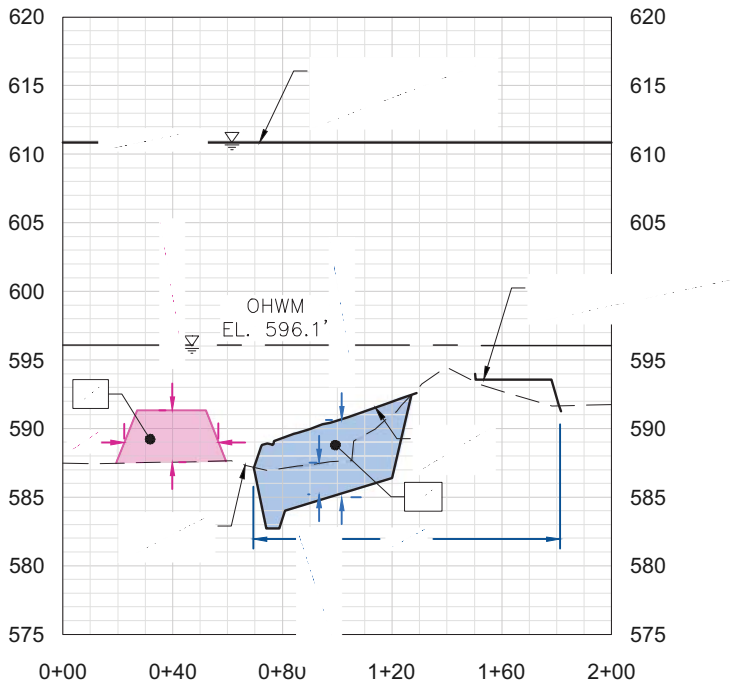
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

GILLETT TO BLUE BRIDGE

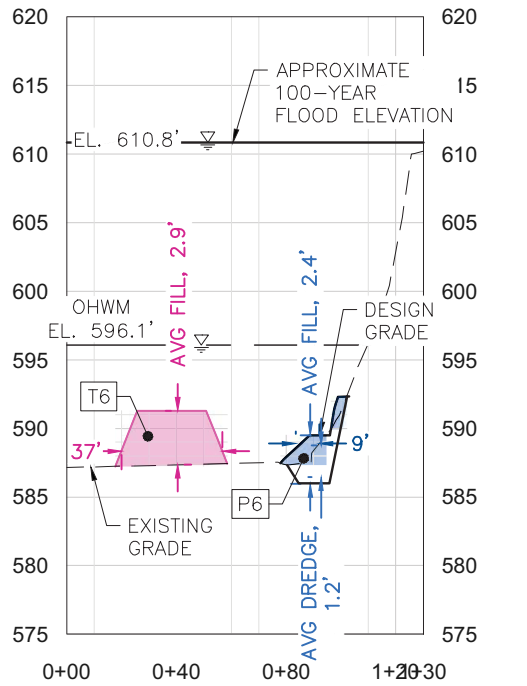
SECTION VIEW

SHEET: 12 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A 13 STREAM IMPACT – BOULDER VANE 2
SECTION VIEW



B 13 STREAM IMPACT – BOULDER VANE 2
SECTION VIEW

LEGEND

- TEMPORARY IMPACT
- PERMANENT IMPACT

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY - FILL	1444	37	2.9	5739	-	-	-
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	50	373	2.3	1589	-	-	-
T8	DAM 1 CAUSEWAY - FILL	60	412	2.4	2197	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	84	34	3.6	381	-	-	-
P4	IN-CHANNEL FEATURE - DREDGE	164	436	1.6	4237	-	-	-
	IN-CHANNEL FEATURE - FILL	164	436	2.1	5561	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	62	9	2.0	41	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	62	9	4.0	83	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	112	9	1.2	45	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	112	9	2.4	90	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	40	9	1.8	24	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	40	9	3.5	47	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	4	406	2.6	156	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	406	3.9	235	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 9 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

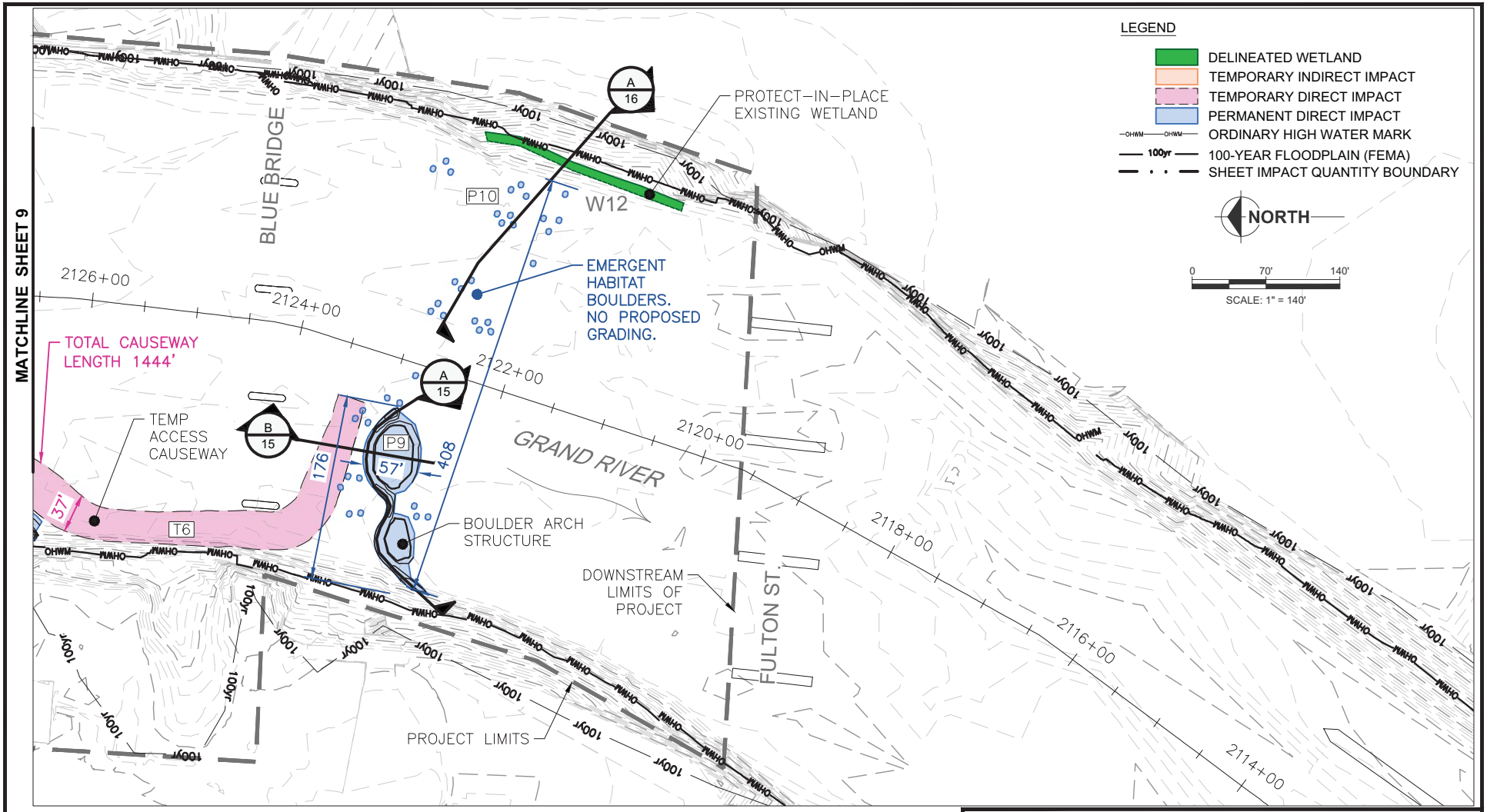
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

GILLETT TO BLUE BRIDGE

SECTION VIEW

SHEET: 13 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



IMPACT SUMMARY TABLE

ID	IMPACT AREA	BELOW OHWM		WITHIN FLOODPLAIN		WITHIN WETLAND	
		AREA sf (ac)	VOLUME cy	AREA sf (ac)	VOLUME cy	AREA ac	VOLUME cy
T6	AH NAB AWEN CAUSEWAY	50675 (1.2)	5739	-	-	-	-
P9	AUGMENTED BANK VANE STRUCTURE - DREDGE	5455 (0.1)	520	-	-	-	-
	AUGMENTED BANK VANE STRUCTURE - FILL	5455 (0.1)	372	-	-	-	-
P10	EMERGENT HABITAT BOULDERS - DREDGE	1476 (0.03)	169	-	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	1476 (0.03)	254	-	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS
4. VOLUME CALCULATIONS SHOWN ON SECTION AND PROFILES SHEETS

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

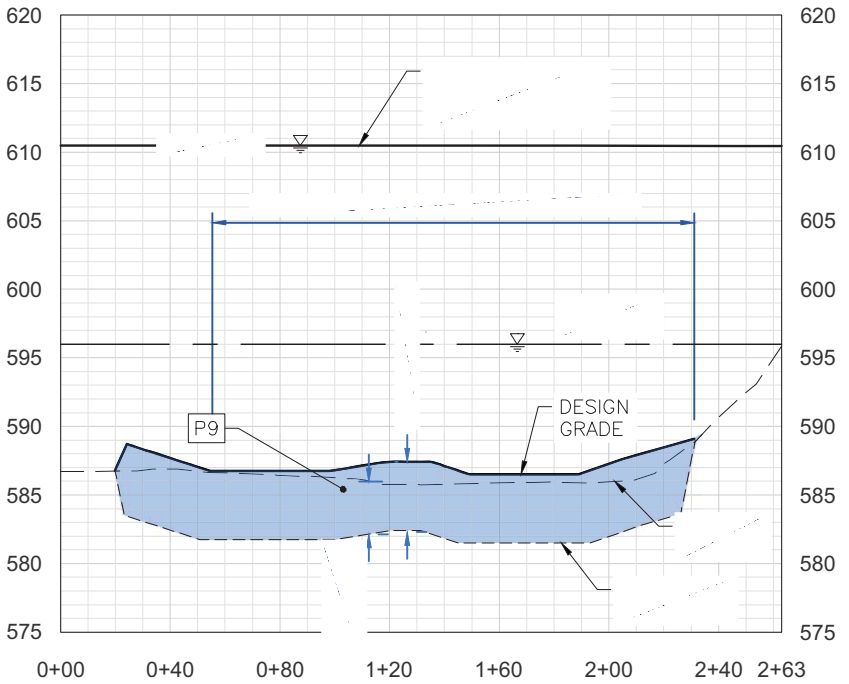
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BLUE BRIDGE TO FULTON ST

PLAN VIEW

SHEET: 14 OF 20 DATE: MAY 2024

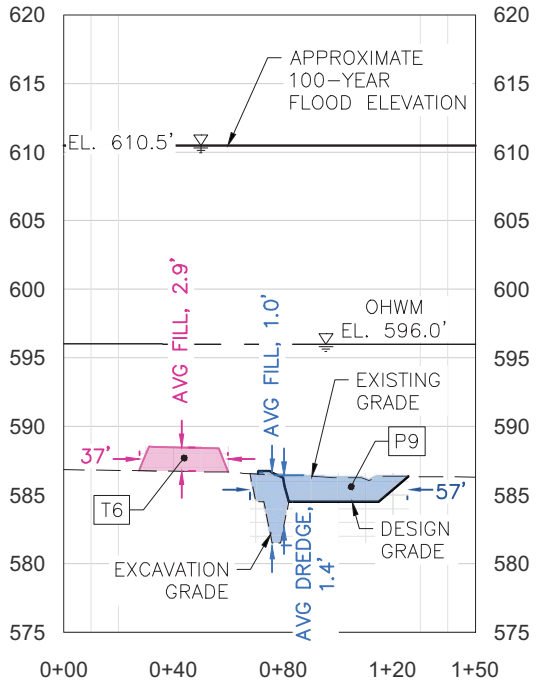
PREPARED FOR EGLE JOINT PERMIT APPLICATION



A
15

STREAM IMPACT – DIVERSIFIED BOULDER DROP STRUCTURE

SECTION VIEW



B
15

STREAM IMPACT – DIVERSIFIED BOULDER DROP STRUCTURE

SECTION VIEW

LEGEND

TEMPORARY IMPACT

PERMANENT IMPACT

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY	1444	37	2.9	5739	-	-	-
P9	AUGMENTED BANK VANE STRUCTURE - DREDGE	57	176	1.4	520	-	-	-
	AUGMENTED BANK VANE STRUCTURE - FILL	57	176	1.0	372	-	-	-
P10	EMERGENT HABITAT BOULDERS - DREDGE	4	408	2.8	169	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	408	4.2	254	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 16 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

0 35' 70'

SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

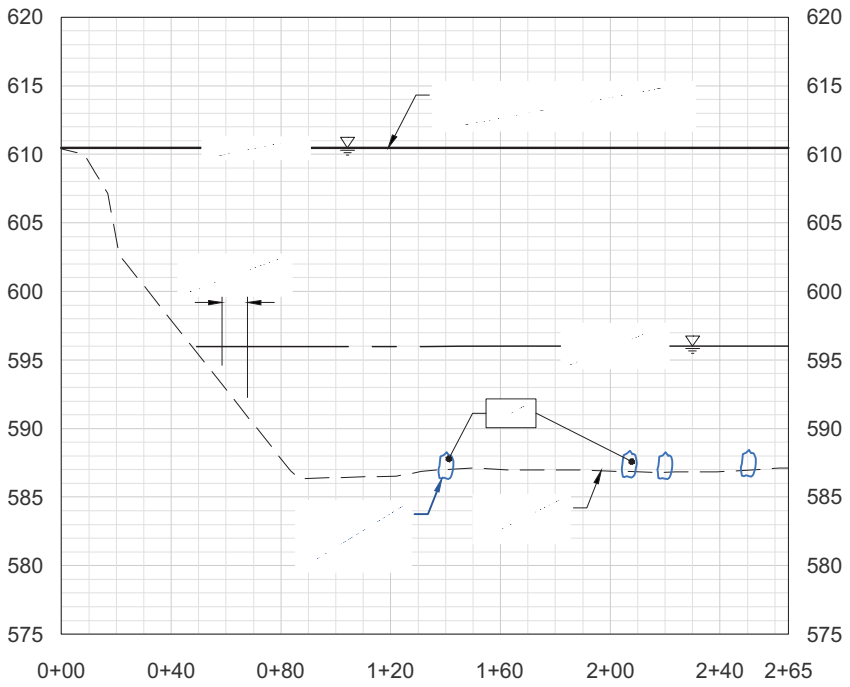
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BLUE BRIDGE TO FULTON ST

SECTION VIEW

SHEET: 15 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A/16 STREAM IMPACT – EMERGENT HABITAT BOULDERS
SECTION VIEW

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN		
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy
T6	AH NAB AWEN CAUSEWAY	1444	37	2.9	5739	-	-	-
P9	AUGMENTED BANK VANE STRUCTURE - DREDGE	57	176	1.4	520	-	-	-
	AUGMENTED BANK VANE STRUCTURE - FILL	57	176	1.0	372	-	-	-
P10	EMERGENT HABITAT BOULDERS - DREDGE	4	408	2.8	169	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	4	408	4.2	254	-	-	-

NOTES

1. ALL PERMANENT IMPACTS ARE BELOW ORDINARY HIGH WATER (OHWM).
2. ALL IMPACTS ASSOCIATED WITH STAGING AREAS ARE LOCATED WITHIN THE FLOODPLAIN AND ARE TEMPORARY.
3. SEE SHEET 16 FOR IMPACT AREAS.
4. SEE CONSTRUCTION DRAWINGS SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS.

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

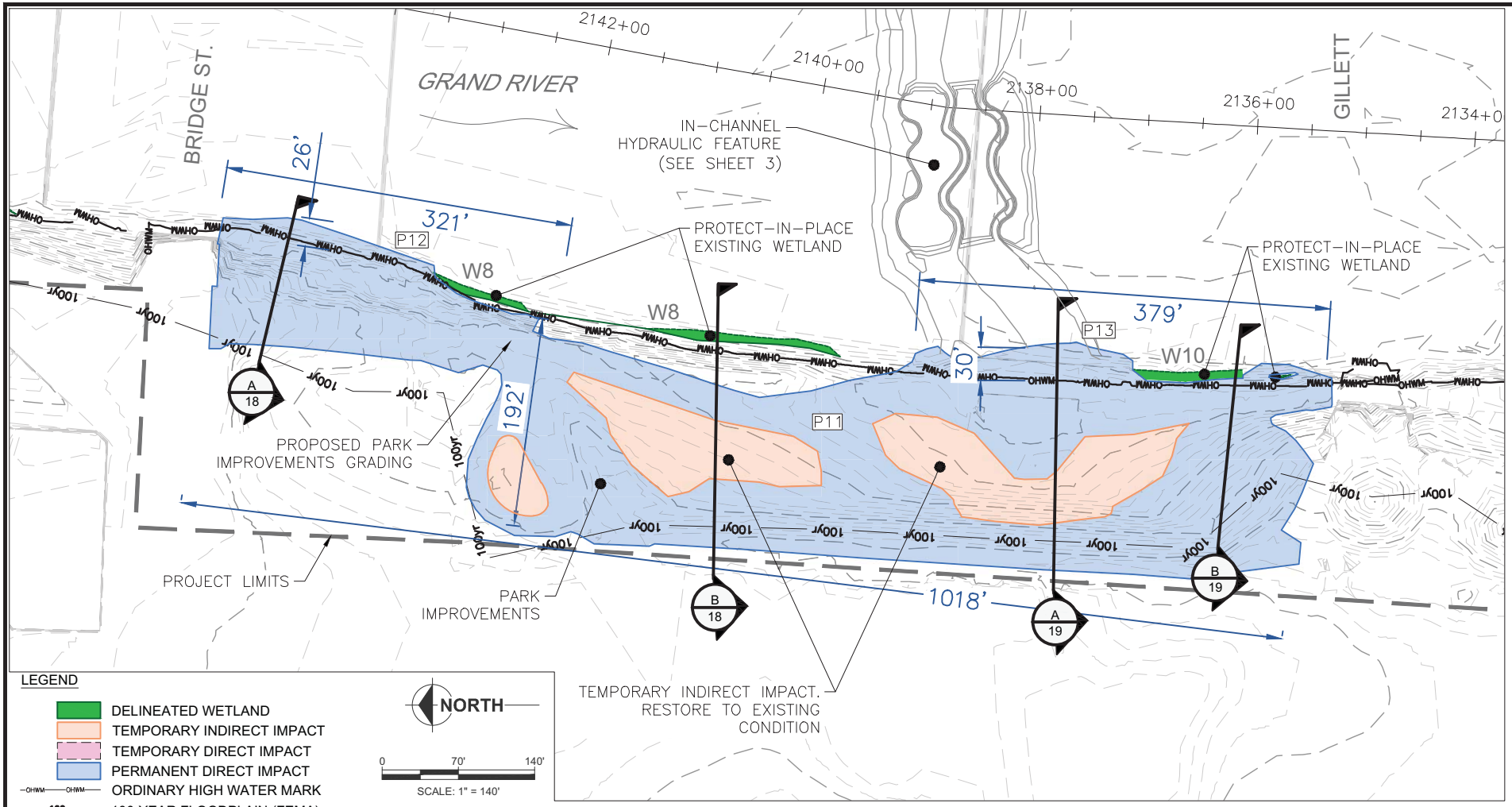
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

BLUE BRIDGE TO FULTON ST

SECTION VIEW

SHEET: 16 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



IMPACT SUMMARY TABLE

ID	IMPACT AREA	BELOW OHWM		WITHIN FLOODPLAIN		WITHIN WETLAND	
		AREA sf (ac)	VOLUME cy	AREA sf (ac)	VOLUME cy	AREA ac	VOLUME cy
P11	PARK IMPROVEMENTS - DREDGE	-	-	119878 (2.8)	1,448	-	-
	PARK IMPROVEMENTS - FILL	-	-	119878 (2.8)	724	-	-
P12	PARK IMPROVEMENTS - DREDGE	2741 (0.06)	371	-	-	-	-
	PARK IMPROVEMENTS - FILL	2741 (0.06)	525	-	-	-	-
P13	PARK IMPROVEMENTS - DREDGE	7090 (0.2)	505	-	-	-	-
	PARK IMPROVEMENTS - FILL	7090 (0.2)	716	-	-	-	-

NOTES

1. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS
2. VOLUME CALCULATIONS SHOWN ON SECTION AND PROFILES SHEETS
3. IMPACT P11 IS THE CUMULATIVE IMPACTS ABOVE THE OHWM WITHIN THE FLOODPLAIN.

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

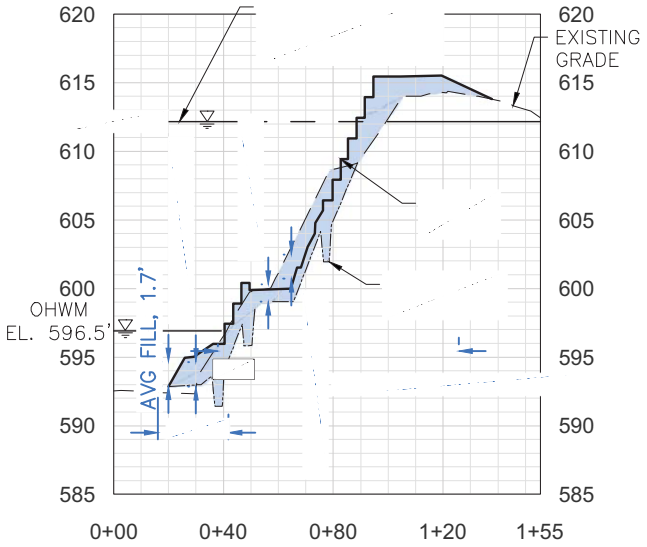
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

AH-NAB-AWEN PARK

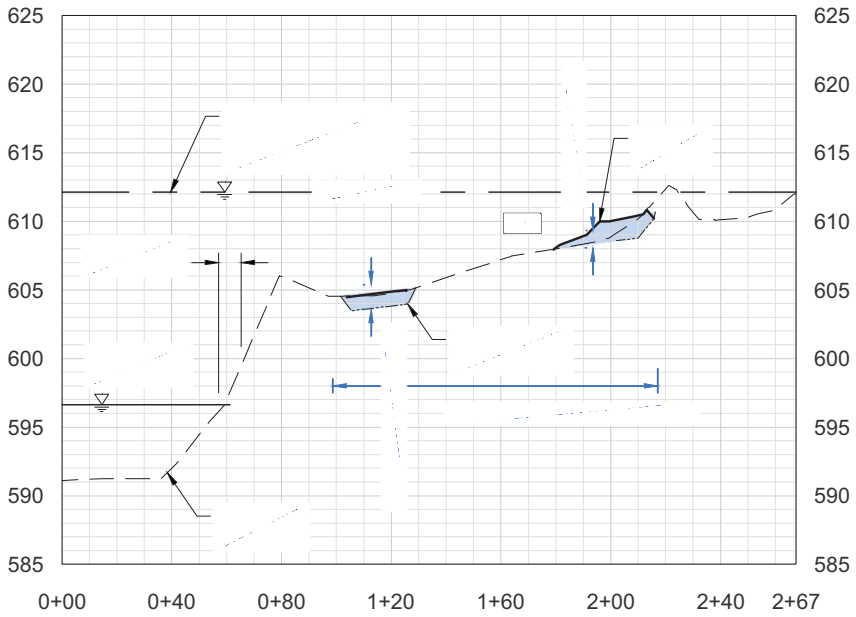
PLAN VIEW

SHEET: 17 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A/18 STREAM IMPACT
SECTION VIEW



B/18 FLOODPLAIN IMPACT
SECTION VIEW

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

NOTES

1. SEE SHEET 20 FOR IMPACT AREAS.
2. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN			WITHIN WETLAND			
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy	LENGTH ft	WIDTH ft	DEPTH ft	VOLUME cy
P11	PARK IMPROVEMENTS - DREDGE	1018	-	-	-	192	0.2	1,448	-	-	-	-
	PARK IMPROVEMENTS - FILL	1018	-	-	-	192	0.1	724	-	-	-	-
P12	PARK IMPROVEMENTS - DREDGE	321	26	1.2	371	-	-	-	-	-	-	-
	PARK IMPROVEMENTS - FILL	321	26	1.7	525	-	-	-	-	-	-	-
P13	PARK IMPROVEMENTS - DREDGE	379	30	1.2	505	-	-	-	-	-	-	-
	PARK IMPROVEMENTS - FILL	379	30	1.7	716	-	-	-	-	-	-	-

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

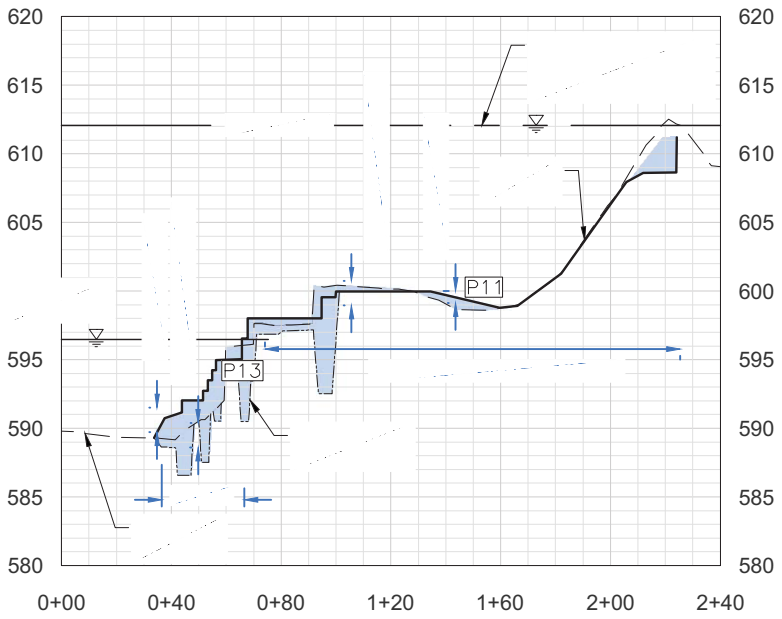
LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

AH-NAB-AWEN PARK

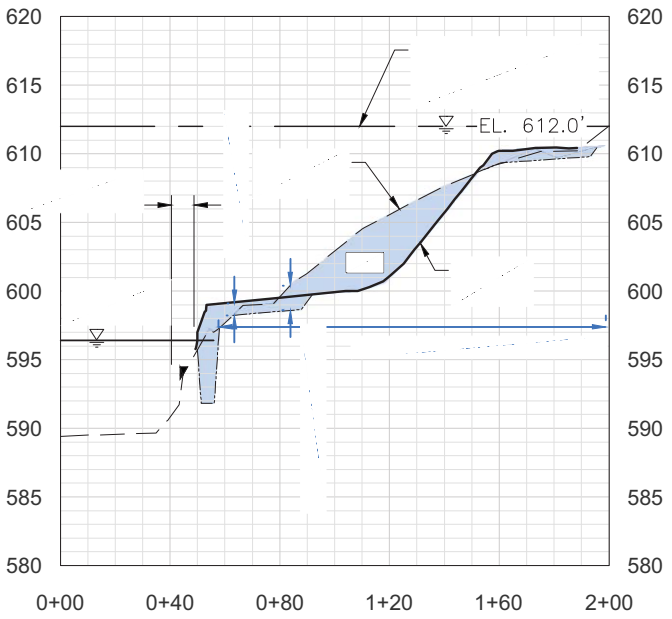
SECTION VIEW

SHEET: 18 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION



A / 19 STREAM AND FLOODPLAIN IMPACT
SECTION VIEW



B / 19 STREAM IMPACT
SECTION VIEW

LEGEND

TEMPORARY IMPACT
PERMANENT IMPACT

NOTES

1. SEE SHEET 20 FOR IMPACT AREAS.
2. SEE CONSTRUCTION DRAWINGS FOR DESIGN ELEVATIONS AND CONSTRUCTION DETAILS

IMPACT VOLUME CALCULATIONS

ID	IMPACT AREA	LENGTH ft	BELOW OHWM			WITHIN FLOODPLAIN			WITHIN WETLAND			
			WIDTH ft	DEPTH ft	VOLUME cy	WIDTH ft	DEPTH ft	VOLUME cy	LENGTH ft	WIDTH ft	DEPTH ft	VOLUME cy
P11	PARK IMPROVEMENTS - DREDGE	1018	-	-	-	192	0.2	1,448	-	-	-	-
	PARK IMPROVEMENTS - FILL	1018	-	-	-	192	0.1	724	-	-	-	-
P12	PARK IMPROVEMENTS - DREDGE	321	26	1.2	371	-	-	-	-	-	-	-
	PARK IMPROVEMENTS - FILL	321	26	1.7	525	-	-	-	-	-	-	-
P13	PARK IMPROVEMENTS - DREDGE	379	30	1.2	505	-	-	-	-	-	-	-
	PARK IMPROVEMENTS - FILL	379	30	1.7	716	-	-	-	-	-	-	-

0 35' 70'
SCALE: 1" = 70'

VERTICAL EXAGGERATION: 5x

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

AH-NAB-AWEN PARK

SECTION VIEW

SHEET: 19 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION

	TEMPORARY IMPACT SUMMARY TABLE						
ID	IMPACT AREA	BELOW OHWM		WITHIN FLOODPLAIN		WITHIN WETLAND	
		AREA sf (ac)	VOLUME cy	AREA sf (ac)	VOLUME cy	AREA ac	VOLUME cy
T1	DAM 4 CAUSEWAY - FILL	25128 (0.6)	2100	-	-	-	-
T2	DAM 3 CAUSEWAY - FILL	2361 (0.05)	747	-	-	-	-
T3	DAM 3 & 4 HAUL ACCESS - FILL	-	-	13563 (0.3)	302	-	-
T4	DAM 2 COFFERDAM - FILL	8755 (0.2)	1500	-	-	-	-
T5	DAM 2 CAUSEWAY - FILL	34136 (0.8)	2102	-	-	-	-
T6	AH NAB AWEN CAUSEWAY - FILL	50675 (1.2)	5739	-	-	0.01	12
T7	GILLETT TEMPORARY SCOUR PROTECTION - FILL	21267 (0.5)	1589	-	-	-	-
T8	DAM 1 CAUSEWAY - FILL	30168 (0.7)	2197	-	-	-	-
T9	PEARL ST & BLUE BRIDGE ACCESS	2810 (0.06)	381	-	-	-	-
T10	CONSTRUCTION STAGING STOCKPILE AREA	-	-	13239 (0.3)	4717	-	-
	Total Dredge:	0 ac	0 cy	0 ac	0 cy	0 ac	0 cy
	Total Fill:	4.2 ac	16355 CY	0.6 ac	5019 cy	0.01 ac	12 cy
	PERMANENT IMPACT SUMMARY TABLE						
ID	IMPACT AREA	BELOW OHWM		ABOVE OHWM		WETLAND	
		AREA sf (ac)	VOLUME cy	AREA sf (ac)	VOLUME cy	AREA ac	VOLUME cy
P1	DAM 4 REMOVAL AND REGRADE - DREDGE	74663 (1.7)	2090	-	-	-	-
	DAM 4 REMOVAL AND REGRADE - FILL	74663 (1.7)	697	-	-	-	-
P2	DAM 3 REMOVAL AND REGRADE - DREDGE	51007 (1.2)	1292	-	-	-	-
	DAM 3 REMOVAL AND REGRADE - FILL	51007 (1.2)	517	-	-	-	-
P3	IN-CHANNEL FEATURE - DREDGE	73714 (1.7)	4794	-	-	0.01	61
	IN-CHANNEL FEATURE - FILL	73714 (1.7)	6658	-	-	0.01	61
P4	IN-CHANNEL FEATURE - DREDGE	65108 (1.5)	4237	-	-	-	-
	IN-CHANNEL FEATURE - FILL	65108 (1.5)	5561	-	-	-	-
P5	BOULDER VANE STRUCTURE 1 - DREDGE	2820 (0.06)	41	-	-	-	-
	BOULDER VANE STRUCTURE 1 - FILL	2820 (0.06)	83	-	-	-	-
P6	BOULDER VANE STRUCTURE 2 - DREDGE	2100 (0.05)	45	-	-	-	-
	BOULDER VANE STRUCTURE 2 - FILL	2100 (0.05)	90	-	-	-	-
P7	BOULDER VANE STRUCTURE 3 - DREDGE	266 (0.01)	24	-	-	-	-
	BOULDER VANE STRUCTURE 3 - FILL	266 (0.01)	47	-	-	-	-
P8	EMERGENT HABITAT BOULDERS - DREDGE	1368 (0.03)	156	-	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	1368 (0.03)	235	-	-	-	-
P9	AUGMENTED BANK VANE STRUCTURE - DREDGE	5455 (0.1)	520	-	-	-	-
	AUGMENTED BANK VANE STRUCTURE - FILL	5455 (0.1)	372	-	-	-	-
P10	EMERGENT HABITAT BOULDERS - DREDGE	1476 (0.03)	169	-	-	-	-
	EMERGENT HABITAT BOULDERS - FILL	1476 (0.03)	254	-	-	-	-
P11	PARK IMPROVEMENTS - DREDGE	-	-	119878 (2.8)	1448	-	-
	PARK IMPROVEMENTS - FILL	-	-	119878 (2.8)	724	-	-
P12	PARK IMPROVEMENTS - DREDGE	2741 (0.06)	371	-	-	-	-
	PARK IMPROVEMENTS - FILL	2741 (0.06)	525	-	-	-	-
P13	PARK IMPROVEMENTS - DREDGE	7090 (0.2)	505	-	-	-	-
	PARK IMPROVEMENTS - FILL	7090 (0.2)	716	-	-	-	-
	Total Dredge:	7.1 ac	14244 CY	2.8 ac	1448 CY	0.01 ac	61 CY
	Total Fill:	7.1 ac	15755 CY	2.8 ac	724 CY	0.01 ac	61 CY

PROJECT: GRAND RIVER REVITALIZATION

APPLICANT: CITY OF GRAND RAPIDS

WATERWAY: GRAND RIVER

LOCATION: SECTION 35, CITY OF GRAND RAPIDS
KENT COUNTY, MICHIGAN

TOTAL IMPACT TABLE

SHEET: 20 OF 20 DATE: MAY 2024

PREPARED FOR EGLE JOINT PERMIT APPLICATION

Map of Easements

River Easements to City of G.R.

City-owned Property

BRIDGE

TURNER

BRIDGE

MICHIGAN

DOUGLAS

WINTER

SUMMER

US131

SCRIBNER

I. No. 201809070069969

MOUNT VERNON

LYON

MONROE

I. No. 201910250083169

PEARL

I. No. 201808100062447

I. No. 201808240066378

CAMBRAU

LOUIS

I. No. 201808240066374

I. No. 201903110015009

I. No. 201808240066375

FRONT

I. No. 201808240066377

I. No. 201808240066377

I. No. 201809070069970

I. No. 201910070076637

MONROE

FULTON

FULTON

I. No. 201910070076637

OTTAWA

WESTON

OTTAWA

FRONT

MARKET

GRANDVILLE

GRANDVILLE

WATSON

I. No. 201910070076637

OAKES

CITY OF GRAND RAPIDS MICHIGAN

River Easements to the City of Grand Rapids
Fulton St. to Bridge St. Jan. 14, 2020

N W E S

1" = 250'

The City of Grand Rapids makes no warranty, expressed or implied, regarding the accuracy, completeness, or correctness of the information presented. Users of this information assume all liability of its fitness for a particular purpose.

Beautification Dam Easements

City property

L. M 34 P. 130
Rowland Lowe

HURON ST. (VACATED)

L. M 34 P. 147
Michigan Railroad Company

L. M 34 P. 132
G. A. Hendricks

L. M 34 P. 128
G. A. Hendricks

L. M 34 P. 155
Trustees for the F. Raniville Company

PEARL

L. M 34 P. 138
C. B. Kelsey

FRONT

LOUIS

CAMPAU

MONROE

FULTON

FULTON

Beautification Dam Easements
Fulton St. to Huron St. (Vac.)

1" = 120'

The City of Grand Rapids makes no warranty, expressed or implied, regarding the accuracy, completeness, or correctness of the information presented. Users of this information assume all liability of its fitness for a particular purpose.

Beautification Dam Easements

I196

I196

L. M 34 P. 101
The Cabinet Shops

L. M 34 P. 119
Alexander Dodds Company

L. M 34 P. 125
ne & Ray W. Munson

L. M 34 P. 114
Berkey & Gay Furniture Company

L. M 34 P. 116
Berkey & Gay Furniture Company

L. M 34 P. 142
Valley City Milling Co.

SCRIBNER

1ST ST.

BRIDGE ST.

MICHIGAN

L. M 34 P. 136
Grand Rapids Furniture Company

L. M 34 P. 134
Grand Rapids Furniture Company

L. M 34 P. 149
Leitelt Iron Works

L. M 34 P. 103
Bissell Carpet Sweeper Company

L. M 34 P. 130
Rowland Lowe

HURON ST. (VACATED)

L. M 34 P. 147
Michigan Railroad Company

CITY OF GRAND RAPIDS MICHIGAN

Beautification Dam Easements
Huron St. (Vac.) to I-196

1" = 120'

The City of Grand Rapids makes no warranty, expressed or implied, regarding the accuracy, completeness, or correctness of the information presented. Users of this information assume all liability of its fitness for a particular purpose.

APPENDIX C

Supporting Maps, Figures, Photos and Tables

Visual Character Photos of Analysis Area

Appendix C. Visual Character of Analysis Area



Photograph 1. Bridge Street Bridge, U.S. Post Office building with floodwall on east bank, viewed from the Riverwalk Trail. View northeast



Photograph 2. Devos Place and low dam. View east.



Photograph 3. Low-head dam, Riverwalk Trail and river access on west bank south of Bridge Street bridge. View southwest.



Photograph 4. River and banks from the Gillette Bridge. Low dam, buildings, floodwall, vegetated riverbanks and the Bridge Street Bridge. View north.

Appendix C. Visual Character of Analysis Area



Photograph 5. River and banks from the Bridge Street Bridge. Two low dams, floodwall and vegetated riverbank, buildings and the Gillett Bridge. View south.



Photograph 6. West bank Riverwalk Trail with view of the Gillett Bridge and buildings along east bank. View southeast.



Photograph 7. Urban plaza, floodwall and buildings on east bank south of Gillett Bridge. View southeast.



Photograph 8. View from east river bank, between Pearl Street Bridge and Gillett Bridge, showing Ah-Nab Awen Park on west bank.



Photograph 9. Pearl Street Bridge and buildings on east bank of river. View southeast.



Photograph 10. Historic and modern buildings, path along riverbank and Blue Bridge on east riverbank. View southeast.



Photograph 11. Pearl Street Bridge and buildings on west bank. View southwest.



Photograph 12. River, Grand Rapids Public Museum, and Blue Bridge. View west.



Photograph 13. River and banks from the Fulton Street Bridge (south of the Project Area), showing the Blue Bridge, public open space and mid- and high-rise buildings. View north.

APPENDIX C

Supporting Maps, Figures, Photos and Tables

Groups Contacted for Consultation

Groups contacted for Consultation

Bay Mills Indian Community
Grand Traverse Band of Ottawa and Chippewa Indians
Hannahville Indian Community
Keweenaw Bay Indian Community
LacVieux Desert Band of Lake Superior Chippewa Indians
Little River Band of Ottawa Indians
Little Traverse Bay Bands of Odawa Indians
Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians
Nottawaseppi Huron Band of the Potawatomi
Pokagon Band of Potawatomi Indians
Saginaw Chippewa Indian Tribe of Michigan
Sault Ste. Marie Tribe of Chippewa Indians
Grand River Band of Ottawa Indians
Burt Lake Band of Ottawa and Chippewa Indians
United Tribes of Michigan
Miami of Oklahoma
Grand River Heritage Water Trail
(Ottawa County Parks and Recreation Department)
Kent County
Great Lakes Fishery Commission
West Michigan Environmental Action Council
St. Mark's Episcopal Church

APPENDIX C

Supporting Maps, Figures, Photos and Tables

Tables

Table 3-1. Summary of Informal Scoping Issues Identified

Item / Concern	Relevant to the Proposed Action?		Rationale for Relevancy and Inclusion in Plan-EA
	Yes	No	
Aesthetics/Scenic beauty	X		Bankside clearing for river access associated with construction of cofferdam and instream work would reduce aesthetic value temporarily.
Air quality and noise	X		Direct impacts to air quality and noise from machinery emissions, noise, and airborne dust may slightly increase ambient noise levels and degrade air quality during construction activity. Indirect impacts on ambient noise are expected to be small, to be somewhat concentrated around the Project Area, and to occur over a relatively long period of time. Indirect impacts on air quality are expected to be less than measurable, to be spread across the greater Grand Rapids metropolitan area, and to occur over a relatively long period of time.
Ecologically critical areas		X	NA. There are none present in the Project Area.
Threatened and endangered species (TES)	X		TES are present within the Project Area and therefore, analysis of effects is required by ESA.
Health and human safety	X		Dam hydraulics are safety risk.
Fishery habitat	X		In-stream work would affect habitat.
Shellfish bed habitat	X		In-stream work would affect habitat.
Water quality	X		Increased sedimentation, turbidity, and other water quality impacts are possible.
Invasive species	X		Sea lamprey are present and could potentially breach in-place barrier and access upstream portions of the watershed.
River flow	X		Removal of dams and installation of substrate enhancement materials would change hydraulics.
Fish Passage	X		In-stream work and change in hydraulics could potentially affect fish passage.
Recreational access for boaters, anglers and the public		X	Future projects are planned to provide improved public access to the river. Not included in current project scope.
Land use, recreation, and visual resources	X		Dam removal and rapids restoration would alter recreation access and safety.
Wetlands	X		Wetland delineation survey confirms there are wetlands present within the Project Area.
Water and Riverine Resources	X		Sediment transport and flood control are potential concerns.
Soils & Geology	X		Soil erosion is a potential issue.
Terrestrial Vegetation and Wildlife	X		Proposed Project activities would potentially generate impacts to terrestrial vegetation and wildlife resources

Table 3-1. Summary of Informal Scoping Issues Identified

Item / Concern	Relevant to the Proposed Action?		Rationale for Relevancy and Inclusion in Plan-EA
Socioeconomics	X		Consideration of Project impact on overall economic benefits factor into decision making.
Cultural resources	X		SHPO and tribal consultation is being conducted as required by the National Historic Preservation Act (NHPA). Analysis of effects to cultural resources reflects the importance of local culture and national context.
Flood control and Protection	X		Dam removal and substrate enhancement would change river hydraulics. Ability of existing flood protection barriers currently protecting development along the riverbanks must not be negatively impacted.
Coral reefs		X	Not relevant to the proposed Project.
Civil rights	X		Consideration of Project impact on civil rights issues factor into decision making.
Essential fish habitat	X		In-stream habitat restoration work will increase fish habitat.
Fish and wildlife (including coordination requirements)	X		Project coordination with state and federal agencies led to the development of the Biological Assessment and issuance by USFWS of the Biological Opinion.
Forest resources		X	No proposed impact to forest resources.
Migratory birds		X	The proposed Project does not anticipate affecting migratory bird populations or habits.
National Economic Development (NED) P&G	X		As a non-water resource project, a NED is not required.
Natural areas	X		The in-stream habitat restoration will result in an increase in natural areas.
Other concerns identified by SLOs, agencies, and the public		X	No additional concerns identified.
Parklands		X	No upland parkland improvements are included under the proposed Project.
Prime and unique farmland, and farmland of statewide significance		X	No farmland work included with the PL 83-566 funding.
Regional water resource plans (including coastal zone plans)		X	Not included under the proposed Project scope.
Riparian areas	X		Access to the river will be required to perform in-stream work and restored following implementation.
Scientific resources		X	Not included under the proposed Project scope.
Sole source aquifers		X	Not included under the proposed Project scope.
Waters of the United States, including special aquatic sites	X		In-stream project is not a special aquatic site, and permitting authority is under State of Michigan
Wild and scenic rivers	X		In-stream improvements take place within the Lower Grand River.

Table 3-2. Past, Present, and Reasonably Foreseeable Future Activities

Project or Activity Name	Location	Description	Time/Status	Resources Potentially Affected
BMP implementation in the Indian Mill Creek and Rogue River watersheds	Terrestrial and riparian areas within the watersheds of Indian Mill Creek and Rogue River, which are tributaries of the Project Area	BMPs regarding agricultural conservation practices will be implemented to address excess sediment loading in both watersheds.	Present and reasonably foreseeable: federal EQIP funds contributed by the RCPP award that would fund the Proposed Action also fund this action	Water and Riverine Resources; Aquatic Species and Habitat
Ongoing City of Grand Rapids forestry practices	Terrestrial areas within City limits	Annual tree pruning, removal, and planting activities would affect terrestrial vegetation within the analysis area but are not expected to affect the Grand River	Present and reasonably foreseeable: current patterns are expected to continue	Terrestrial Vegetation and Wildlife
Residential and commercial development	Terrestrial areas in the Grand Rapids metropolitan area	Residential and commercial development in the analysis area is expected to continue to expand, especially outside of the Project Area	Present and reasonably foreseeable: current patterns are expected to continue	Terrestrial Vegetation and Wildlife; Land Use, Recreation, and Visual Resources
Mill Creek restoration	The Mill Creek Watershed, upstream of the Project Area	Stream restoration and water quality improvements projects, removing concrete walls to reconnect stream to floodplain	Present and reasonably foreseeable: Kent County Parks is undertaking a stream restoration project funded through EGLE, and other nonpoint source reduction projects are recommended	Water and Riverine Resources; Aquatic Species and Habitat
MDOT westbound I-196 project	In and upstream of the Project Area, in the Grand River and along both banks in the immediate vicinity of the I-196 bridge	The project extended bridge piers in the Grand River and then built a new lane of westbound I-196. Cofferdams to facilitate construction extended into the river channel, increasing Dam tailwater levels and altering hydraulics. Construction lasted approximately two years. The fill has been removed from the river and the staging area is being restored.	Recent past: 2017–2019	Water and Riverine Resources; Wetlands; Aquatic Species and Habitat

Table 3-2. Past, Present, and Reasonably Foreseeable Future Activities

Project or Activity Name	Location	Description	Time/Status	Resources Potentially Affected
MDOT eastbound I-196 project	In and upstream of the Project Area, outside the LDB in the immediate vicinity of the I-196 bridge	Repair of existing bridge structures and ramps. Work on the bridge substructure will be performed from anchored barges. No alteration of the river channel will occur.	Reasonably foreseeable: scheduled for 2021	Air Quality and Noise; Terrestrial Vegetation and Wildlife; Aquatic Species and Habitat; Land Use, Recreation, and Visual Resources; Public Health and Safety; Urban Dynamics
Upstream sediment sampling project	In and just upstream of the Project Area, in the Grand River from Ann Street to the low-head dam upstream of Bridge Street	Boat anchoring, sediment sampling, and sediment coring to characterize contaminants of concern and particle size distribution	Recent past: spring and summer 2020	Water and Riverine Resources; Aquatic Species and Habitat
Ann Street to Bridge Street Grand River Project	In and just upstream of the Project Area, in the Grand River and terrestrial areas from Ann Street to the low-head dam upstream of Bridge Street	Removal of the 6th Street Dam and installation of a new solution for a lamprey barrier, perhaps including an adjustable hydraulic structure	Reasonably foreseeable: design, development of alternatives, and NEPA processes are underway	Air Quality and Noise; Water and Riverine Resources; Wetlands; Terrestrial Vegetation and Wildlife; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Socioeconomics; Cultural Resources; Public Health and Safety; Urban Dynamics
River for All: Leonard to Ann Street Trail Connection	Terrestrial areas near the Grand River from Leonard Street to Ann Street	A paved non-motorized trail connection along the Grand River	Reasonably foreseeable: concept planned by City of Grand Rapids	Floodplain Management; Land Use, Recreation, and Visual Resources
River for All: The Water Department Storage Yard park	LDB of the Grand River and terrestrial areas approximately 0.3 miles upstream of Leonard Street	Ground-level and elevated trails, a small boat portage way, and other park facilities	Reasonably foreseeable: concept planned by City of Grand Rapids	Water and Riverine Resources; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Public Health and Safety
River for All: Coldbrook Site park and creek restoration sites	LDB of the Grand River and terrestrial areas just downstream of Leonard Street, upstream of Project Area within the Coldbrook Creek Watershed	Stepped river access, surfacing/daylighting a portion of Coldbrook Creek, stormwater treatment, and an emergency boat access ramp	Present and reasonably foreseeable: concept planned by City of Grand Rapids and activities ongoing and planned by Coldbrook Creek Watershed Group	Water and Riverine Resources; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Public Health and Safety

Table 3-2. Past, Present, and Reasonably Foreseeable Future Activities

Project or Activity Name	Location	Description	Time/Status	Resources Potentially Affected
River for All: Monroe North Site park	LDB of the Grand River and terrestrial areas just upstream of I-196	Stepped seating terraces, a public boat ramp, a stormwater treatment marsh	Reasonably foreseeable: concept planned by City of Grand Rapids	Air Quality and Noise; Water and Riverine Resources; Wetlands; Terrestrial Vegetation and Wildlife; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Public Health and Safety
River for All: Grand Rapids Public Museum Site park	RDB of the Grand River and terrestrial areas between Pearl Street and the Blue Bridge	Multiple gathering spaces and park facilities	Reasonably foreseeable: concept planned by City of Grand Rapids	Air Quality and Noise; Soils and Geology; Terrestrial Vegetation and Wildlife; Floodplain Management; Land Use, Recreation, and Visual Resources; Cultural Resources
River for All: Fish Ladder Park Site park	RDB of the Grand River and terrestrial areas just upstream of I-196	Stepped river access, new trees, trails, and an emergency boat access ramp	Reasonably foreseeable: concept planned by City of Grand Rapids	Air Quality and Noise; Water and Riverine Resources; Wetlands; Terrestrial Vegetation and Wildlife; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Public Health and Safety
Sidewalk repair within the Project Area	LDB bank of the Grand River from Louis Street to the Blue Bridge	Repair of the sidewalk may require some work in the wet and flowing river within 30 feet of the bank.	Reasonably foreseeable: concept planned by City of Grand Rapids	Air Quality and Noise; Soils and Geology; Water and Riverine Resources; Wetlands; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Cultural Resources; Public Health and Safety; Urban Dynamics
Ah-Nab-Awen Park redevelopment	Land areas of Ah-Nab-Awen Park and the RDB of the Grand River within said park	Stepped river access, universally accessible ramp, widening of existing River Walk path, new trees, viewing terrace, and elements from Native American culture	Reasonably foreseeable: concept planned by City of Grand Rapids	Air Quality and Noise; Soils and Geology; Water and Riverine Resources; Wetlands; Aquatic Species and Habitat; Floodplain Management; Land Use, Recreation, and Visual Resources; Cultural Resources; Public Health and Safety; Urban Dynamics

Table 4-1. Background Air Quality Concentrations for the Grand Rapids-Monroe Street Monitoring Station (No. 260810020)

Air Pollutant	Period	Concentration [a]	USEPA NAAQS [b]
Ozone, O_3 (8-hour)	2022	0.071 ppm[c]	0.070 ppm
Particulate matter with diameter of less than 2.5 micrometer, $PM_{2.5}$ (annual, 3-year average)	2022	9.2 µg/m^3	12.0 µg/m^3
Particulate matter with diameter of less than 2.5 micrometer, $PM_{2.5}$ (24-hour, 3-year average)	2022	23 µg/m^3	35 µg/m^3
Particulate matter with diameter less than 10 micrometer, PM_{10} (24-hour)	N/A	No data	150 µg/m^3
Lead, Pb (highest 3-month average per year)	2019	0.01	0.15 µg/m^3
Nitrogen dioxide, NO_2 (annual)[d]	2022	12.58 ppb	53 ppb
Nitrogen dioxide, NO_2 (daily maximum 1-hour, 3-year average)	N/A	No data	100 ppb
Sulfur dioxide, SO_2 (1-hour, 3-year average)	2022	4 ppb	75 ppb
Carbon monoxide, CO (2nd highest 8-hour average not exceeded more than once per year)	2022	1.2 ppm	9 ppm
Carbon monoxide, CO (2nd highest 1-hour average not exceeded more than once per year)	2022	1.5 ppm	35 ppm

N/A = not applicable, ppm = parts per million, µg/m^3 = micrograms per cubic meter, ppb = parts per billion
Values in red exceed USEPA NAAQS
[a] Source: Michigan DEGLE 2023
[b] Source: 40 Code of Federal Regulations, Part 50 (https://www.law.cornell.edu/cfr/text/40/part-50)
[c] 3-year average calculated using the Max. Allowable values, which are the maximum 4th-highest value that can occur in each year without violation of the standard
[d] The monitoring station measures reactive oxides of nitrogen (NO_y) and is not used for NAAQS determinations

Table 4-2. Typical Noise Levels and Possible Human Effects

Common Noises	Noise Level (dBA)	Effect
Rocket launching pad (no ear protection)	180	Irreversible hearing loss
Carrier deck jet operation	140	Painfully loud
Air raid siren		
Thunderclap	130	Painfully loud
Jet takeoff (200 feet)	120	Maximum vocal effort
Auto horn (3 feet)		
Pile driver	110	Extremely loud
Loud concert		
Garbage truck	100	Very loud
Firecrackers		
Heavy truck (50 feet)	90	Very Annoying
City traffic		Hearing damage (8 hours of exposure)
Alarm clock (2 feet)	80	Annoying
Hair dryer		
Noisy restaurant	70	Telephone use difficult
Freeway traffic		
Business office		
Air conditioning unit	60	Intrusive
Conversational speech		
Light auto traffic (100 feet)	50	Quiet
Living room	40	Quiet
Bedroom		
Quiet office		
Library/soft whisper (15 feet)	30	Very quiet
Broadcasting studio	20	Very quiet
Pin dropping	10	Just audible
Threshold of hearing	0	Hearing begins

Source: WSDOT 2018

dBA = A-weighted decibel 7 I

Table 4-3. Listed Unionid Mussels Species Potentially Occurring in the Analysis Area

Scientific Name	Common Name	Federal Status	State of Michigan Status	Preferred Habitat	Reported Host Fish Known in the Analysis Area
Epioblasma triquetra	Snuffbox	E		Cobble, gravel, and sand substrate with moderately high current velocity	Logperch, Blackside Darter, Rainbow Darter, Largemouth Bass
Alasmidonta marginata	Elktoe		SC	Large creeks to medium rivers in mixed sand, gravel, and/or cobble with swift currents	White Sucker, Northern Hogsucker, Shorthead Redhorse, Rock Bass
Alasmidonta viridis	Slippershell		T	Generally found in small creeks and headwater streams with variable sand and gravel substrate, often behind large boulders. Considered intolerant to impoundment.	Mottled Sculpin, Johnny Darter
Cyclonaias tuberculata	Purple wartyback		T	Large creeks and rivers with coarse sand or gravel substrate with moderate to swift current	Yellow Bullhead, Channel Catfish, Flathead Catfish
Lasmigona compressa	Creek heelsplitter		SC	Variable sized streams, but typically in creeks and headwaters in pools above and below riffles with compact sand and gravel, or mud patches near shore	Carp and true minnows, gar, suckers, catfish, Bluegill, darters and Yellow Perch
Lasmigona costata	Fluted shell		SC	Small to medium-sized rivers in variable substrate	Variable; many species
Ligumia recta	Black sandshell		E	Sandy mud to coarse sand and gravel substrate with a moderately high current	Rosyface Shiner, sucker species, Yellow Perch, Walleye
Pleurobema sintoxia	Round pigtoe		SC	Medium to large rivers with mixed mud, sand, and gravel in moderate to swift current	Carp and true minnows, sunfish, Spotfin Shiner, Bluegill
Potamilus alatus	Pink heelsplitter		SC	Medium to large rivers and impoundments in silty sand and mud with slow moving current	Freshwater Drum
Toxolasma parvum	Lilliput		E	Soft substrate such as mud, sand and fine gravel with slow-moving water	Sucker species and Johnny Darter
Truncilla truncata	Deertoe		SC	Small, medium and large rivers, and lakes with various substrate including sand, gravel, and mud	Freshwater Drum
Utterbackia imbecillis	Paper pondshell		SC	Slow moving pools of rivers, streams, and impoundments with soft sand and mud substrates	Sunfishes, carp and true minnows, non-fish species including tiger salamander and bullfrog
Venustaconcha ellipsiformis	Ellipse		SC	Small to medium streams in sand and gravel substrates	Darters, Logperch
Villosa iris	Rainbow		SC	Large creeks to medium rivers with substrates of mixed sand, gravel, and/or cobble with swift current	White Sucker, Northern Hogsucker, Shorthead Redhorse, Rock Bass

Source: EcoAnalysts 2020
E = endangered
T = threatened
SC = species of special concern

Table 4-4. Population Trends in Michigan, Kent County and Grand Rapids

Jurisdiction	Population 2000	Population 2010	Population 2017	Population 2022	Percent Change 2000-2022
State of Michigan	9,938,444	9,883,640	9,925,568	10,034,118	0.95%
Kent County	574,335	602,622	636,376	659,083	12.86%
City of Grand Rapids	197,800	188,040	195,355	196,904	-0.45%

Source: U.S. Census Bureau 2000, 2010, 2018, 2022

Table 4-5. Demographic Composition in Michigan, Kent County and Grand Rapids

Jurisdiction	Population 2022	Percent Non-Hispanic White	Percent Non-White and/or Hispanic[1]	Median Age	Proportion of Residents 65 or older
State of Michigan	10,034,118	73%	27%	40.3	25%
Kent County	659,083	71%	29%	35.9	21%
City of Grand Rapids	196,904	62%	38%	33.1	18%

Source: U.S. Bureau 2022

[1]Includes individuals who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino. That is, all people other than non-Hispanic individuals who identify as white and not as any other race.

Table 4-6. 2022 Economic Characteristics

Jurisdiction	Population[1]	Median income ($)[1]	Percentage of individuals below the poverty level[1]	Total employment[1]	Unemployment rate[2]
State of Michigan	10,077,331	66,986	13.4%	5,915,393	4.9%[2]
Kent County	657,974	77028	10.6%	438,211	3.1%[3]
City of Grand Rapids	198,917	65,660	15.8%	136,059	3.1%[3]

Sources:

[1]U.S. Census Bureau 2022

[2] Michigan Labor Market Information 2024

[3]Michigan Labor Market Information 2024 (Grand Rapids-Wyoming MSA)

Table 4-7. 2022 Industry Employment Characteristics

Jurisdiction	Civilian employed population 16 years and over	Educational services/ health care/ social assistance	Entertainment / visitor services	Manufacturing	Construction	Public administration
State of Michigan	4,755,016	23.4%	9.9%	18.5%	5.7%	3.3%
Kent County	345,415	22.7%	9.3%	19.8%	5.9%	1.6%
City of Grand Rapids	111,148	26.3%	8.9%	16.4%	3.5%	1.6%

Source: U.S. Census Bureau 2022

Table 4-8. Previously and Newly Recorded Historic Resources in the APE

Survey Number/ Field Number	Previously Recorded	Approximate Year	Description	Direct or Indirect APE	NRCS Determination of Eligibility
DM 1	N	ca. 1960	U.S. Post Office Building	Indirect	Ineligible
DM 2	N	ca. 1910	Commercial Building	Indirect	Ineligible
DM 3	N	1932	Civic Auditorium	Indirect	Ineligible
DM 4	N	ca. 1910	Commercial Building	Indirect	Ineligible
P23733/DM 5	Y	1913	Pantlind Hotel (Amway Grand Plaza Hotel)	Indirect	Eligible
P23718/DM 6	Y	1923	Fine Arts Building	Indirect	Listed
DM 7	N	ca. 1915	Commercial Building	Indirect	Ineligible
DM 8	N	1903	Old Town Riverfront Building	Indirect	Ineligible
DM 9	N	1915	Gillette Bridge	Indirect	Ineligible
P51124/DM 10	Y	1892	Grand Rapids and Indiana Railroad Grand River Bridge (Blue Bridge)	Indirect	Eligible
DM 11	N	ca. 1903	Bridge Street Bridge	Indirect	Eligible
DM 12	N	1900	Pearl Street Bridge	Indirect	Eligible
DM 13	N	1927	Fulton Street Bridge	Indirect	Ineligible
DM 14	N	Undetermined	Garritt's Piling; historic resource in Grand River	Indirect	Ineligible
DM 15	N	ca. 1980	Grand Rapids Historic Riverwalk	Indirect	Ineligible (possibly not of age)
DM 16	N	1927	Dam 1	Direct	Eligible
DM 17	N	1927	Dam 2	Direct	Eligible
DM 18	N	1927	Dam 3	Direct	Eligible
DM 19	N	1927	Dam 4	Direct	Eligible

Table 5-1. Comparison of Alternatives

	No Action (Existing Conditions)	Proposed Action
Stream Habitat Improvements Installed (acres)	0	11
Improvement in Aquatic Organism Passage (acres)	0	4
# of Dams Removed (each)	0	4
Boulder Arches, Riffles, Habitat Boulders and Bank Vanes Installed (cubic yards)	0	16,000
Riverbed Disturbed by Construction (acres)	0	6.1
Improves Public Fish &Wildlife while not Increasing Flood Risk	No	Yes
Allows Native Riverine and Potamodromous Fish Species to Migrate Freely	No	Yes
Cost to Implement	$0	$22,053,390.86

Table 6-1. Impact Analysis

Resource	Type of Impact	Magnitude of Impact			Likelihood of Impact	Significance
		Extent	Dura on	Intensity		
Air Quality & Noise	Positive, none	Local	Temporary	Negligible	Unlikely	Negligible
	Negative, emissions	Local	Temporary	Negligible	Likely	Negligible
Climate and Climate Change	Positive, none	Global	Permanent	Negligible	Unlikely	Negligible
	Negative, emissions	Global	Permanent	Negligible	Unlikely	Negligible
Soils and Geology	Positive, none	Site	Short	Negligible	Unlikely	Negligible
	Negative, disturbance	Site	Short	Negligible	Likely	Negligible
Water & Riverine Resources	Positive, habitat, form	Site/Regional	Permanent	Moderate	Definite	Moderate
	Negative, disturbance	Site/Regional	Temporary	Moderate	Definite	Low
Wetlands	Positive, none	Site	Permanent	Negligible	Unlikely	Negligible
	Negative, disturbance	Site	Temporary	Low	Definite	Low
Terrestrial Vegetation and Wildlife	Positive, none	Local/Regional	Permanent	Low	Unlikely	Negligible
	Negative, displacement	Local/Regional	Temporary	Negligible	Unlikely	Negligible
Aquatic Species and Habitat	Positive, habitat	Site/Regional	Permanent	Moderate	Definite	Moderate
	Negative, disturbance	Site/Regional	Temporary	Moderate	Definite	Low
Floodplain Management	Positive, none	Local	Permanent	Negligible	Unlikely	Negligible
	Negative, flood rise	Local	Temporary	Negligible	Unlikely	Negligible
Land Use, Recreation, and Visual Resources	Positive, recrea on	Regional	Permanent	Moderate	Definite	Moderate
	Nega ve	Site	Temporary	Low	Likely	Low
Socioeconomics and Environmental Justice	Positive	Local	Permanent	Negligible	Unlikely	Negligible
	Nega ve	Local	Permanent	Negligible	Unlikely	Negligible
Cultural and Historic Resources	Positive	Site	Permanent	Negligible	Unlikely	Negligible
	Nega ve	Site	Permanent	Negligible	Unlikely	Negligible
Public Health and Safety	Positive, dam removal	Regional	Permanent	Moderate	Definite	Moderate
	Negative, construction	Regional	Temporary	Low	Unlikely	Negligible
Urban Dynamics	Positive	Local	Permanent	Low	Likely	Low
	Nega ve	Local	Temporary	Negligible	Unlikely	Negligible

Table 6-2. Construction Equipment Noise Emission Levels

Equipment	Typical Noise Level (dBA), 50 feet from Source
Air Compressor	80
Backhoe	80
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane, Mobile	83
Dozer	85
Generator	82
Grader	85
Jack Hammer	88
Loader	80
Paver	85
Pile-driver (impact)	101
Pile-driver (sonic)	95
Pneumatic Tool	85
Pump	77
Roller	85
Truck	84

dBA = A-weighted decibel
Source: FTA 2018

Table 6-3. Hydraulic Characteristics of the River between the 6th Street Dam and Fulton Street

	No Action (Existing Conditions)	After the Proposed Action
Velocity at 3,900 cfs		
Range (ft/s)	0 to 12	0 to 7.5
Average (ft/s)	2.7	2.7
Coefficient of Variation	38%	42%
Depth at 3,900 cfs		
Range (ft)	0 to 8.3	0 to 8.3
Average (ft)	2.9	3.0
Coefficient of Variation	38%	38%
Wetted Area at 890 cfs (ft^2)	1,793,267 (41.2 acres)	1,801,609.51 (41.4 acres)

Table 6-4. Potential Impacts and Benefits to Aquatic Species and Habitat

Construction Activity	Potential Temporary Impacts	Long-term Benefits of Restored River Conditions
Installation of temporary construction access	Slight impacts from increased sedimentation and turbidity if erosion control is inadequate.	No impact or benefit; temporary access removed at end of construction.
Establishment of isolation areas	Noticeable impacts from crushing of unionid mussels and increased turbidity caused by machinery working in the wet. Many fish would flee the Construction Area. Slight to nonexistent impacts from increased shear stress on LDB of river that could stress unionid mussels. Increased physiological stress from relocation activities.	Isolation areas removed at end of construction; no impact or benefit other than the minimization of impacts from other construction activities.
Mussel relocation	Mussel population reduced in Construction Area and increased in recipient sites. Increased physiological stress from relocation activity.	Eventual recolonization of Construction Area from nearby mussel beds.
Demolition of four low-head dams	Direct impacts from crushing of unionid mussels and increased turbidity caused by machinery working in the wet.	Improved access to unionid mussel habitat. Improved upstream fish passage for desirable, non-jumping fish species and mussel host species (e.g., catfish, Lake Sturgeon, River Redhorse, Walleye, Smallmouth Bass, Logperch and other small-bodied species) due to improved hydraulic diversity. Improved mussel diversity upstream of existing low head dams, due to increased host fish species passage.
Excavation and grading of river channel to form runs, riffles, glides, pools, rapids, and eddies	Noticeable impacts from crushing of unionid mussels by machinery working in the wet.	Increased diversity of habitats would benefit of aquatic species. Improved hydraulic diversity.
Installation of diversified hydraulic features	Noticeable impacts from crushing of unionid mussels by machinery working in the wet.	May increase available pool and run habitat for some fish species. Improved hydraulic diversity.
Installation of boulder, cobble, gravel substrate	Noticeable impacts from crushing of unionid mussels by machinery working in the wet.	Improved unionid mussel and fish habitat. Increased refuge areas and eddies for various fish species. Improved hydraulic diversity.
Augmentation of scour protection on existing bridges, if needed	Noticeable impacts from crushing of unionid mussels by machinery working in the wet.	Slight reduction in mussel habitat. Slight to nonexistent effect from increased resistance to scouring and subsequent loss of integrity.

Source: EcoAnalysts 2020, Holtgren 2019

Table 6-5. EGLE Flood Flow Rates

Recurrence Interval	Flow (cfs)
100-year	50,000
50-year	44,000
25-year	38,000
10-year	31,000
5-year	26,000
2-year	18,000
Bankfull	13,000

Table 6-6. Potential Unavoidable Adverse Impacts of the Proposed Action

Resource Area	Potential Unavoidable Adverse Impact of the Proposed Action
Air Quality and Noise	•Temporary increases in dust, combustion/exhaust pollutants, and noise during construction
Soils and Geology	•Temporary shallow soil disturbance by construction equipment and activities in staging areas and at the river banks
Water and Riverine Resources	•Temporary increase in bed mobility and downstream turbidity and sediment transport during construction
Wetlands	•Potential minor adverse impact on wetland communities from increased foot traffic and littering on wetlands adjacent to the river during the operational phase
Terrestrial Vegetation and Wildlife	•Temporary impacts on terrestrial wildlife from noise and vibration during construction •Damage to vegetation and wildlife through the planned removal of several trees during construction
Aquatic Species and Habitat	•Temporary impacts on both listed and other unionid mussel species during construction resulting from mussels being physically crushed as a result of machinery use and placement of substrates, and to a lesser extent from increased turbidity, shear stress or water velocity •Temporary impacts on fish species during construction as a result of physically crushing fish that are not able to easily escape during construction, temporary habitat loss, increased turbidity, and temporary loss of spawning areas
Floodplain Management	•Slight increases in water surface elevation for 2-year to 50-year flood events, but contained within the existing flood protection system
Land Use, Recreational and Visual Resources	•Temporary restrictions on river access for recreational use during construction •Temporary impairment of visual quality during construction
Socioeconomics	•Temporary hindrances to river-oriented activities could result in slightly fewer customers for businesses near the river during construction
Cultural Resources	•Removal of the low-head dams considered eligible for listing on the National Register of Historic Places (NRHP)--to be mitigated •No other impacts as currently proposed, but if the Project design changes to include grading in areas (and to depths) that may contain culture-bearing soil horizons, potential impacts could be mitigated through further testing, avoidance, and presence of a qualified archaeological monitor during construction activity
Public Health and Safety	•New hydraulic features would present different safety risks and new safety hazards
Urban Dynamics	•Increased congestion due to improved safety

Table 6-7. Irreversible and Irretrievable Commitment of Resources by Resource Area

Resource Area	Irreversible Impacts	Irretrievable Impacts	Explanation
Air Quality and Noise	No	No	Impacts would be limited to slight, temporary construction-related dust and emissions.
Soils and Geology	No	No	Soils would be impacted by temporary access and staging areas during construction. All areas to be disturbed are classified as being previously disturbed and lack the characteristics of their natural state. Disturbed areas would be restored to the extent practicable after construction.
Water and Riverine Resources	No	No	Temporary disturbance during construction would be minimized through best management practices and monitoring. Impacts would be further minimized by conducting the construction in stages, with activities occurring within isolation areas. Following construction, impacts on water and riverine resources would be beneficial.
Wetlands	No	No	No wetlands would be filled or converted to other uses.
Terrestrial Vegetation and Wildlife	No	No	Vegetation communities, including trees, would be removed during construction. Loss of vegetation would be temporary and replacement plantings would be provided.
Aquatic Species and Habitat	No	Yes	Potential reproductive failure during construction would be an irretrievable loss of production. Long-term impacts on aquatic species and habitat would be beneficial. Unionid mussels would experience population decline during construction, but the populations are anticipated to recover after several years following completion.
Floodplain Management	No	No	Floodplain management impacts would be slight and reversible.
Land Use, Recreation and Visual Resources	No	No	No impacts on land uses are anticipated. Construction-related impacts on recreational and visual resources would be temporary and reversible. Upon completion, potential beneficial impacts on recreation and visual resources are anticipated.
Socioeconomics	No	No	Beneficial impacts on socioeconomics are anticipated.
Cultural Resources	Yes	No	The Proposed Action would remove four low-dams constructed in the early 1900s, determined to be NRHP eligible. A mitigation plan has been developed and implemented in an MOA to address impacts to the dams.
Public Health and Safety	No	No	Consequences for public health and safety would be slight and/or beneficial.
Urban Dynamics	No	Yes	The Construction Area, both in the River and on land, would not be available for public events during the construction period.

Table 6-8. Cumulative Effects

Ann Street to Bridge Street Grand River Project	This potential future project, dependent on availability of funds, would include removal of the 6th Street Dam and installation of a new solution for a lamprey barrier. The barrier would be installed first and would curtail migration of Sea Lamprey, which is one of the existing functions of the 6th Street Dam. This project would have the potential for direct impacts on unionid mussels and fish from the equipment used for the implementa on of this project and could indirectly impact any downstream mussels or fish if turbidity is not locally controlled during construction. Other indirect impacts could include the migration of Sea Lamprey to upstream reaches of the Grand River if the barrier does not function adequately, and fish (including unionid fish host species) could be negatively impacted. The potential impacts from this project will be assessed in a separate NEPA process, and impacts related to ESA-listed species will also be addressed in a separate consultation process. If mussel relocation, fish passage practices, and conservation and mitigation measures are used during construction similar to those of the Proposed Action, the impacts would be minimized. By improving habitat adjacent to the Project Area and by allowing upstream fish passage to river reaches upstream of the current 6th Street Dam, the two projects would likely result in benefits to aquatic species and populations that would be greater than the sum of each project on its own.
Upstream Sediment Sampling Project	Another action associated with the Ann Street to Bridge Street Grand River Project is a recently completed upstream sediment sampling project that occurred in and just upstream of the Project Area, in the Grand River from Ann Street to the low-head dam upstream of Bridge Street. This project was estimated to directly harm up to 226 individual mussels, 10 of which would have been of federally or state listed species. Temporary impacts from this project will have recovered before the proposed Project begins construction.
River of All Opportunity Sites	The *River for All* plan is dependent on future funding and includes the design and creation of six opportunity sites along and adjacent to the Grand River shoreline. Where possible, the City of Grand Rapids is exploring opportunities to naturalize flood walls and improve the community's connection and access to the Grand River in these locations. The six opportunity sites include: • A Leonard Street to Ann Street non-motorized trail connection along the Grand River; • The Water Department Storage Yard park, which may include a small boat portage way; • The Coldbrook Site park and creek restoration, which may include stepped river access, surfacing/daylighting a portion of Coldbrook Creek, stormwater treatment, and an emergency boat access ramp; • The North Monroe Site Plan, which may include a public boat ramp and a stormwater treatment marsh; • Fish Ladder Park Site Plan, which may include stepped river access and an emergency boat access ramp; and Any in-water work for these future projects would have the potential to directly impact unionid mussels, fish species, and habitats if equipment must work within the wetted channel or if increased river-wading foot traffic disturbs fish or unionid habitat. Additionally, indirect impacts could result from increased turbidity or sedimentation if erosion or turbidity control devices are not adequately utilized during construction. Additional fish and/or unionid mussel educa on incorporated during these Projects would also help minimize the potential effects of increased river access. If adequate conservation and mitigation measures are used during these opportunity projects, there likely would be negligible additive impacts to those of the Proposed Project.
Sidewalk Repairs	The sidewalk along the LDB from Louis Street to Blue Bridge is currently in need of repair. If the City of Grand Rapids initiates the repair of this sidewalk, the construction activity may require some work in the wet and flowing river within 30 feet of the bank. Repairs are expected to coincide with construction of this Project but would be permitted separately.

Table 6-8. Cumulative Effects

	Temporary impacts to fish and unionid mussels could occur if work in the wet and flowing river increases turbidity and/or harms individual fish and/or mussels. Use of construction best management practices and translocating mussels could minimize the potential impacts, especially if this project were coordinated with the Proposed Action.
Mill Creek Restoration	Upstream of the Construction Area and downstream of the Ada mussel recipient site, Kent County Parks plans to undertake stream restoration and water quality improvement projects, including removing concrete walls to reconnect Mill Creek to its floodplain. Increased turbidity during construction could flow into the Construction Area and contribute to temporary cumulative impacts, although this is expected to have only a slight contribution.
Ah-Nab-Awen Park redevelopment	Along the RDB of the Grand River within Ah-Nab-Awen Park, stepped river access, universally accessible ramp, widening of existing River Walk path, new trees, viewing terrace, and elements from Native American culture will be constructed. Temporary impacts to fish and unionid mussels could occur if work in the wet and flowing river increases turbidity and/or harms individual fish and/or mussels. Use of construction best management practices and translocating mussels could minimize the potential impacts, especially if this project were coordinated with the Proposed Action.
Canal Park	On the LDB upstream from the project areas Canal Park will be improved through enhanced flood protection and ecological resiliency, trail enhancements, renovated playground, improved access to the Grand River and flexible programming spaces. Temporary impacts to fish and unionid mussels could occur if work in the wet and flowing river increases turbidity and/or harms individual fish and/or mussels. Use of construction best management practices and translocating mussels could minimize the potential impacts, especially if this project were coordinated with the Proposed Action.
Acrisure Amphitheater	A new 12,000-seat outdoor riverfront amphitheater at 201 Market Ave. SW including public green space, plaza, and outdoor dining area. Temporary impacts to fish and unionid mussels could occur if work in the wet and flowing river increases turbidity and/or harms individual fish and/or mussels. Use of construction best management practices and translocating mussels could minimize the potential impacts, especially if this project were coordinated with the Proposed Action.
Grand River Edges Trail, Fulton To Wealthy	Fulton St. to Wealthy Street, on the LDB downstream of the project area, an existing trail segment will be rehabilitated of from Wealthy St (west of river) into the Black Hills neighborhood at Oxford St., with proposed extension to Hall St and connections to Kent Trails and Millennium Park. Temporary impacts to fish and unionid mussels could occur if work in the wet and flowing river increases turbidity and/or harms individual fish and/or mussels. Use of construction best management practices and translocating mussels could minimize the potential impacts, especially if this project were coordinated with the Proposed Action
Oxford Trail	Rehabilitation of the existing trail segment from Wealthy St (west of river) into the Black Hills neighborhood at Oxford St., with proposed extension to Hall St and connections to Kent Trails and Millennium Park. Temporary impacts to fish and unionid mussels could occur if work in the wet and flowing river increases turbidity and/or harms individual fish and/or mussels. Use of construction best management practices and translocating mussels could minimize the potential impacts, especially if this project were coordinated with the Proposed Action

Table 8-1. Project Measures to be Implemented

Project	Unit	Quantity
Stream Habitat Improvements (installation of boulders, weirs, etc.)	Acres	6.1
Aquatic Organism Passage (obstruction removal)	Number	4

Table 8-2. Anticipated Permitting and Construction Schedule

Task/Milestone	Schedule
Biological Opinion	
Final Biological Assessment Submitted to NRCS	February 2024
NRCS Submittal of Biological Assessment (BA) to USFWS	April 23, 2024
USFWS Formal Consultation of BA	April - July 2024
Biological Opinion Issued by USFWS	August 14, 2024
Mussel Relocation	
Initial Mussel Relocation	August – October 2024
EGLE Permit	
EGLE Permit Submission	May 16, 2024
EGLE Review	May-July 2024
Public Comment Period	July – August 2024
EGLE permit receipt	December 2024
Environmental Assessment	
Send draft EA to NRCS State office for review - 60 days	April 8, 2024
NRCS send EA to NWMC for technical review	September 3, 2024
Address Comments from NWMC	November 2024
Submit Draft Plan-EA to Headquarters	November 2024
Address comments from HQ Programmatic Review	December 2024
Release notice of Public and Agency Review and Comment	January, 2025
Prepare Final EA to submit to NRCS State office	April 2025
If document outcome is FONSI, prepare FONSI	May 2025
Prepare a Notice of Availability and distribute to public	May 2025
Sign Watershed Agreement	May 2025
Plan-EA is submitted for Authorization	May 2025
WPB submits Plan-EA to chief for Authorization	June 2025
Construction	
Mobilization	Spring 2025
Construction	July 1, 2025 – December 31, 2026

[1]Assumes responses to NWMC comments on the Draft EA are accepted and approved with no other revisions needed.

Table 8-3. (Economic Table 1)
Estimated Installation Cost, Lower Grand River Watershed, Michigan, [$22M]

(This table corresponds to Economic Table 1, as required per the National Watershed Program Manual)

		Number		Estimated Costs		
Waterbody	**Works of Improvement**	**Unit**	**Non-Federal Land**	**PL 83-566 Authority**	**Sponsor Funds[1]**	**Total**
				Non-Federal Land	**Non-Federal Land**	
Grand River	Stream Habitat Improvement	Acres	6.1	$7,113,132.27	$7,113,132,27	**$14,226,264.54**
	Aquatic Organism Passage	Number	4	$3,913,563.16	$3,913,563.16	**$7,827,126.32**
				$11,026,695.43	$11,026,695.43	**$22,053,390.86**

Prepared:11/25/24

[1]This cost-share rate chosen for this project is consistent with that of similar NRCS projects of a 50% cost-share rate for PL-566 funding.

Table 8-4. Financing of Installation Costs

Installation Funding	Cost
NRCS PL 83-566 Funding	$11,026,695.43
State of Michigan	$8,250,000.00
Local Governments	$1,700,000.00
Private Foundations/Private Gifts	$1,076,695.43
Total	**$22,053,390.86**

Table 8-5. OMRRR Schedule for Elements of the Grand River Habitat Restoration Project

Element	Operation	Maintenance	Repair	Rehabilitation	Replacement
	Years	Years	Years	Years	Years
Earthwork	5	N/A	15	50	N/A
Bases (Aggregate)	5	N/A	15	50	N/A
Drainage Features	5	N/A	15	50	N/A
Structures	5	N/A	15	50	N/A
Incidental Construction	5	N/A	15	50	N/A

Table 8-6. (Economic Table 4)
Estimated Average Annual NED Costs Lower Grand River Watershed, MI, $22M
(Lower Grand River Watershed, Michigan, in 2024 dollars. This table corresponds to Economic Table 4, as required per the National Watershed Program Manual)

Works of Improvement	Project Outlays Amortization of Annual Cost	Project Outlays Annualized Operation, Maintenance, and Replacement Cost	Total
Stream Habitat Improvements	$14,226,264.53	$355,656.61	$14,581,921.14
Aquatic Organism Passage	$7,827,126.32	$195,678.16	$8,022,804.48
Total	$22,053,390.85	$551,334.77	$22,604,725.62

Prepared: 4/24/2024

[1]Price base: $22,053,390.85 amortized over 50 years at a discount rate of 2.5%.

APPENDIX D

Investigation and Analyses Report and Preliminary Investiga on

- Preliminary Investigation Report
- Investigation and Analyses Report
- Basis of Design Attachment 1 – Concept Design Drawings
- Basis of Design Attachment 2 – Cost Estimates

APPENDIX D

Investigation and Analyses Report and Preliminary Investiga on

Preliminary Investigation Report

Environmental Consulting & Technology, Inc.
3125 Sovereign Drive, Suite 9C, Lansing, Michigan 48911

Grand River Revitalization Project

Preliminary Investigation Report

A Portion of the Lower Grand River Watershed
Habitat Restoration – Farmland Conservation Project
RCPP #1603

GVMC

LOWER GRAND RIVER ORGANIZATION of WATERSHEDS

Grand Rapids, Michigan

December 21, 2018

ECT No. 180081-0300

Document Review

The dual signatory process is an integral part of Environmental Consulting & Technology, Inc.'s (ECT's) Document Review Policy No. 9.03. All ECT documents undergo technical/peer review prior to dispatching these documents to any outside entity.

This document has been authored and reviewed by the following employees:

Anne M. Power	Tonya M. Lewandowski
Author	Peer Review
	
Signature	Signature
December 21, 2018	December 21, 2018
Date	Date

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List of Acronyms and Abbreviations

°F	degree Fahrenheit
AEG	Anderson Economic Group
EA	environmental assessment
ECT	Environmental Consulting & Technology, Inc.
EPA	U.S. Environmental Protection Agency
ERM	Environmental Resources Management
ESI	Ecological Specialists, Inc.
FEMA	Federal Emergency Management Agency
FTCH	Fishbeck, Thompson, Carr & Huber, Inc.
GRFD	Grand Rapids Fire Department
GRWW	Grand Rapids Whitewater
GVMC	Grand Valley Metropolitan Council
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MSA	Metropolitan Statistical Area
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
NWPM	National Watershed Program Manual
PPP	Public Participation Plan
TES	threatened, endangered, and special concern
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WPP	watershed project plan

1.0 Introduction

1.1 The State of the Resource

Grand River is the longest river in Michigan; travelling from Jackson to its outlet into Lake Michigan at Grand Haven, this river stretches 260 miles through primarily agricultural areas, draining numerous smaller rural watersheds, but also through some of Michigan's largest urban areas. In days past, there were rapids that ran through what is now the heart of Grand Rapids. Historically, the river has played a central role in the life of the city, serving as a thoroughfare for lumber that fed the burgeoning furniture industry. To meet the needs of this growing and industrious city, in the late 1800s and early 1900s the river was extensively modified, especially between Ann Street and Fulton Street, altering the bedform and even installing "beautification dams" to alleviate odors associated with the city's combined sewer system. Despite the historical alterations, some physical characteristics of the river that made the area so unique remain. The river bed still drops 18.5 feet over the distance between Ann Street and Fulton Street, and some of the original bedrock outcroppings that served as surgeon habitat are still present.

Between Lake Michigan and the city of Ada, a distance of approximately 60 river miles, the river gradient sufficient to restore rapid habitat only exists at the project reach. The geographical extent of the project was identified to maximize rapid potential and encompasses areas between Fulton Street and Ann Street in the main channel of the Grand River (Figure 1-1). The project envisions extensive in-stream habitat restoration activities over an area of approximately 36 acres of river bed that will restore the historic rapids and help recreate some of the lost ecosystem functions that were once provided by the river.

The existing dams alter sediment transport, flow velocity, block fish passage, and are a public safety hazard. As a tributary of Lake Michigan, removal of the four low-head beautification dams would allow fish passage and connectivity of the watershed, access to historical spawning grounds, and previously isolated fish populations. It would also reduce or eliminate the existing public safety hazards created by dam hydraulics. Proposed substrate enhancements would serve to improve habitat diversity and quality, benefitting fish and invertebrates, including the federally-listed endangered snuffbox mussel (*Epioblasma triquetra*), Michigan-listed threatened lake sturgeon (*Acipenser fulvescens*) and river redhorse (*Moxostoma carinatum*), and potentially improving their productivity, which is not as robust as it should be (Figure 1-2).

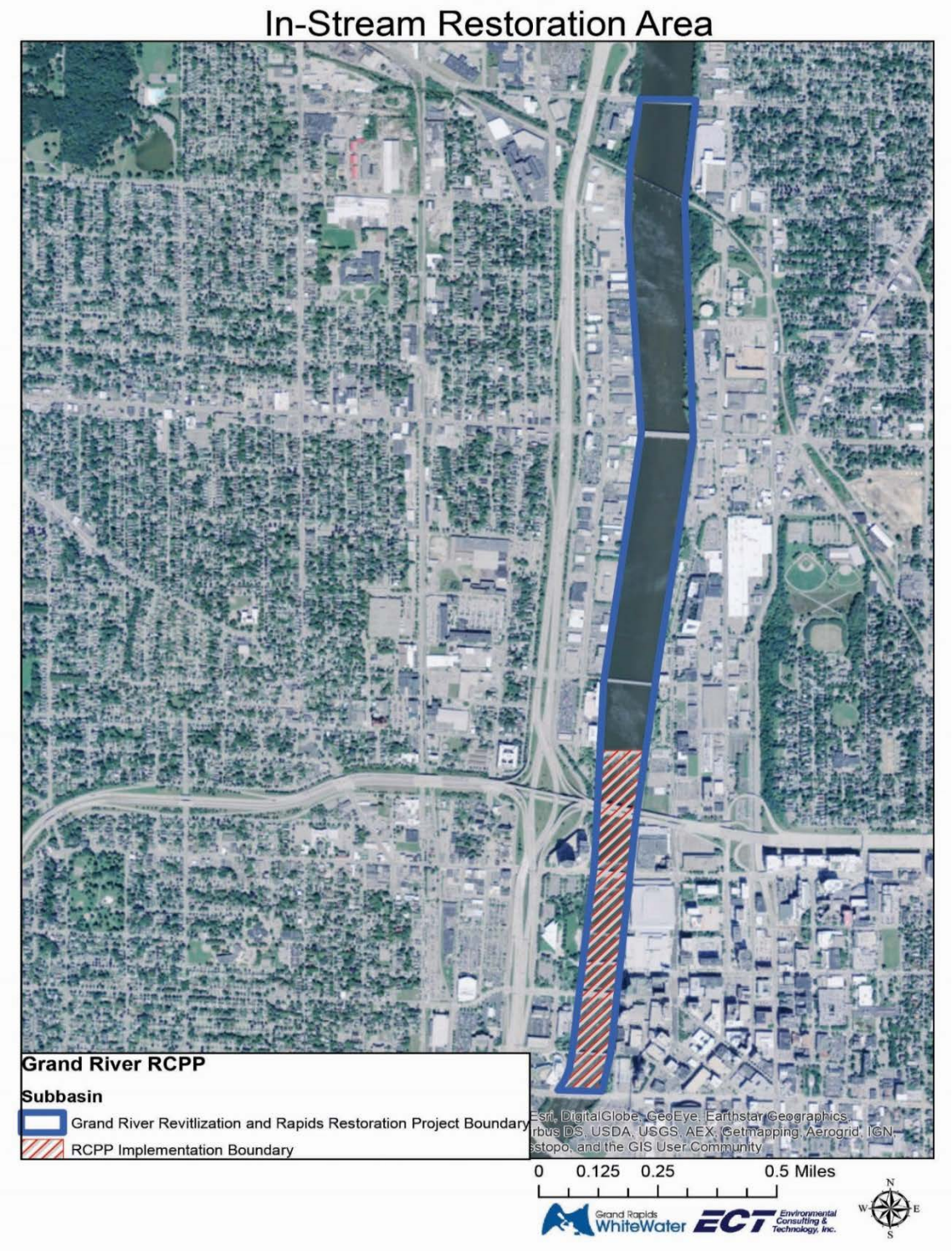


Figure 1-1. Project Area Boundary

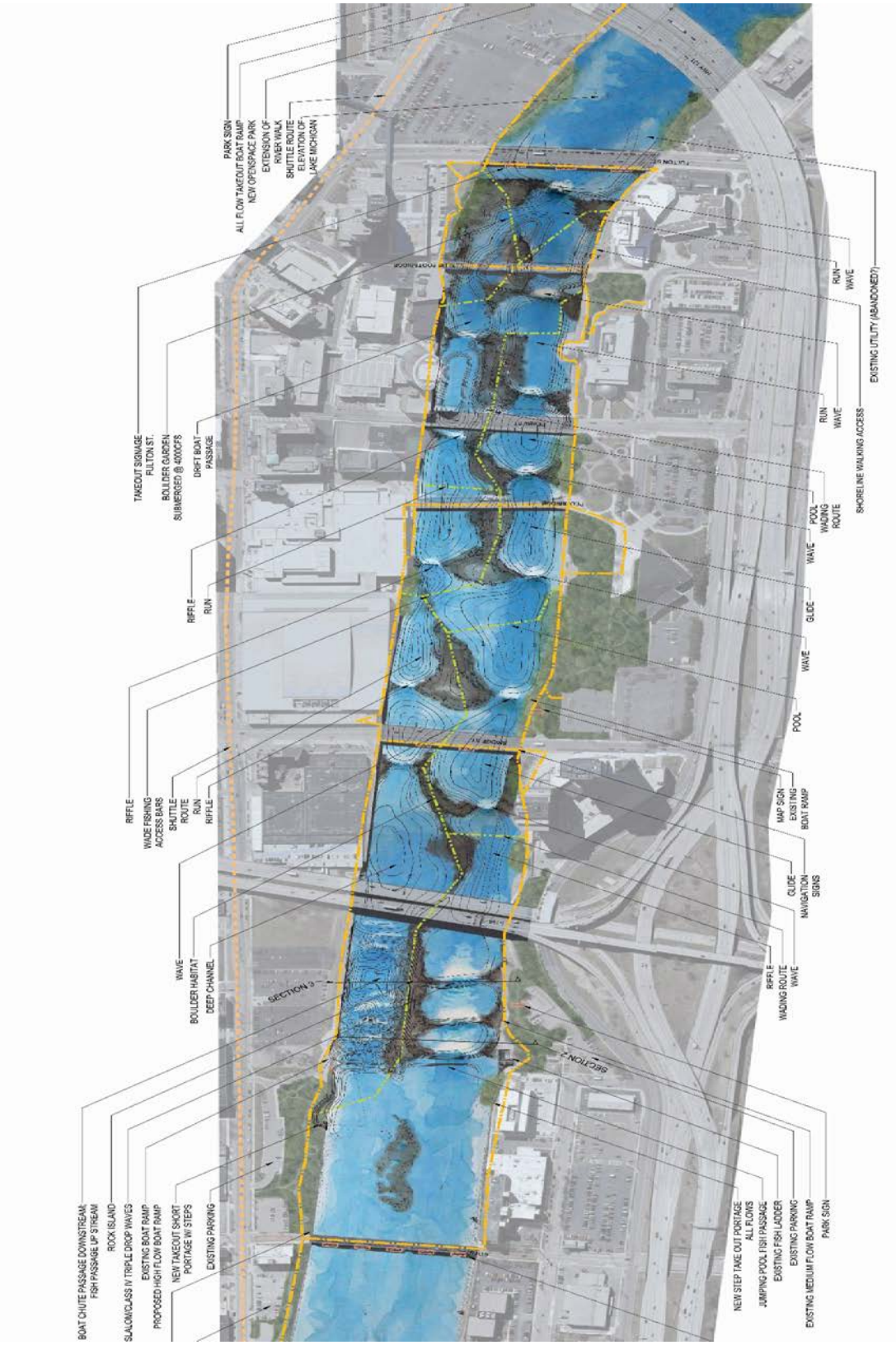


Figure 1-2. Conceptual Image of Proposed Project Enhancements

1.2 Restoring the Resource

Rapids restoration between Ann Street and Fulton Street would serve to oxygenate the water, another benefit to aquatic life, and create new recreational opportunities for the public, such as whitewater boating and fly fishing. Figure 1-1 depicts the current project area.

The project is expected to have an overall long-term beneficial effect on water resources, fish and aquatic species, including threatened and endangered species, and the local economy. An economic impact analysis prepared in 2014 indicated the local economy would benefit from increased access and use of the river by citizens and visitors. An updated economic impact analysis is in process to better gauge the current value of those benefits.

In addition to the in-stream work taking place under the watershed project plan (WPP), farmland conservation practices will be implemented in areas of the upper watershed to reduce soil erosion and improve water quality.

Future projects in the Grand River include the removal of the 6th Street dam and installation of an adjustable hydraulic structure to provide a barrier to migrating sea lamprey. These additional activities will help the WPP project achieve its full potential.

1.3 Compliance with Natural Resources Conservation Service Requirements

The components required by the Natural Resources Conservation Service (NRCS) are addressed within this document and have been checked for completeness against NRCS-CPA-52 form. Appendix B contains an evaluation checklist, including the criteria addressed.

To meet the requirements outlined in NRCS-CPA-52, the following criteria were addressed:

- Objectives (purpose)
- Need for action
- Resource concerns and existing/benchmark conditions, including economic considerations and public health and safety
- Special environmental concerns (e.g., endangered species)

- Alternatives (including the no-action alternative, effects of alternatives, and the preferred alternative)
- Impacts to special environmental concerns
- Mitigation

1.4 Proposed Alternatives

Along the reach of the river that courses through downtown Grand Rapids, the Grand River drops an impressive 18.5 feet, representing the steepest grade anywhere along its entire length. Only 1 percent of the river habitat in the lower peninsula of Michigan is comprised of rapid-type habitat, which is important to the life cycle of many aquatic species. Rapid-type habitat is defined as a river system with a steep energy gradient, coarse bed substrates, and nonuniform distribution of instream velocities.

Three project alternatives are being evaluated to support the project:

1. No action
2. Removal of four, low-head beautification dams without substrate improvements
3. Removal of four, low-head beautification dams with substrate improvements

1.5 The Recommended Alternative

The preferred alternative to meet the needs of this project is Item 3, removal of four, low-head beautification dams in the Grand River from 20 meters (65 feet) upstream of Interstate 196 to Fulton Street (the Project Area) and improving substrates over 1 kilometer (3,300 feet) of the Grand River. This will create substrate diversity in more than 36 acres of river bottom and will facilitate revitalization of the ecological, cultural, and recreational functions of the historical rapids. Through implementation of this preferred alternative, project opportunities that will be realized include:

- Protection of threatened, endangered, and special concern (TES) species of fish and mussels, including lake sturgeon, river redhorse, and snuffbox mussel.
- Enhancement of recreational activities with safe public access in an urbanized Great Lakes river corridor.
- Improved habitat diversity and suitability in more than 36 acres of the Grand River, resulting in increased Great Lakes native fish and mussel diversity and productivity.

2.0 Purpose and Need for Action

2.1 Purpose and Need

The purposes of the Lower Grand River Watershed Habitat Restoration – Farmland Conservation Project are to revitalize, enhance, and maintain the rapids in downtown Grand Rapids. The project will facilitate restoration of the ecological, cultural, and recreational functions of the historic rapids by:

- Restoring aquatic habitat diversity and suitability for threatened, endangered, and special concern (TES) native Great Lakes fish and mussel species.
- Reducing or eliminating public safety hazards generated by existing hydraulics.
- Diversifying in-stream features that will improve habitat and create/enhance recreational activities in the river.

The project's need for federal action is due to the degraded natural resource of the river and several recognized safety problems. Historical physical changes to the Grand River as it flows through downtown Grand Rapids, including construction of four, low-head beautification dams and removal of substrate, have impacted native and TES species of fish and mussels, limited public recreational activities, and altered habitat. Studies have determined TES species of fish and mussel community diversity and productivity are currently much lower than possible. According to the *Lake Sturgeon Habitat* report completed by River Restoration in 2013, "The Grand River is one of only four rivers on the eastern shoreline of Lake Michigan where a known remnant population of lake sturgeon (*Acipenser fulvescens*) successfully reproduces (Smith, MDNR unpublished data). The availability of spawning and staging habitats in rivers is considered a major factor limiting the recovery of lake sturgeon in Lake Michigan (Daugherty *et al.*, 2009; Auer, 1999). Furthermore, remnant sturgeon populations throughout the Great Lakes Basin have been found to be genetically unique, with the Grand River population likely included, and protection of each population is a priority of federal, state and tribal agencies (Welsh *et al.*, 2010; Holey *et al.*, 2000). Recently numerous sturgeon restoration projects have begun (Holtgren *et al.*, 2007); however, very few have focused on increasing spawning and staging habitat in Michigan."

Four, low-head beautification dams alter flow velocity and create public safety hazards. From 2005 to 2016, the Grand Rapids Fire Department has rescued 72 people from water-related incidents in this reach of the river, resulting in 40 civilian injuries as well as 5 civilian deaths from 2005 to 2016.

Habitat diversity has been significantly reduced. Along the reach of the river that courses through downtown Grand Rapids, the Grand River drops an impressive 18.5 feet, representing the steepest grade anywhere along its entire length. Only 1 percent of the river habitat in the lower peninsula of Michigan is comprised of rapid-type habitat, which is important to the life cycle of many aquatic species. Rapid-type habitat is defined as a river system with a steep energy gradient, coarse bed substrates, and nonuniform distribution of instream velocities.

Three project alternatives are being evaluated to support the project:

1. No action
2. Removal of four, low-head beautification dams without substrate improvements
3. Removal of four, low-head beautification dams with substrate improvements

The preferred alternative to meet the needs of this project is Item 3, removal of four, low-head beautification dams in the Grand River from 20 meters (65 feet) upstream of Interstate 196 to Fulton Street (the Project Area) and improving substrates over 1 kilometer (3,300 feet) of the Grand River. This will create substrate diversity in more than 36 acres of the river bottom and will facilitate revitalization of the ecological, cultural, and recreational functions of the historical rapids. Through implementation of this preferred alternative, project opportunities that will be realized include:

- Protection of TES fish and mussel species, including lake sturgeon, river redhorse, and snuffbox mussel.
- Enhancement of recreational activities with safe public access in an urbanized Great Lakes river corridor.
- Improved habitat diversity and suitability in more than 36 acres of the Grand River, resulting in increased Great Lakes native fish and mussel diversity and productivity.

In addition, project implementation will align with the goals and objectives of the following regional planning documents:

- Lake Sturgeon Recovery – *Lake Sturgeon Rehabilitation Strategy Draft*. Hayes, Dr. D.B., and Dr. D.C. Caroffino. December 2011. Michigan Department of Natural Resources.
- Restoration of habitats, fishery improvements and encouragement of outdoor recreation – *Lower Grand River Watershed Management Plan*. Lower Grand River Organization of Watersheds. 2011.
- Rapid restoration effect on the local fisheries in the river, productivity and diversity of Lake Michigan, productivity and diversity of Grand River native fish and mussel populations, and river accessibility recreational opportunities – *Grand River Fisheries Assessment*. Hanshue, S.K., and A.H. Harrington. 2017. Michigan Department of Natural Resources Fisheries Report 20, Lansing.

In tandem with these in-stream restoration activities, the region is engaging in multiple actions directed at creating better water quality within the Grand River. Regional Conservation Partnership Program funding has been obtained for best management practices in two upper watersheds: the Rogue River and Indian Mill Creek. The City of Grand Rapids has invested more than $400 million dollars to separate its sewer system, eliminating combined sewer overflows to the Grand River. The City of Grand Rapids and many surrounding communities draining to the Grand River are proactively managing stormwater. Concerted efforts between communities and conservation organizations in the Grand River are planning and implementing efforts to improve water quality. Such previous, ongoing, and future efforts will help ensure the restored rapids habitat between Interstate 196 and Fulton Street will be productive and sustainable.

2.2 Watershed Problems and Resource Concerns

2.2.1 Habitat Conditions

The habitat of the Grand River through Grand Rapids is severely degraded, but it offers a unique opportunity for Michigan and the Great Lakes.

The ecosystem processes of the Grand River have been degraded from loss of the rapids, channelization, dredging, and urban development. Only 1 percent of the river habitat in the lower peninsula of Michigan is comprised of rapid-type habitat, which is important to the life cycle of many aquatic species. Rapid-type habitat is defined as a river area with a steep energy

gradient, coarse bed substrates, and nonuniform distribution of instream velocities. Prior to dam installation and subsequent dredging and channelization, the Grand River rapids ran through Grand Rapids.

The historical modifications were made to support development of the region, but those industries and practices have long lost their relevance. Five dams have been constructed within Grand Rapids, including the 6th Street Dam and four smaller, low-head beautification dams. The 6th Street Dam was constructed more than 100 years ago to facilitate the floating of logs over the bedrock outcrop upstream of Leonard Street. Four smaller, low-head beautification dams were subsequently constructed downstream of the 6th Street Dam to maintain channel width during low flow to prevent the concentration of raw sewage that was discharged into the river. Dredging and mining of large substrate has occurred in the channel where it runs through the city. In addition, the river is constrained between more than a mile of flood protection walls on both sides of the channel. These modifications have together created a straight, uniform channel with little diversity in flow depth, substrate, or velocity, limiting natural aquatic ecosystem processes and constraining the physical, chemical, and biological processes of the river ecosystem.

Despite drastic modifications to the river system, the habitat supports important species. Snuffbox mussel (federally listed as endangered), lake sturgeon, and river redhorse (state listed as threatened) are species known to inhabit the project area, along with many host fish species. Section 7.7, Fish and Aquatic Species, discusses this further.

2.2.2 Supporting the Important Species of the Region

The removal of four, low-head beautification dams, followed by diversification of in-stream features through creation of riffles, runs, glides, drops, and pools with variable depths and flow velocity throughout the project area reach, will serve to improve habitat quality for the threatened and endangered species and their hosts. This project would:

- Diversify river conditions, providing variability in flow velocity and depth.
- Improve quality of habitat for threatened and endangered species and host fish along 3,300 feet by 476 feet (36 acres) of Grand River.
- Reduce barriers of access for native and regional species, potentially increasing genetic diversity through reconnection with formerly segregated fish populations.
- Initiate Phase 1 of a multiphase project to reconnect access for lake sturgeon to historical spawning grounds just above the 6th Street Dam.

2.2.3 Risks to Human Health and Safety

The historical modification made to the Grand River have created a public safety concern. Four of the city's five low head dams are located within the project area outlined in this project plan. While the data is not specific to only the dams, the hydraulics created by the dams are a safety risk to boaters and swimmers alike and have contributed to multiple rescue and recovery operations over the years.

According to Grand Rapids Fire Department (GRFD) data, from 2005 to 2016 there were 40 civilian injuries and 5 civilian deaths. Within the same time period, the Grand Rapids Fire Department rescued 72 people from water-related incidents. On average, the Grand Rapids Fire Department averages 10 water rescue incidents per year (GRFD, 2016)

2.2.4 Economic and Social Considerations

Use of the river is expected to increase after project completion. More people are expected to spend time in and around the river using the scenic waterway and enjoying easy access to greater recreational opportunities. As a result, Grand Rapids can expect to attract new businesses that want to capitalize on the improvements made to the river.

Anderson Economic Group (AEG) authored a 2014 economic impact analysis report. In it, the restored river and riverfront were projected to generate between 232,434 and 538,313 new visitor days for Grand Rapids each year. For a breakdown of net new visitor days, AEG estimated an additional 13,090 to 15,400 for whitewater boating users, 42,500 to 50,000 for non-whitewater boating users, 66,844 to 80,213 for fishing users, and between 110,000 to 392,700 for shore-based users. The low-end estimate is a conservative scenario based on data and observations of smaller-scale river restoration projects. The higher estimate is a potential scenario reflecting possible increased draws given the project's location, broad scope, potential to attract several major events, and overall community and statewide interest. The economic impact under these scenarios is $15.9 million to $19.1 million in net new activity every year, respectively. This is driven by direct net new spending of $12.9 million to $15.5 million, which stimulates an additional $3.0 million to $3.6 million in indirect economic impacts within Grand Rapids. This economic impact includes 80 to 96 new jobs and $2 million to $2.3 million in new earnings for the Grand Rapids' workforce.

AEG is updating their 2014 analysis to address additional impacts such as impacts of construction, installation, and maintenance of the project. They are also performing a cost-benefit analysis for the WPP.

3.0 Public Participation Plan

The intent of the public participation plan is to provide the public with information about the Restore the Rapids Project and encourage their engagement within the planning process. Appendix A contains a copy of the public participation plan that outlines outreach methods and activities that have been or will be employed to reach the broader community of Grand Rapids.

3.1 Sponsors, Local Partners, Agencies, and Tribal Participation

The Sponsor for the project is the City of Grand Rapids, Michigan.

Project sponsors must have the legal authority and resources to carry out, operate, and maintain works of improvement (Public Law 83-566 Section 2).

For the purpose of the project, Partners are the agencies involved in scheduling, facilitating communication, and project design and development. Local partners for the project include:

- Grand Valley Metropolitan Council (GVMC) – Lead Partner.
- Grand Rapids Whitewater (GRWW) – Supporting Partner.

Consultants were procured to provide environmental and economic assessments. The consulting team supporting the effort include:

- AEG.
- EcoAnalysts, Inc.
- Environmental Consulting & Technology, Inc. (ECT).
- Environmental Resources Management (ERM).
- Fishbeck, Thompson, Carr & Huber, Inc. (FTCH).

Agencies involved with the project include state and federal resource agencies such as:

- NRCS.
- U.S. Fish and Wildlife Service (USFWS).
- Michigan Department of Natural Resources (MDNR).
- Michigan Department of Environmental Quality (MDEQ).

- U.S. Army Corps of Engineers (USACE).
- U.S. Environmental Protection Agency (EPA).

Tribes that have been contacted and invited to participate in the project include:

- Little River Band of Ottawa Indians (federally recognized).
- Grand River Band of Ottawa Indians (federal recognition pending).
- Nottawaseppi Huron Band of the Potawatomi, Anishinaabe community (federally recognized).
- Gun Lake Tribe (federally recognized).
- United Tribes of Michigan (representatives from 12 federally recognized tribes)

Other stakeholders for this project that have contributed time and effort include:

- Downtown Grand Rapids, Inc.
- Grand Rapids Public Museum.
- Kent County Drain Commissioner.
- Lower Grand River Organization of Watersheds.
- Michigan League of Conservation Voters.
- Private foundations and businesses.

3.2 Permits and Compliance

The project will comply with applicable state and federal regulations.

This project will be funded in part using NRCS federal dollars. A prerequisite for funding is a WPP environmental assessment (EA). This process requires compliance with relevant federal and state regulations, including PL 83-566, Section 7, of the Endangered Species Act; Section 106 of the National Historic Preservation Act; and relevant parts of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended by the State of Michigan, as required by the joint permit being submitted (with MDEQ).

3.3 Mitigation

Mitigation measures will be necessary during implementation of the habitat restoration process because of anticipated detriment to some of the fish and aquatic life within the project area.

Threatened and endangered species unionid mussels within the project area could be harmed during project construction; therefore, a mussel relocation and monitoring plan will be put in place to reduce the number of mussels affected. After the construction area is isolated and the water level lowered, but before dam removal and substrate enhancement activities begin, a team of malacologists/biologists will search and collect unionid mussels for tagging and translocation, with an 80-percent recovery goal. Translocated mussels will be monitored 1 year following each translocation, and an annual report summarizing translocation and monitoring results will be produced.

To mitigate the loss of mussels crushed or otherwise not successfully recovered and translocated, a donor-advised fund will be established to fund research, monitoring, and other conservation measures within the Grand River basin. Wetlands are not known to be present within project area boundaries; however, a delineation survey will be performed for confirmation. Mitigation activity would be incorporated into the project should construction activity negatively impact wetlands found to be within or adjacent to the project area.

4.0 Environmental Evaluation

As part of the preliminary investigation process, the components required by NRCS are addressed within this document and have been checked for completeness against NRCS-CPA-52 form. Appendix B contains an evaluation checklist, including the criteria addressed.

To meet the requirements outlined in NRCS-CPA-52, the following criteria were addressed:

- Objectives (purpose)
- Need for action
- Resource concerns and existing/benchmark conditions, including economic considerations and public health and safety
- Special environmental concerns (e.g., endangered species)
- Alternatives (including no-action alternative, effects of alternatives, and the preferred alternative)
- Impacts to special environmental concerns
- Mitigation

5.0 Studies Completed

Several studies are under review/revision or are being conducted by consultants concurrently with the preliminary investigation and will be used to inform and develop the WPP. These studies include a biological assessment prepared by EcoAnalysts, Inc. (formerly Ecological Specialists, Inc.), that is currently under review, and an updated economic impact analyses being prepared by AEG.

Other existing local studies and sources of information are noted in Section 13.0, References.

6.0 Scope of the WPP

The NRCS-compliant watershed project plan under PL 83-566 will use analyses of current conditions and expected impacts of the proposed project and will leverage existing studies and reports providing relevant data collected within the watershed. The WPP will:

- Meet the requirements of Public Law 83-566, NRCS policy, congressional criteria, executive orders, the National Environmental Policy Act (NEPA), USACE Principles and Guidelines (as applicable), and other applicable laws and regulations.
- Utilize commissioned economic and environmental analyses that evaluate the potential alternatives, including the no-action alternative.
- Include consultation with the State Historic Preservation Office as part of the EA.

The WPP will follow the outline presented in the National Watershed Planning Manual. GVMC and other project Partners will engage all concerned parties in the planning process, including conducting public outreach to obtain input from the local communities.

Project Partners will work together to identify issues and concerns, incorporating them into the final WPP. This project is a non-water resources project, and, as such, the alternatives analysis will not include a national economic development alternative. The development of alternatives will follow the federal "*Principles and Guidelines for Water and Related Land Resources Implementation Studies.*"

6.1 Scoping and Public Participation

The WPP and EA planning processes include scoping and public participation to identify environmental, natural resource, economic, and social concerns associated with this watershed project.

Coordination will take place between GVMC, its project Partners, stakeholders, NRCS, and other NEPA agencies involved to determine the format and schedule for the scoping meeting(s) in compliance with Part 501, Subpart C, Section 501.24 of Title 390, National Watershed Program Manual (NWPM).

6.2 Alternatives

The WPP will include all reasonable alternatives that meet the purpose and need for action. They will be studied and analyzed in the EA plan. Because the WPP and EAs are being produced concurrently by two separate contractors, coordination will be necessary during identification and selection of project alternatives. This coordination will allow WPP development to continue concurrently with the EA development. The coordination meetings will be used to identify project alternatives that meet the following NRCS requirements (Part 501, Subpart B, Section 501.12[A], Title 390 NWPM):

- Inclusion of all reasonable alternatives meeting the purpose and need for action
- Inclusion of the future-without-project condition or no-action alternative
- Rationale provided for excluding alternatives from study
- Discussion of environmental and natural resource concerns raised during WPP scoping

6.3 WPP Development

The WPP will be prepared as required to meet funding approval under Public Law 83-566 as a final comprehensive report containing the EA and the content listed. The WPP will be developed using existing available information and the results of studies conducted by GVMC, GRWW, and other project Partners. Cost estimates and a cost-benefit analysis, focusing specifically on how the project alternatives meet the purpose and need for action, will be included.

The WPP will include the EA in accordance with NRCS requirements. The WPP will also contain information and analyses pertaining to the following required content pursuant to Part 501, Subpart D, Title 390 NWPM.

- Abstract
- Summary
- Purpose and need for action
- EA scope
- Affected environment
- Alternatives
- Environmental consequences
- Documentation of consultation, coordination, and public involvement
- Preferred alternative
- References
- List of preparers
- Distribution list
- Index

7.0 Affected Resources – Existing Conditions

7.1 Project Setting

The project is in the urbanized section of Grand River as it traverses through the core of Grand Rapids. Surrounded by urban development, the project area runs from just north of the Interstate 196 Bridge to the Fulton Street Bridge, passing right through Grand Rapids. The banks in some areas are channelized with concrete flood protection walls. In some cases, these walls are foundational walls to buildings that act as part of the flood protection system. The river banks are also developed with public parks, multi-use buildings, and parking lots. Bridges and highways cross the river.

Between Lake Michigan and the city of Ada, a distance of approximately 60 river miles, the river gradient sufficient to restore rapid habitat only exists at the project reach. The geographical extent of the project was identified to maximize rapid potential and encompasses areas between Fulton Street and Ann Street in the main channel of Grand River.

7.2 Current Infrastructure

Current infrastructure within the project reach includes a concrete flood protection system, four low-head beautification dams, a fish ladder, and bridge support columns.

7.3 Topography

The topography of the Lower Grand River Watershed is heavily influenced by the region's glacial origins. Proglacial lakes around the state drained through the land that would become the Grand River creating the incised and confined channel that exists to this day. The valley is broad, with a relatively uniform width of 1 mile, which includes incised gullies and relic flood terraces. The river itself has some significant topographical variability along its length. In the 2-mile stretch of Grand River that winds its way through downtown Grand Rapids, the riverbed elevation drops 18.5 feet and contains some of the most dynamic topography in the region (Churches, 2013).

7.4 Climate

Local climate is heavily influenced by latitude, variation of land surface altitude, and proximity to Lake Michigan. Mean precipitation within the Grand River watershed is approximately 31 inches, whereas annual snowfall can range from as low as 30 inches to more than 100 inches, depending on proximity to the lake (Hanshue and Harrington, 2017). Records from 1981 to 2010 show the mean annual total precipitation within Grand Rapids was 38.1 inches, and mean annual temperature was 48.5 degrees Fahrenheit (°F), with a mean of 129 days per year that fall below 32°F (GLISA. 2016).

The area has short, mild springs and falls, warm and humid summers, and cold, snowy winters. Without the lake's moderating influence on regional temperature, the area would have a much more continental climate; because the seasonal temperature variation is moderated by the presence of a nearby water body, the Grand Rapids area can support diverse agricultural products such as peaches, apples, corn, and soybeans.

7.5 Geology and Soils

7.5.1 Geology

"Surficial geology is varied and ranges from coarse-textured end moraine and ice contact topography to glacial lake plains. In some portions of the watershed glacial tills and deposits are several hundred feet thick while other areas are characterized by exposed bedrock" (Hanshue and Harrington, 2017).

7.5.2 Soils

"Soil groups in the Grand River watershed are widely distributed and are largely characterized as having moderately low runoff potential. Soil types with low runoff potential comprise 18 percent of the watershed, whereas soils with high runoff potential comprise 14 percent. Presettlement land cover in the watershed was primarily beech-maple, mixed oak, and coniferous forests. Forested wetlands, shrub-swamp/emergent wetland, wet prairie and open water accounted for approximately 18 percent of the presettlement land cover. Contemporary land use is dominated by agriculture (57 percent); forested land cover has been reduced to 25 percent and wetlands reduced by over 50 percent. Urban land use accounts for 9 percent of the current landscape" (Hanshue and Harrington, 2017).

The primeval state of the soils in the project area is sandy and reflects the character of the glacial outwash that once coursed through the Grand River Valley. Today the soils in the immediate vicinity of the project area are heavily urbanized, and few retain the hydrologic qualities of their natural state. Most of these areas retain little to no ability to infiltrate water and are heavily dependent on local infrastructure for drainage. In the upper reaches of the project area, the soils drain better and retain many more of the characteristics of the original glacial outwash material (Soil Survey Staff, 2015).

7.6 Water Resources

7.6.1 Surface Water Quality

Water quality in the Grand River basin is influenced by many human activities, including agriculture, industry, and urban development. Waters of the State are protected for designated uses of warmwater or coldwater fisheries, indigenous aquatic life and other wildlife, agriculture, industrial and municipal water supply, navigation, and recreation. Waters of the State that are designated as trout streams or are principal migratory routes for potamodromous salmonids have more stringent dissolved oxygen and temperature standards set to protect coldwater fish. The Grand River main stem from Lake Michigan to the Moores Park Dam is identified as a principal migratory route for salmon and steelhead and therefore receives this additional protection (Hanshue and Harrington, 2017).

Water quality within the project area has been consistently improving and was given a huge boost in 2017 when the city completed the total separation of their combined sewer system. The city of Grand Rapids has monitored water quality within the downtown reach of Grand River going back to 1985. The City of Grand Rapids Environmental Services Department maintains data on dissolved oxygen, fecal coliforms, pH, biological oxygen demand, temperature change, total phosphate, nitrates, total suspended solids, and chlorides. Water quality records specifically pertaining to the project reach will be obtained from the City of Grand Rapids Environmental Services Department and MDEQ.

The Grand River basin historically suffered from poor water quality because of unregulated discharges from municipal and industrial point source discharges. Water quality in the basin is steadily improving, and virtually all point source discharges are now regulated through the National Pollutant Discharge Elimination System permitting program administered by the MDEQ Water Resources Division.

Nonpoint source pollution remains the greatest factor degrading water quality. This type of pollution enters the water from atmospheric deposition and surface runoff and generally consists of sediment, nutrients, bacteria, organic chemicals, and inorganic chemicals from agricultural fields, livestock feedlots, construction sites, parking lots, urban streets, septic seepage, and open dumps. Implementing best management practices with farmland, construction sites, and urban development designs can significantly reduce runoff, erosion, and influxes of sediment, nutrients, and other chemicals into lakes and streams.

7.6.2 Ground Water

The Grand Rapids area sits on top of thick glacial drift before reaching the Marshall Sandstone formation at approximately 550 feet above sea level. The city does not depend on subterranean aquifers to supply water to its citizens but pipes the water in from Lake Michigan instead (NARA, 2015). While the glacial drift is too thin to support a viable aquifer, many agricultural operations and residential properties in the area around Grand Rapids tap the aquifer supported by the Marshall Sandstone.

7.6.3 Water Rights

As a traditionally navigable waterway, the Grand River from its outlet at Lake Michigan upstream to Fulton Street is under USACE and MDEQ jurisdiction. Waters in Michigan are not divided into water-right owners as in western states; however, permits for water withdrawals are required (MDEQ and MLARA, 2018).

7.7 Fish and Aquatic Species

According to the MDNR Grand River Fisheries Assessment, the Grand River watershed supports 107 species of fish. This fish community includes several species of conservation interest within the project area and/or the larger watershed, including lake sturgeon and river redhorse, which are state-listed as threatened.

The watershed rates highly for Catostomid diversity (11 of 15 species present), sunfish and minnow communities (9 of 16 species present), as well as channel catfish, flathead catfish, largemouth bass, smallmouth bass, walleye, black buffalo, black redhorse, golden redhorse, spotted sucker, river chub, striped shiner, and grass pickerel. These species may not be present

within the project area but are present within the surrounding watershed. These species are species of great conservation concern within the state of Michigan.

Lake Michigan's proximity to Grand River causes significant seasonal influence, with many potadroumous species like lake whitefish and salmon migrating up the river during the spring and summer, changing the species composition. The major impediment for many of these species is the 6th Street Dam north of the proposed in-stream habitat construction area. This dam blocks all species except steelhead and salmon, which can make use of the fish ladder attached to the 6th Street Dam (Hanshue and Harrington, 2017).

Grand River is known to support numerous unionid mussels, including the federally listed endangered snuffbox mussel (discussed further in Subsection 7.10). Unionid habitat preferences include sand and gravel substrates in small to medium-sized rivers, which is limited under existing conditions. Table 7-1 identifies unionid mussels known to exist within the project area, as well as their host fish.

Table 7–1. Unionid and Host Species Known to Reside in the Project Area

Unionid Mussels		Host fish
Epioblasma triquetra	Snuffbox	Percidae (perches)
Alasmidonta viridis	Slippershell	Percidae (perches)
Cyclonaias tuberculata	Purple wartyback	Ictaluridae (catfish)
Ligumia recta	Black sandshell	Centrarchidae (sunfish and bass), Percidae (perches), *Aplodinotus grunniens* (freshwater drum)
Toxolasma parvum	Lilliput	Centrarchidae (sunfish and bass), Percidae (perches)
Pleurobema sintoxia	Round pigtoe	Cyprinidae (minnows), Centrarchidae (sunfish and bass)
Potamilus alatus	Pink heelsplitter	*Aplodinotus grunniens* (freshwater drum)
Truncilla truncata	Deertoe	*Aplodinotus grunniens* (freshwater drum)
Venustaconcha ellipsiformis	Ellipse	Percidae (perches)
Villosa iris	Rainbow	
Alasmidonta Marginata	Elktoe	Catastomidae (suckers), Centrarchidae (sunfish and bass)
Lasmigona Compressa	Creek heelsplitter	
Lasmigona Costata	Fluted shell	Cyprinidae (minnows), Catastomidae (suckers), Ictaluridae (catfish), Centrarchidae (sunfish and bass), Percidae (perches), *Aplodinotus grunniens* (freshwater drum)
Utterbackia Imbecillis	Paper pondshell	Ictaluridae (catfish), Centrarchidae (sunfish and bass), Percidae (perches)

Source: EcoAnalysts, Inc. 2018.

The Great Lakes have been invaded many times by species from outside the basin, and controlling their spread and impact is of upmost concern to the people who live in the basin. Many species, such as common carp, round goby, zebra mussel, curly leaf pondweed, and Eurasian water milfoil, are present in Grand River, but for this particular project the greatest threat comes from sea lamprey.

Lamprey are a parasitic species that was introduced to the Great Lakes accidentally when the Welland Canal was constructed. Lamprey lack bones and a jaw and instead have a large sucking disk that they use to cut into the sides of healthy animals. The species is now present throughout the Great Lakes, and its migration to upstream Grand River tributaries is believed to be stopped by the 6th Street dam. However, there is some evidence to suggest lamprey may be able to bypass the dam at certain flow rates (LGRWMP, 2011) (GLFC, 2018).

“Floodplain forests and nearshore environments within the watershed have been significantly altered as a result of the introduction of terrestrial exotics such as the emerald ash borer, Dutch elm disease, garlic mustard, phragmites and purple loosestrife. These changes are transferred to the aquatic ecosystem in the form of reduced productivity and altered habitat” (Hanshue and Harrington, 2017).

7.8 Wildlife

Wildlife as it pertains to land animals will be minimally impacted by the project, as the project area is solely within the river. Wildlife such as mink have been observed in the surrounding area. Species that could occur in the project surrounding area include the federally listed endangered northern long-eared bat (*Myotis septentrionalis*), Indiana bat (*Myotis sodalis*), Karner blue butterfly (*Lycaeides melissa samuelis*), and eastern Massasauga rattlesnake (*Sistrurus catenatus*), a Michigan state-listed species of special concern; however, they are highly unlikely to be present because of the lack of existing suitable habitat and/or they have never been reported in Kent County (MNFI, 2018).

7.9 Vegetation

“The Grand River catchment contains several unique and rare plant communities ranging from dry mesic southern forest to southern floodplain forest to interdunal wetlands. These plant communities represent remnants of the pre-settlement landscape and are rich in biodiversity. These communities provide critical habitats for numerous vertebrate and invertebrate species of

conservation interest including several that are identified as endangered, threatened, or of special concern" (Hanshue and Harrington, 2017).

7.10 Threatened and Endangered Species

Any modification of habitat must consider species of local and national concern that are present in the project area. Because the project work is either confined to within the river or in the urbanized areas that border it, aquatic species or species that depend on aquatic environments are assumed to be of particular interest. The Lower Grand River Watershed includes many species that meet these criteria along its length; however, relatively few of these species are present in the vicinity of the WPP area.

Species that are present include:

- Snuffbox Mussels—Protected both at the federal and state level and located in and around the project area. The mussels are medium-sized reaching approximately 2 inches and with a roughly triangular shape. Generally, the mussel's habitat is sandy, gravelly substrates in swift-flowing small streams (MNFI, 2018).
- River Redhorse—Fish species in the genus Catostomidae, or suckers, that reaches the northern limit of its range in Michigan. This sucker is the largest in the family and is emblematic of good water quality and good habitat quality (ODNR, 2012). While the species is rare, records kept by the Michigan Natural Features indicate some of the most recent sightings (2007) occurred in Kent County (MNFI, 2018).
- Lake Sturgeon—Grand River supports a remnant but stable population of lake sturgeon, though their habits are somewhat mysterious. The fish is a long-lived species that only reaches sexual maturity at 17 to 20 years; creating sustainable breeding populations within the state is vital. The species is threatened in Michigan, and there are limitations on how much the population can be boosted with enhanced breeding techniques, since sturgeon populations are genetically linked to their home river (Hanshue and Harrington, 2017) (MNFI, 2018).

7.11 Wetlands

Historically, 42 percent of the wetlands in the Lower Grand River Watershed were drained and converted to agriculture (LGRWMP, 2011). In the more densely populated areas, such as that surrounding the project area, the watershed has been highly urbanized. A wetland delineation survey will be conducted to identify wetlands within and adjacent to the project boundaries.

7.12 Land Use, Zoning, and Ownership

The project area is located within Grand River as it runs through Grand Rapids. Land uses bordering the project area are a combination of open space, public walkways, and commercial/ mixed-use properties. Zoning surrounding the river is presumed to be mixed-use and commercial, and shoreline property is owned by the City and private investors. Under Michigan law adjacent riverfront property owners own the river bottom to the thalwag, i.e., the lowest elevation within the water course (City of Grand Rapids, 2017).

7.13 Cultural and Historical Properties

The cultural and historical properties assessment has yet to be completed. An archaeologist will be consulted to assess the presence of and potential impact on any significant sites of cultural and historical importance. Investigation of any existing tribal water rights and treaty boundaries that fall within the project area, or that would be affected by the project, will be conducted. Any findings of significance will be factored into the final WPP.

7.14 Recreation

The Grand River supports a variety of game fish, and recreational use by anglers is high throughout the middle and lower reaches of its main stem. The areas near the fish ladder and dams where hydraulics have created deeper pools in which fish congregate are popular locations where the public can be seen fishing. There are numerous coldwater tributaries in the lower segment of the Grand River, both above and below the project area, that support popular fisheries for brown trout, brook trout, and steelhead. “Diverse warm water fisheries for walleye, smallmouth and largemouth bass, northern pike, panfish, and channel and flathead catfish are found on the main stem, tributaries and inland lakes” (Hanshue and Harrington, 2017). Coho and Chinook salmon migrate from Lake Michigan upstream through the project area and fish ladder to access upper reaches of the river.

Recreational boating is also enjoyed within the project area and all along the river, although connection of the upper reach to the lower reach is impeded by the dams. Hydraulic conditions created by these dams cause a public safety hazard when boaters get caught up in the hydraulics and capsize. Pathways and parks adjacent to the proposed project area are enjoyed by the public for numerous activities, including walking, running, picnicking, biking etc., and are conveniently

accessed from numerous access points along the waterfront by those who visit and/or work in downtown Grand Rapids.

7.15 Socioeconomics

7.15.1 Population

The human population in the project area is increasing at a higher rate than both the state of Michigan as a whole and the region of West Michigan.

The project is located within the second largest city in the state of Michigan. The city is characterized by a population of just under 200,000 residents and is central to the Grand Rapids-Wyoming Metropolitan Statistical Area, with a population of nearly one million people. Grand Rapids has been growing at an accelerated rate relative to West Michigan as a whole, with the population increasing an average 4.2 percent annually over the last 5 years, compared to just 0.7 percent of West Michigan. This compares to a population growth rate of 0.8 percent in Michigan, overall. The percentage of the Grand Rapids population represented by people of color within the metropolitan region is 32.4 percent, whereas the West Michigan proportion is 13.7 percent.

Grand Rapids, much like the entire country, is undergoing massive demographics shifts. In the last 30 years, the percent of the population who identify as people of color has risen from 20 to 42 percent as of 2014 (Table 7-2). This trend, toward a more diverse population, is also reflected in the divide between a more diverse younger population and a more homogenous older population. The trend is expected to continue, with Kent County expected to have a majority of people of color by 2050.

Table 7–2. Selected Regional Population Demographics

Population	1980 (percent)	2014 (percent)
People of color	20	42
White	80	58

Source: PolicyLink and PERE, 2017

7.15.2 Area Employment, Income, and Agriculture

Grand Rapids currently has a per capita income of $27,549 in 2016 dollars, which is comparable to all of Kent County where the per capita income is $28,070 in 2016 dollars. The biggest employers by number of jobs in the metropolitan region are manufacturing, followed by health care and social assistance, and administrative and support and waste management and remediation services.

On a larger scale, the Grand Rapids-Wyoming Metropolitan Statistical Area (MSA) encompasses four counties in West Michigan: Montcalm, Kent, Ottawa, and Barry. It is one of the most robust, economic regions within the state of Michigan as evidenced by the demographics data displayed in Table 7-3.

Table 7–3. Selected Regional Demographics

Demographic	Grand Rapids Wyoming MSA	State of Michigan
Population	1,050,000	9,900,000
Number of households	384,790	3,880,000
Median household income	$60,212	$52,492
Median home value	$164,500	$147,100
Percentage minority residents	20.9%	24.7%
Percentage age 65 and over	13.6%	16.2%
Median age	36	39.7
Percentage in poverty	11%	15
Percentage involved in amusement and recreation activities	1.86%	1.23%
Percentage involved in natural resource occupations (farming, fishing, forestry)	2%	0.07%
Top three industries by number of positions	• Manufacturing • Healthcare and social assistance • Retail trade	• Motor vehicles and motor vehicle equipment manufacturing • Restaurants and food services • Hospitals

Source: PolicyLink and PERE, 2017

The median household income within the MSA is roughly 15 percent higher than in the state of Michigan as a whole. The median home value in the Grand Rapids-Wyoming MSA is also approximately 12 percent higher than the state of Michigan as a whole (PolicyLink and PERE, 2017).

8.0 Estimated Project Implementation Costs

Interstate 196 to Fulton Street (Base Project)

Line No.	60 Percent Design Cost Opinion August 2017	Quantity	Unit Issue	Unit Cost	□artner	A□□□tant	□e□□e□t	Total ($)
	General							
1	Mobilization/demobilization/Bonding/Insurance	1	LS	$826,595				$826,595
2	Construction Review/Survey/ Stake/ As Built	1	LS	$165,319				$165,319
3	Construction Oversight and Management	1	LS	$247,978				$247,978
4	Care of water / ESC Program Management	1	LS	$40,000				$40,000
5								
6							**Sub-total**	**$1,279,892**
7								
8	SA 06 Scribner / Fish Ladder Staging Area	SA 06						
9	Project Signage	4	EA	$750				$3,000
10	Fueling Area	1	EA	$750				$750
11	Concrete Washout	1	EA	$1,250				$1,250
12	Wheel Wash Area	2	EA	$1,500				$3,000
13	Job Trailer	200	DAYS	$18				$3,600
14	Sanitation Facility	12	MONTHS	$225				$2,700
15	Water Truck for Dust Control	40	DAYS	$400				$16,000
16	Tree Removal and Replacement	4	EA	$1,200				$4,800
17	Protect in Place Mature Trees	2	EA	$300				$600
18	Remove, store and replace light pole	4	EA	$500				$2,000
19	Project in Place Utilities	10	EA	$300				$3,000
20	Protect in Place Existing Wetland	1	LS	$2,500				$2,500
21	Chain Link Construction Fence	450	LF	$5				$2,250
22	Orange Construction Fence	0	LF	$3				$0
23	Certified Weed Free Haybales	100	EA	$22				$2,200
24	Security Gate	2	EA	$2,000				$4,000
25	Silt Fence	2000	LF	$3				$6,000
26	Miscellaneous Erosion Control BMPs	1	LS	$5,000				$5,000
27	Traffic Control	1	LS	$25,000				$25,000
28	Site Restoration	1	LS	$100,000				$100,000
29							**Sub-total**	**$187,650**
30								
31	SA 07 North Monroe Lot Staging Area	SA 07						
32	Project Signage	4	EA	$750				$3,000
33	Fueling Area	1	EA	$750				$750
34	Concrete Washout	1	EA	$1,250				$1,250
35	Wheel Wash Area	2	EA	$1,500				$3,000
36	Dewatering Area	1	EA	$2,500				$2,500
37	Job Trailer	200	DAYS	$18				$3,600
38	Sanitation Facility	12	MONTHS	$225				$2,700
39	Water Truck for Dust Control	40	DAYS	$400				$16,000
40	Tree Removal and Replacement	14	EA	$1,200				$16,800
41	Remove, store and replace light pole	2	EA	$500				$1,000
42	Chain Link Construction Fence	1000	LF	$5				$5,000
43	Certified Weed Free Haybales	100	EA	$22				$2,200
44	Security Gate	2	EA	$2,000				$4,000
45	Silt Fence	1000	LF	$3				$3,000
46	Miscellaneous Erosion Control BMPs	1	LS	$4,000				$4,000
47	Cut and Restore Floodwall	1	LS	$75,000				$75,000
48	Traffic Control	1	LS	$25,000				$25,000
49	Site Restoration	1.00	LS	$5,000				$5,000
50							**Sub-total**	**$173,800**
51	SA 08 Bridge Street Staging Area	SA 08						
52	Project Signage	4	EA	$750				$3,000
53	Fueling Area	1	EA	$750				$750
54	Concrete Washout	1	EA	$1,250				$1,250
55	Wheel Wash Area	2	EA	$1,500				$3,000
56	Job Trailer	150	DAYS	$18				$2,700
57	Sanitation Facility	12	MONTHS	$225				$2,700
58	Water Truck for Dust Control	40	DAYS	$400				$16,000
59	Remove and Replace Tree	8	EA	$1,500				$12,000
60	Protect in Place Mature Trees	13	EA	$300				$3,900
61	Protect in Place Utilities	0	EA	$300				$0
62	Remove, store and replace light pole	4	EA	$500				$2,000
63	Chain Link Construction Fence	749	LF	$5				$3,745
64	Post Construction Fence	290	LF	$8				$2,320
65	Security Gate	2	EA	$2,000				$4,000
66	Certified Weed Free Haybales	50	EA	$22				$1,100
67	Silt Fence	256	LF	$3				$768
68	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
69	Protect in Place Existing Wetland	1	LS	$2,500				$2,500
70	Site Restoration	1	LS	$100,000				$100,000
71							**Sub-total**	**$163,233**
72								
73	SA 09 Gillett Bridge West Staging Area	SA 09						
74	Project Signage	4	EA	$750				$3,000
75	Fueling Area	1	EA	$750				$750
76	Concrete Washout	1	EA	$1,250				$1,250
77	Wheel Wash Area	2	EA	$1,500				$3,000
78	Dewatering Area	1	EA	$2,500				$2,500
79	Job Trailer	150	DAYS	$18				$2,700
80	Sanitation Facility	12	MONTHS	$225				$2,700
81	Water Truck for Dust Control	40	DAYS	$400				$16,000
82	Remove and Replace Tree	2	EA	$1,500				$3,000
83	Protect in Place Mature Trees	4	EA	$300				$1,200
84	Protect in Place Utilities	0	EA	$300				$0

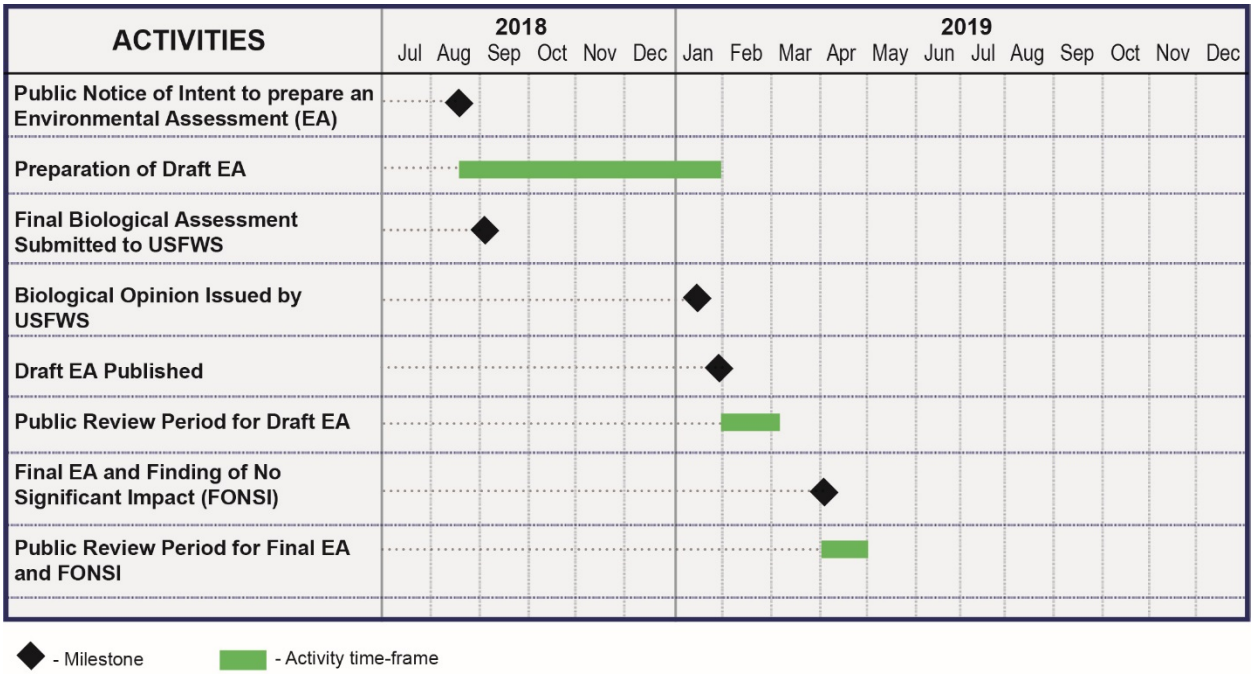
Line No.	60 Percent Design Cost Opinion August 2017	Quantity	Unit Issue	Unit Cost	□artner	A□□□cant	□e□□e□i	Total ($)
85	Remove, store and replace light pole	7	EA	$500				$3,500
86	Chain Link Construction Fence	663	LF	$5				$3,315
87	Security Gate	1	EA	$2,000				$2,000
88	Certified Weed Free Haybales	70	EA	$22				$1,540
89	Silt Fence	380	LF	$3				$1,140
90	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
91	Protect in Place Existing Wetland	1	LS	$2,500				$2,500
92	Site Restoration	1	LS	$100,000				$100,000
93							**Sub-total**	**$151,595**
94								
95	SA 10 Gillett Bridge East Staging Area	SA 10						
96	Project Signage	3	EA	$750				$2,250
97	Fueling Area	0	EA	$750				$0
98	Concrete Washout	0	EA	$1,250				$0
99	Wheel Wash Area	0	EA	$1,500				$0
100	Job Trailer	0	DAYS	$18				$0
101	Sanitation Facility	2	MONTHS	$225				$450
102	Water Truck for Dust Control	0	DAYS	$400				$0
103	Remove and Replace Tree	1	EA	$1,500				$1,500
104	Protect in Place Mature Trees	2	EA	$300				$600
105	Project in Place Utilities	1	EA	$500				$500
106	Remove, store and replace light pole	1	EA	$500				$500
107	Chain Link Construction Fence	132	LF	$5				$660
108	Security Gate	1	EA	$2,000				$2,000
109	Certified Weed Free Haybales	20	EA	$22				$440
110	Silt Fence	0	LF	$3				$0
111	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
112	Site Restoration	1	LS	$20,000				$20,000
113							**Sub-total**	**$30,400**
114								
115	SA 11 Blue Pedestrian Bridge	SA 11						
116	Project Signage	6	EA	$750				$4,500
117	Fueling Area	0	EA	$750				$0
118	Concrete Washout	0	EA	$1,250				$0
119	Wheel Wash Area	2	EA	$1,500				$3,000
120	Job Trailer	150	DAYS	$18				$2,700
121	Sanitation Facility	12	MONTHS	$225				$2,700
122	Water Truck for Dust Control	40	DAYS	$400				$16,000
123	Remove and Replace Tree	9	EA	$2,500				$22,500
124	Protect in Place Mature Trees	6	EA	$300				$1,800
125	Protect in Place Utilities	1	EA	$300				$300
126	Protect in Place Concrete stairs	1	ES	$300				$300
127	Temporary relocation and storage of Statue	1	EA	$3,000				$3,000
128	Temporary demo of wall and railing	1	LS	$3,000				$3,000
129	Remove, store and replace light pole	8	EA	$500				$4,000
130	Chain Link Construction Fence	534	LF	$5				$2,670
131	Security Gate	1	EA	$2,000				$2,000
132	Certified Weed Free Haybales	50	EA	$22				$1,100
133	Silt Fence	160	LF	$3				$480
134	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
135	Site Restoration	1	LS	$150,000				$150,000
136							**Sub-total**	**$221,550**
137								
138	SWPPP and Care of Water	CW06 CW07 CW11 CW12						
139	Traffic Control	1	LS	$120,000				$120,000
140	Care of Water Pumping	400	EA	$250				$100,000
141	Care of Water Filter	1	LS	$60,000				$60,000
142	Turbidity Curtain	1200	LF	$18				$21,600
143	Oil Boom	1200	LF	$10				$12,000
144	Silt Fence	995	LF	$3				$2,985
145	Barrier Fence	2414	LF	$2				$4,828
146	Furnish and Install Stage 3 (River Right) Alluvial Coffer Dam	13000	CY	$42				$546,000
147	Reconfigure Causeway Coffer System	13000	CY	$18				$234,000
148	Furnish and Install Stage 1 Sheetpile (20' lengths)	55000	SF	$20				$1,100,000
149	Demo and Dispose Sheetpile	55000	SF	$0				$0
150	Stage 1 Access Ramps	2	EA	$35,000				$70,000
151	Stage 2 Sheetpile re-configuration	1480	LF	$30				$44,400
152	Stage 2 Work Bridges	2	EA	$150,000				$300,000
153	Install Stage 3 (Pearl to Fulton) Sheetpile (re-use stage 1)	1408	LF	$30				$42,240
154	Stage 3 (Pearl to Fulton) Access Ramps	1	EA	$35,000				$35,000
155	Stage 4 (Pearl to Fulton) Sheetpile re-configuration	1480	LF	$30				$44,400
156	Stage 4 (Pearl to Fulton) Work Bridges	1	EA	$150,000				$150,000
157	Certified Weed Free Haybales	100	EA	$22				$2,200
158	Rip Rap Scour Protection	1973	TONS	$75				$147,941
159	Temporary Grade Control	785	TONS	$75				$58,874
160	Sediment Removal	5000	TONS	$10				$50,000
161	Filter Area	3	EA	$4,500				$13,500
162	PIP or Maintain Stormwater outfall	4	EA	$2,500				$10,000
163	PIP Existing Wetland	2	LS	$2,500				$5,000
164	PIP Existing USGS Stream Gage	1	EA	$3,000				$3,000
165	Care of water / ESC Program Management	1	LS	$40,000				$40,000
166	Plant Native E.C. Grass with mulch/tackifier	5	ACRES	$3,500				$17,500
167							**Sub-total**	**$3,235,468**
168								
169	Bank Improvements and Access	R300 R310 R320						
170	Excavation hauloff and dispose of grouted boulder	40	CY	$45				$1,800
171	Excavation of riprap	35	CY	$12				$420
172	Slab Rock, delivered & placed	200	TONS	$450				$90,000
173	Tie-in boulder (12"-24"), delivered & placed	150	TONS	$156				$23,400
174	Hauloff or stockpile excavated riprap	38	TONS	$20				$759
175	3" Minus Gravel Bedding, furnish and place	14	TONS	$35				$479
176	Excavation backfill with alluvium produced on site	29	CY	$12				$346
177	Filter Fabric	149	SY	$4				$598
178	Tie-in to exisitng path and finish	4	LS	$2,000				$8,000
179							**Sub-total**	**$125,803**
180								
181	In Channel Earthwork	R300 R310 R320						
182	Removal of low Head Existing Dam	2109	CY	65				$137,085
183	Unclassified Excavation	3610	CY	6				$21,658
184	Furnish and Deliver Boulder	11091	tons	75				$831,805
185	Placement Boulder	11091	tons	56				$621,081
186	Furnish and Deliver Riprap Substructure	3883	CY	65				$252,369

Line No.	60 Percent Design Cost Opinion August 2017	Quantity	Unit Issue	Unit Cost	□artner	A□□□cant	□e□□e□i	Total ($)
187	Placement Riprap Substructure	3883	CY	12				$46,591
188	Grading of Alluvium (Imported)	27583	CY	12				$330,996
189	Grading of Alluvium (Native)	3896	CY	12				$46,752
190	Furnish and Deliver Alluvium (assumes repurposed cut)	23117	CY	42				$970,925
191	Install Grout in Boulder Matrix	200	CY	200				$40,000
192	Precast Structures	17	CY	15000				$255,000
193	Excavate & Dispose Unsuitable non-HTRW	100	CY	45				$4,500
194	Bridge Riprap	6426	CY	65				$417,685
195							**Sub-total**	**$3,976,448**
196								
197								
198								
199								

Construction Soft Costs	**$1,279,892**
Total for Downstream of Bridge Street	**$8,265,946**
15% Contingency	**$1,431,876**
Total with Contingency	**$10,977,714**

9.0 Schedule for Plan – EA Completion

The EA is being conducted by ERM and is currently in progress. The anticipated schedule is as follows:



10.0 Additional Studies Needed

The following studies are being performed on behalf of this project:

- Biological assessment prepared by EcoAnalysts, Inc. (formerly Ecological Specialists, Inc.)
- Economic impact analyses being prepared by AEG
- Cost benefit analysis being prepared by AEG
- EA being prepared by ERM
- Sediment transport study prepared by River Restoration
- Flood modeling prepared by River Restoration

11.0 Interdisciplinary Technical Procedures

Generation of the necessary technical documents, as identified in Section 10.0, include interdisciplinary efforts performed by stakeholders. The technical procedures required for each of these documents is driven by regulatory agencies, including:

- NEPA.
- MDEQ.
- NRCS.
- USFWS.
- U.S. Department of Agriculture.
- Security and Exchange Commission.
- Bureau of Consumer Financial Protection.

12.0 Alternatives

12.1 Formulation Process

To determine the most viable alternatives to meet the project's purpose and need, the City of Grand Rapids, lead partner GVMC, and supporting partner GRWW considered the goals for conservation and restoration, needs of recreational users (anglers, boaters, general public), the current status of the existing infrastructure, and resources and funding available for project implementation. Alternatives considered during project development but proposed for elimination from detailed study due to lack of feasibility or lack of consistency with the project's purpose and need is discussed in Section 12.2. The preferred Proposed Action Alternative is described in Section 12.3.1 and the No-Action Alternative is described in Section 12.3.2.

12.2 Alternatives Proposed for Elimination from Detailed Study

Alternative 2, removal of four low-head beautification dams without substrate enhancements, will likely be eliminated from detailed study, because it fails to meet all the needs identified in the purpose and needs statement.

Alternative 2 involves removal of the four aged low-head beautification dams between the Interstate 196 Bridge and Fulton Street Bridge without subsequent substrate enhancement. Removal of the low-head dams would improve connectivity for fish migration up-stream and remove the dangerous hydraulic conditions that create a public safety hazard that has caused drownings and numerous rescues over the years. Without substrate enhancement, however, the quality of the habitat will not be improved, and expanded recreational opportunities will not be realized.

12.3 Description of Alternatives Considered

12.3.1 Preferred Proposed Action

Alternative 3 (preferred alternative) entails removal of the four aged low-head beautification dams and enhancement of substrate to improve habitat and expand recreational opportunities. These actions would fulfill the purpose and needs of the project. Removal of the low-head dams would improve connectivity for fish migration up-stream and remove the dangerous hydraulic

conditions that create a public safety hazard that has caused drownings and numerous rescues over the years. Substrate enhancement will improve the quality of habitat for threatened and endangered species, in addition to other local and regional aquatic species, and create river features that provide additional recreational opportunities that currently do not exist, such as whitewater boating and fly-fishing.

12.3.2 No-action Alternative

The no-action alternative (Alternative 1) would leave the current conditions as they are. The low-head beautification dams would be left in place, and the related public safety issues would continue to be present. There would be no substrate enhancement; therefore, habitat quality would not be improved. The existing limited recreational activities would not be affected.

12.4 Economics

In accordance with Title 390, NWPM, Part 501, Subpart B, Section 501.11B(1), a national economic development analysis is not required because this project is not a water resources project. However, an economic impact analysis for a larger area (of which this project is a portion) was conducted by AEG in 2014 and is now being updated (by AEG) to specifically assess the impacts of this specific project. AEG is also generating an economic impact cost-benefit analyses report for the project. The alternative that achieves the agreed-on level of resource protection while maximizing the net economic benefit will be the preferred alternative. All costs, including operation, maintenance, and replacement, expected to be incurred over the period of analysis will be included.

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Appendix A

Public Participation Plan

Appendix A
Public Participation Plan

The public participation plan (PPP) is an integral part of the project development process and is designed to encourage collaboration between stakeholders, including partners, agencies, tribes, and the public. This preliminary investigative report was prepared to provide information to assist in evaluation of further planning, objectives, and goals, and aid in the securing of funding for the Lower Grand River Watershed Habitat Restoration – Farmland Conservation Project. During development of this report, the project Sponsor, lead Partner, and supporting Partner conducted initial consultation with natural resource agencies and stakeholders. The project Sponsor and its Partners will conduct further comprehensive public scoping prior to preparation of the WPP as described in Section 6.0, Scope of the WPP.

The purpose of the PPP is to outline methods for encouraging involvement of citizens, organizations, and other interested parties in the development of the WPP. The objective of the PPP is to:

- Create awareness among the public regarding the Lower Grand River Habitat Restoration -Farmland Conservation Project and alternatives considered.
- Educate the public about the purpose and need for the draft Grand River WPP goals and objectives.
- Establish a process that encourages members of the public and other interested parties to participate in development of the WPP.
- Make sure interested stakeholders can review and comment on the draft WPP.

Public Participation Events

Public participation events will be hosted in three locations within the project area to provide opportunities for the public to obtain information, ask questions, and express concerns they may have regarding the proposed project. These events may include community/business forums, public meetings, or other scheduled community events such as farmer's markets. Concerns brought forth through this process will be noted in the WPP and addressed as necessary.

Advertisement of PPP Events

The public and other interested parties will be notified of the WPP and PPP events using one or more of the following tools:

- Printed Information—Printed flyers about the WPP and PPP event dates will be prepared and distributed.
- Web Sites—Information about the WPP and PPP event dates will be made available for existing websites and online calendars.
- Social Media—Information about the WPP and PPP event dates will be made available for use on Twitter, Facebook, Instagram, or other social media outlets.
- Press and Media—Information about the WPP and PPP event dates will be provided to local press and media for print, radio, or online dissemination.

These tools will be used for distribution of notices through Partner and stakeholder agencies and organizations including, but not limited to:

- Grand Valley Metro Council.
- City of Grand Rapids.
- West Michigan Environmental Action Council.
- West Michigan Sustainable Business Forum.
- Grand Rapids Public Library.
- West Grand Neighborhood Association.
- Lower Grand River Organization of Watersheds.
- Grand Rapids Press.
- The Grand Rapids Times.
- MLive.com.
- Radio (stations WBLU, WYCE, WGRD, WFGR).

PPP Event Engagement Tools

An open house format will be used to introduce the purpose and need for the WPP, introduce the Grand River Revitalization project, and offer opportunities to ask questions and express concerns. Content will be focused around the four aspects of the project: physical, biological, economical, and social. Additionally, outreach participants and the public will be invited to

provide input through a survey using Survey Monkey, an online survey development cloud-based software. This will allow the community to engage when time allows.

PPP Outcomes

Questions and concerns received through public participation events will be documented for WPP planning efforts. Additional information documented for each public participation event will include the date, type, and purpose of the activity, as well as the names of the participating organizations and the public. Questions and concerns received at the events will be used to focus the scope of the WPP, and specific concerns will be addressed in the WPP.

Appendix B

Environmental Evaluation Checklist (NRCS-CPA-52)

U.S. Department of Agriculture | NRCS-CPA-52
Natural Resources Conservation Service | 4/2013

ENVIRONMENTAL EVALUATION WORKSHEET

A. Client Name:

B. Conservation Plan ID # (as applicable)**:**
Program Authority (optional)**:**

C. Identification # (farm, tract, field #, etc. as required)**:**

D. Client's Objective(s) (purpose):

E. Need for Action:

H. Alternatives

No Action √ if RMS ☐	***Alternative 1*** √ if RMS ☐	***Alternative 2*** √ if RMS ☐

Resource Concerns

In Section "F" below, analyze, record, and address concerns identified through the Resources Inventory process. (See FOTG Section III - Resource Planning Criteria for guidance).

I. Effects of Alternatives

F. Resource Concerns and Existing/ Benchmark Conditions (Analyze and record the existing/benchmark conditions for each identified concern)	***No Action***		***Alternative 1***		***Alternative 2***	
	Amount, Status, Description *(Document both short and long term impacts)*	**√ if does NOT meet PC**	**Amount, Status, Description** *(Document both short and long term impacts)*	**√ if does NOT meet PC**	**Amount, Status, Description** *(Document both short and long term impacts)*	**√ if does NOT meet PC**
SOIL: *EROSION*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
SOIL: *SOIL QUALITY DEGRADATION*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
WATER: *EXCESS / INSUFFICIENT WATER*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
WATER: *WATER QUALITY DEGRADATION*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC

F. Resource Concerns and Existing/ Benchmark Conditions (Analyze and record the existing/benchmark conditions for each identified concern)	I. (continued)					
	No Action		*Alternative 1*		*Alternative 2*	
	Amount, Status, Description *(Document both short and long term impacts)*	**√ if does NOT meet PC**	**Amount, Status, Description** *(Document both short and long term impacts)*	**√ if does NOT meet PC**	**Amount, Status, Description** *(Document both short and long term impacts)*	**√ if does NOT meet PC**
AIR: *AIR QUALITY IMPACTS*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
PLANTS: *DEGRADED PLANT CONDITION*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
ANIMALS: *INADEQUATE HABITAT FOR FISH AND WILDLIFE*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
ANIMALS: *LIVESTOCK PRODUCTION LIMITATION*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
ENERGY: *INEFFICIENT ENERGY USE*						
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
		☐ NOT meet PC		☐ NOT meet PC		☐ NOT meet PC
HUMAN: *ECONOMIC AND SOCIAL CONSIDERATIONS*						

Special Environmental Concerns: Environmental Laws, Executive Orders, policies, etc.

In Section "G" complete and attach Environmental Procedures Guide Sheets for documentation as applicable. Items with a "•" may require a federal permit or consultation/coordination between the lead agency and another government agency. In these cases, effects may need to be determined in consultation with another agency. Planning and practice implementation may proceed for practices not involved in consultation.

G. Special Environmental Concerns (Document existing/ benchmark conditions)	**J. Impacts to Special Environmental Concerns**					
	No Action		***Alternative 1***		***Alternative 2***	
	Document all impacts (Attach Guide Sheets as applicable)	√ if needs further action	Document all impacts (Attach Guide Sheets as applicable)	√ if needs further action	Document all impacts (Attach Guide Sheets as applicable)	√ if needs further action
•Clean Air Act *Guide Sheet FS1 FS-2*		☐		☐		☐
•Clean Water Act / Waters of the U.S. *Guide Sheet Fact Sheet*		☐		☐		☐
•Coastal Zone Management *Guide Sheet Fact Sheet*		☐		☐		☐
Coral Reefs *Guide Sheet Fact Sheet*		☐		☐		☐
•Cultural Resources / Historic Properties *Guide Sheet Fact Sheet*		☐		☐		☐
•Endangered and Threatened Species *Guide Sheet Fact Sheet*		☐		☐		☐
~~Environmental Justice~~ *Guide Sheet Fact Sheet*		☐		☐		☐
•Essential Fish Habitat *Guide Sheet Fact Sheet*		☐		☐		☐
Floodplain Management *Guide Sheet Fact Sheet*		☐		☐		☐
Invasive Species *Guide Sheet Fact Sheet*		☐		☐		☐
•Migratory Birds/Bald and Golden Eagle Protection Act *Guide Sheet Fact Sheet*		☐		☐		☐
Natural Areas *Guide Sheet Fact Sheet*		☐		☐		☐
Prime and Unique Farmlands *Guide Sheet Fact Sheet*		☐		☐		☐
Riparian Area *Guide Sheet Fact Sheet*		☐		☐		☐
Scenic Beauty *Guide Sheet Fact Sheet*		☐		☐		☐

•Wetlands *Guide Sheet* *Fact Sheet*		☐		☐		☐
•Wild and Scenic Rivers *Guide Sheet* *Fact Sheet*		☐		☐		☐

K. Other Agencies and Broad Public Concerns	***No Action***	***Alternative 1***	***Alternative 2***
Easements, Permissions, Public Review, or Permits Required and Agencies Consulted.			
Cumulative Effects Narrative (Describe the cumulative impacts considered, including past, present and known future actions regardless of who performed the actions)			
L. Mitigation (Record actions to avoid, minimize, and compensate)			
M. Preferred Alternative √ preferred alternative	☐	☐	☐
Supporting reason			

N. Context (Record context of alternatives analysis)

The significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality.

O. Determination of Significance or Extraordinary Circumstances

Intensity: Refers to the severity of impact. Impacts may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

If you answer ANY of the below questions "yes" then contact the State Environmental Liaison as there may be extraordinary circumstances and significance issues to consider and a site specific NEPA analysis may be required.

Yes	No	
☐	☐	• Is the preferred alternative expected to cause significant effects on public health or safety?
☐	☐	• Is the preferred alternative expected to significantly affect unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas?
☐	☐	• Are the effects of the preferred alternative on the quality of the human environment likely to be highly controversial?
☐	☐	• Does the preferred alternative have highly uncertain effects or involve unique or unknown risks on the human environment?
☐	☐	• Does the preferred alternative establish a precedent for future actions with significant impacts or represent a decision in principle about a future consideration?
☐	☐	• Is the preferred alternative known or reasonably expected to have potentially significant environment impacts to the quality of the human environment either individually or cumulatively over time?
☐	☐	• Will the preferred alternative likely have a significant adverse effect on ANY of the special environmental concerns? Use the Evaluation Procedure Guide Sheets to assist in this determination. This includes, but is not limited to, concerns such as cultural or historical resources, endangered and threatened species, ~~environmental justice,~~ wetlands, floodplains, coastal zones, coral reefs, essential fish habitat, wild and scenic rivers, clean air, riparian areas, natural areas, and invasive species.
☐	☐	• Will the preferred alternative threaten a violation of Federal, State, or local law or requirements for the protection of the environment?

P. To the best of my knowledge, the data shown on this form is accurate and complete:

In the case where a non-NRCS person (e.g. a TSP) assists with planning they are to sign the first signature block and then NRCS is to sign the second block to verify the information's accuracy.

Signature (TSP if applicable)	**Title**	**Date**
Signature (NRCS)	**Title**	**Date**

If preferred alternative is not a federal action where NRCS has control or responsibility and this NRCS-CPA-52 is shared with someone other than the client then indicate to whom this is being provided.

The following sections are to be completed by the Responsible Federal Official (RFO)

NRCS is the RFO if the action is subject to NRCS control and responsibility (e.g., actions financed, funded, assisted, conducted, regulated, or approved by NRCS). These actions do not include situations in which NRCS is only providing technical assistance because NRCS cannot control what the client ultimately does with that assistance and situations where NRCS is making a technical determination (such as Farm Bill HEL or wetland determinations) not associated with the planning process.

Q. NEPA Compliance Finding (check one)

The preferred alternative:		**Action required**
☐	1) is **not a federal action** where the agency has control or responsibility.	Document in "R.1" below. No additional analysis is required
☐	2) is a federal action **ALL** of which is **categorically excluded** from further environmental analysis **AND** there are **no extraordinary circumstances as identified in Section "O".**	Document in "R.2" below. No additional analysis is required
☐	3) is a federal action that has been **sufficiently analyzed** in an existing Agency state, regional, or national NEPA document **and** there are no predicted significant adverse environmental effects or extraordinary circumstances.	Document in "R.1" below. No additional analysis is required.
☐	4) is a federal action that has been sufficiently analyzed in another Federal agency's NEPA document (EA or EIS) that addresses the proposed NRCS action and its' effects **and has been formally adopted by NRCS**. NRCS is required to prepare and publish its own Finding of No Significant Impact for an EA or Record of Decision for an EIS when adopting another agency's EA or EIS document. (**Note: This box is not applicable to FSA)**	Contact the State Environmental Liaison for list of NEPA documents formally adopted and available for tiering. Document in "R.1" below. No additional analysis is required
☐	5) is a federal action that has **NOT** been sufficiently analyzed or may involve predicted significant adverse environmental effects or extraordinary circumstances and may require an EA or EIS.	Contact the State Environmental Liaison. Further NEPA analysis required.

R. Rationale Supporting the Finding

R.1 Findings Documentation	
R.2 Applicable Categorical Exclusion(s) **(more than one may apply)**	
7 CFR Part 650 *Compliance With NEPA*, subpart 650.6 *Categorical Exclusions* states prior to determining that a proposed action is categorically excluded under paragraph (d) of this section, the proposed action must meet six sideboard criteria. See NECH 610.116.	

I have considered the effects of the alternatives on the Resource Concerns, Economic and Social Considerations, Special Environmental Concerns, and Extraordinary Circumstances as defined by Agency regulation and policy and based on that made the finding indicated above.

S. Signature of Responsible Federal Official:

Signature	**Title**	**Date**

Additional notes

APPENDIX D

Investigation and Analyses Report and Preliminary Investiga on

Investigation and Analyses Report

Investigation and Analysis Report for the Watershed Project Plan
Grand River Habitat Restoration and Farmland Conservation Project

Appendix D

Grand Valley Metro Council City of Grand Rapids, Michigan

The purpose of the Investigation and Analyses Report is to present information that supports the formulation, evaluation and conclusions of the Draft Watershed Project Plan and Environmental Assessment for Grand River Habitat Restoration and Farmland Conservation Project (Draft Plan-EA). The report is required and must be included as an appendix to the Final Plan-EA.

The procedures, techniques, assumptions, and the scope and intensity of the investigations for each subject is described in sufficient detail so that a reader not familiar with the watershed or its problems can form an opinion on the adequacy of the Draft Plan-EA. This report supplements information contained in the Draft Plan-EA and is not intended to replace or duplicate information contained therein.

July 2020

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ATTACHMENTS

Attachment 1 Concept Design Drawings
Attachment 2 Cost Estimates

INTRODUCTION

The planning studies presented in this Investigation and Analysis Report (I&A Report) are based on standard methods, procedures, and computer programs used and approved for use by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). The following information gives a summary of the investigation and analysis for the key planning studies in the preparation of the Watershed Project Plan (Plan) - Environmental Assessment (EA) for the Lower Grand River Habitat Restoration project (proposed Project). Additional information relevant to each of the sections provided in this report is available upon request as part of the administrative record for the project. Requests for additional information can be submitted to the following address:

USDA-NRCS
3001 Coolidge Road, Suite 250
East Lansing, Michigan 48823

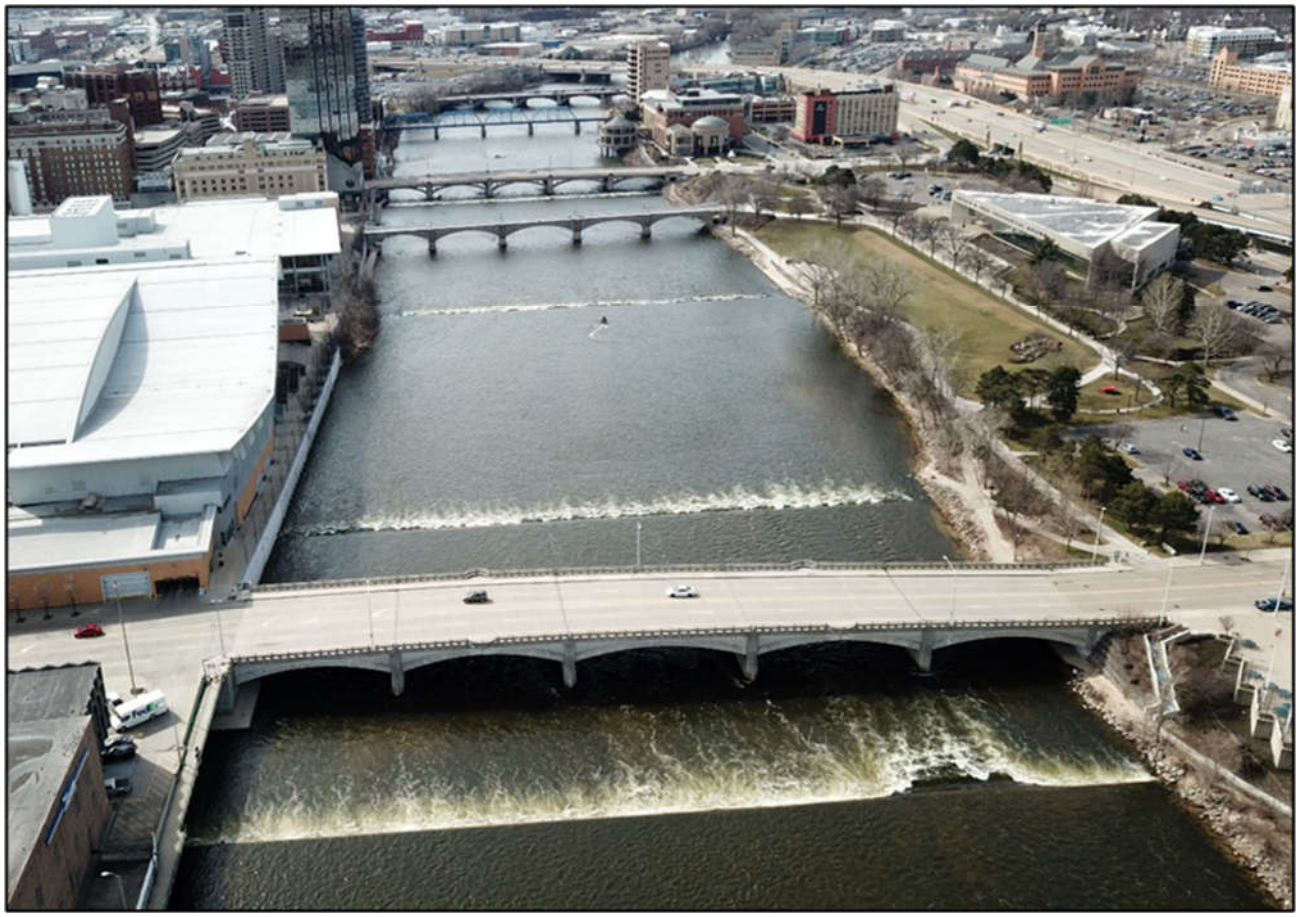

Figure 1. Image of the Grand River, City of Grand Rapids – Proposed Project Reach (looking downstream)

The proposed Project is located within the Lower Grand River, as it flows within the City of Grand Rapids. As the second-largest city in the state of Michigan, Grand Rapids is located in central-western Kent County on the Grand River, within the Lower Grand River Watershed (LGRW). Located on the west side of the state, Grand Rapids site approximately 30 miles east of Lake Michigan, 137 miles south of Traverse City and 60 miles northwest of the state capital Lansing. The Grand River Watershed is the second largest in the State of Michigan with an overall drainage area of 5,572 square miles. The grand River is the longest river in Michigan, about 252 miles, and has an elevation change of about 680 feet over its length. Figure 2 illustrates the four Hydrologic Unit Codes (HUC-14) within the larger Grand River Watershed that are the focus of the Watershed Project Plan-Environmental Assessment.

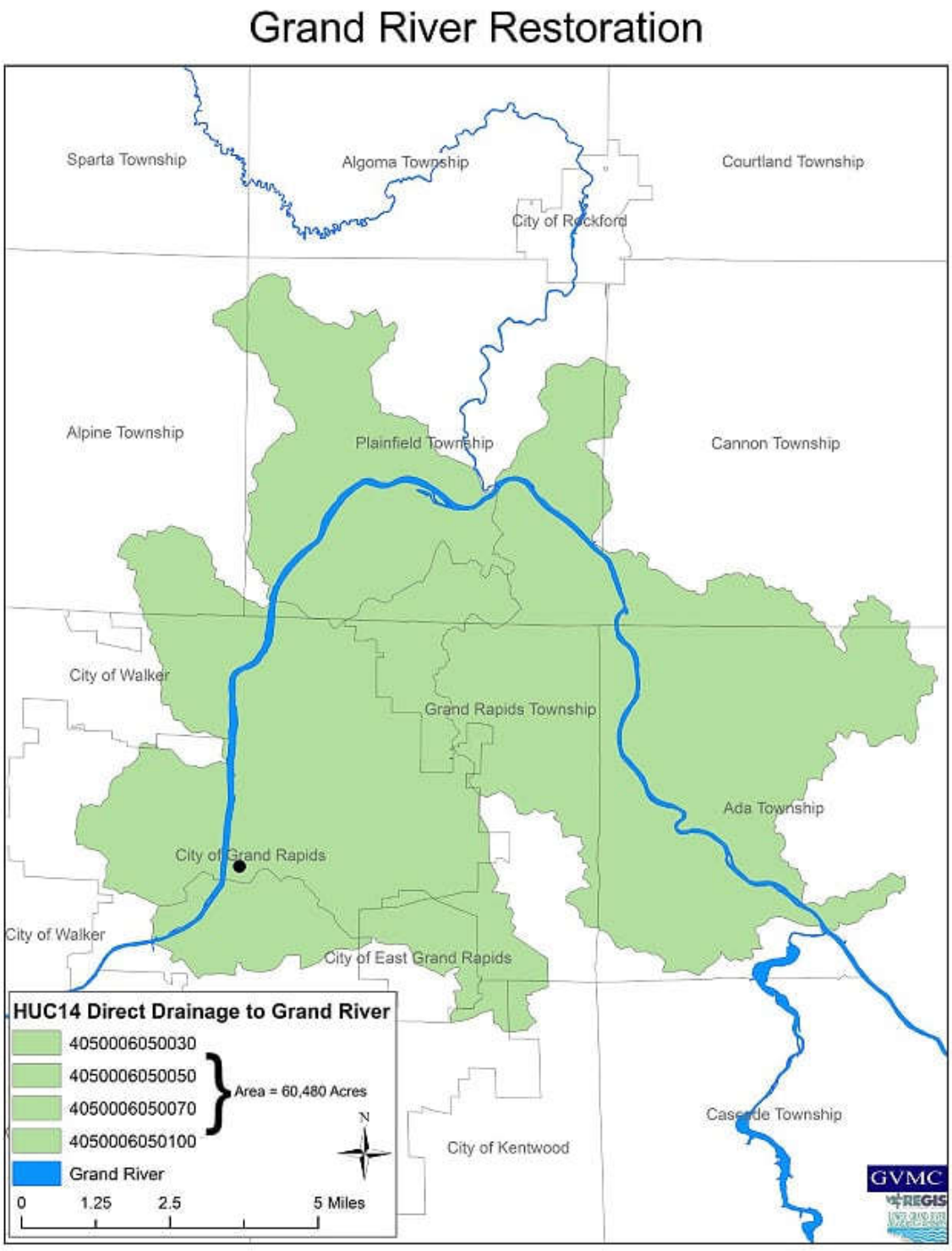

Figure 2. HUC14 Map - Direct Drainage to Grand River

The location of the proposed Project is the approximately two-mile reach through downtown Grand Rapids, approximately 40 river miles upstream of Lake Michigan. The 2.2 mile stretch of the Grand River running directly through the city once featured large boulders, rock islands, and natural reefs. Industrialization in the nineteenth century impacted the river greatly through the downtown stretch as it was greatly abused by water-powered, river-dependent industries; large increases in population; stripping of the forests; and discharges of chemical and sewage wastes. The Great Flood of 1904 inspired city leaders to invest in many improvements along the river, including flood walls and earthen embankments. The resulting floodwalls still dictate much of the Grand River's banks through downtown Grand Rapids. By the early 1900s, so much water had been diverted from the river to power downtown industries that the Grand River was dirty and nearly dry at times. Numerous rustic dams made of wood, stone and debris had been installed in the river by the mid-1800's for purposes of power. "Beautification" efforts in the 1920s added five low-head dams to the river in an attempt to keep the water levels higher in the summer, reducing unsightly odors and improving aesthetics. (see Figure 1 above)

The City of Grand Rapids proposes to make improvements in and along the Grand River within City boundaries to improve aquatic habitat/diversity and enhance access to the river and increase recreational opportunities. The Grand River through the proposed Project reach has been heavily modified, including dredging and channelization. The proposed Project action includes the demolition of the four low-head dams, excavation of areas of the existing channel, and placement of natural materials including boulders, cobble, and gravel to create riffles, pools, runs, glides, and wave features through a portion of the downtown reach. The need arises from the degraded condition of the river, which is an important natural resource for Grand Rapids and the State of Michigan, and several recognized safety problems associated with that degraded condition. The purpose of the proposed project is to reduce public safety hazards generated by low-head dams and create diverse riffle, run, wave, and pool features to restore aquatic riverine habitat and diversity and create/enhance recreational opportunities such as whitewater activities and angling in the Grand River in downtown Grand Rapids.

SEDIMENTATION AND GEOTECHNICAL ANALYSIS

The debris deposited by the glaciers forms the parent material for the soils throughout the LGRW. The almost infinite variety of combinations of mineral materials located in many conditions of topography and climate have resulted in a great number of soil types of varying fertility. Sandy and loamy soils are common throughout the basin.

It is suspected that much of the rapids within the Grand River was flowing upon or very near the top of bedrock surface of the Bayport Limestone Formation. Within these historic rapids, it is expected that numerous boulders and cobbles were present in the region of the rapids as glacial outwash flows would have deposited such erratics. Although several feet of variation is noted, the top of bedrock at Leonard Street is approximately elevation 600 ft, while it is approximately elevation 590 ft at Bridge Street. Floodwalls, bridges and the 6th Street Dam throughout this area are largely founded on bedrock.

The gravity sections of boulder floodwalls north and south of Pearl Street are believed to have been constructed with primarily granite boulders pulled from the river and are founded at the river bottom with very little embedment or scour protection.

Sediment sampling within the proposed Project reach was conducted by Material Testing Consultants. They completed sampling at 12 locations between 6th Street dam and Fulton Street bridge, see Figure 3 below. The samples were collected using a petite Ponar Grab sample. Supplementary probing was

performed along the sides the boat in a repeatable pattern to subjective evaluate the consistency of the river bottom based on the presence of cobble and boulder greater than or equal to 6-inches or the presence of sand, gravel, or cobble smaller than 6-inches. This information was used for the sediment transport analysis.

The sediment transport analysis was performed by the engineers at River Restoration. The analysis found that long-term aggradation or degradation through the project reach is not anticipated to occur due to the transport limited supply reach, the relative increased energy throughout the project, and proposed stable gradation of imported/placed substrate. The project would function as a threshold reach, conveying the inflowing sand sediment loads to the downstream reach over a typical annual hydrograph. No long-term changes to inflowing or outflowing sediment are proposed.

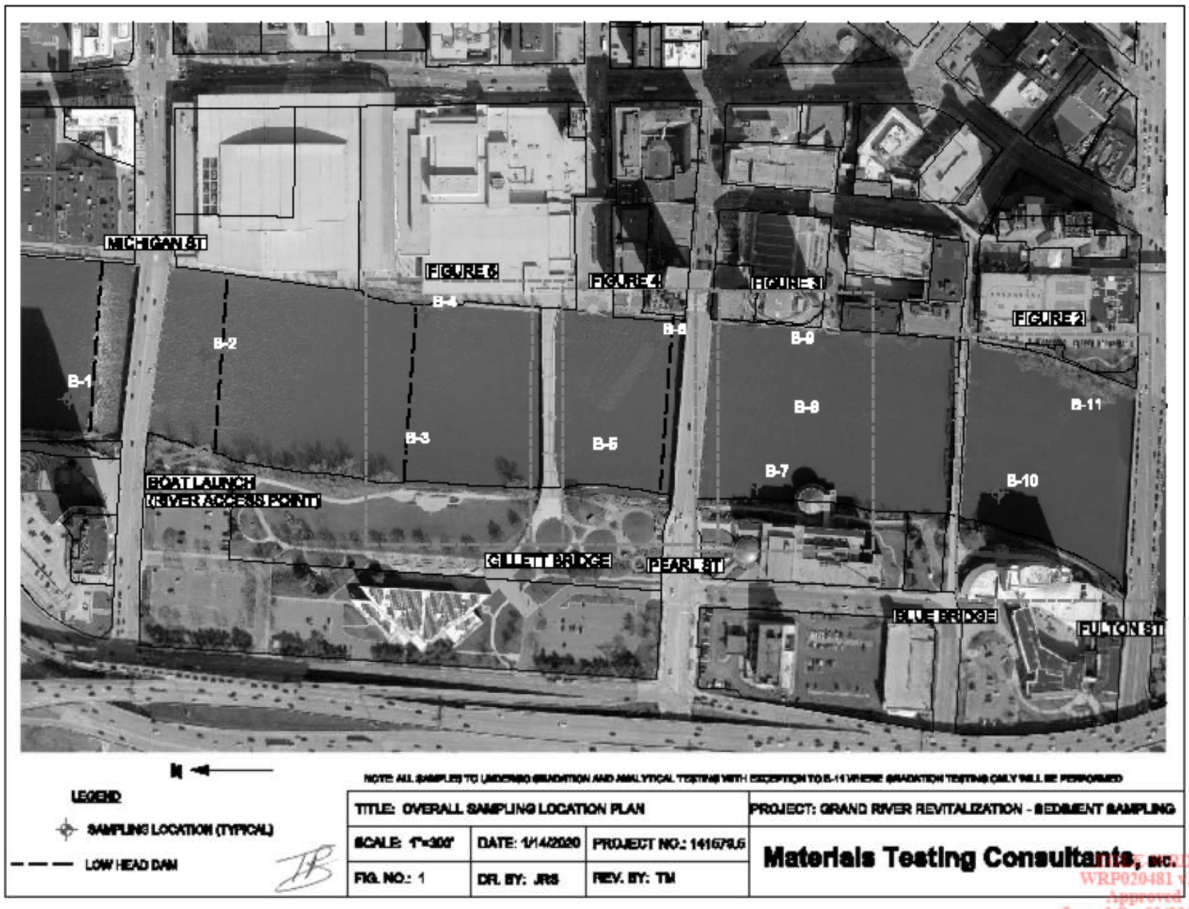

Figure 3. Sediment Sampling Location Map

FLOODING AND RISK ANALYSIS

The City of Grand Rapids built major floodwalls before World War I and obtained Works Progress Administration (WPA) funds to work on flood protection and river beautification during the 1930s. In addition, significant sections of the Grand River bed and adjacent floodplain have been filled within the City of Grand Rapids. Based on the study completed by the MDNRE (Fongers, 2008) on the flashiness

index of the LGR and its tributaries, it appears that the flashiness index for the LGR is increasing over time due to development and climate change indicators.

Understanding the above existing condition challenges, the proposed project goals, and subsequent constraints, were identified through continued agency coordination. Constraints due to flood conveyance, scour potential and integrity of existing infrastructure was further evaluated by the design team, including the means by which each would be evaluated were determined and several project design approaches, concepts, and possible iterations were presented, considered, and reviewed by the project partners. The design process and evaluation of goals and constraints for the project has benefited from ongoing coordination with the regulatory agencies, including MDNR, EGLE, USFWS, and GLFC. Consultation with these agencies was initiated in early 2015 and has continued through the completion of the Basis of Design report.

The project designs evaluated in this section represent different channel configurations that result in varying degrees of restoration potential of the historic rapids and aquatic habitat. The project location places constraints on the complete restoration of the rapids to pre-development conditions due to existing infrastructure (e.g., bridges and flood walls) and public uses. The pre-developed channel was significantly wider with multiple side channels and islands and likely covered a much broader area during periods of flooding. The existing encroachments of infrastructure on the river include floodwalls, bridges, properties, and other facilities, which make restoration to pre-development conditions infeasible. Therefore, all design alternatives were evaluated to determine the relative benefits and detriments of enhancing the rapid habitat and function within the existing planform.

The design alternatives have all been evaluated against the project goals and constraints that were identified by stakeholder. The designs are also compared in regard to activities below the ordinary high-water mark, impacts to wetlands, and activities in the floodplain as is shown in the comparison of design alternatives. Modeling results have verified that hydraulic conditions; including velocity, depth, and shear stress, would allow for feasible construction work windows. The site will be stabilized and inundated at the end of each construction season. The isolated construction area has been modeled to be inundated during flow rates greater than 10,000 cfs. This flowrate was a good compromise between available work window and flood conveyance. If a large flood event is forecasted, the contractor will coordinate with the City and take necessary action to ensure that harmful interference from flooding is avoided and the integrity of existing and temporary structures is maintained. The proposed project preferred alternative is the result of this thoughtful modeling effort and thorough technical review process.

The City of Grand Rapids prepared a final revised levee certification for the Grand River Flood Protection System in response to the *FEMA Completeness Check and Comments for 44 CFR 65.10 Submission* dated February 12, 2018. The City of Grand Rapids, in partnership with neighbor City of Walker, prepared a Freeboard Analysis Report, Closure Evaluation Report, Embankment Protection Analysis Report, Levee/Floodwall Stability and Settlement Report, Interior Drainage Analysis, Operation, Maintenance, and Inspection Manual, and As-Built Drawings to FEMA for their review. The City of Grand Rapids asked for FEMA to designate the Reach E-5 at the Water Resource Recovery Facility of the levee system as an accredited Sound Reach and FEMA designation of the remainder of the Grand River Flood Protection System, including the portion that extends into the City of Walker as Freeboard Deficient. The certification request and its associated documents are currently under review by FEMA.

GEOLOGY AND TOPOGRAPHY

The LGRW encompasses 2,909 square miles, with the Lower Grand River originating below the Looking

Glass River confluence, near the City of Portland, flowing northwest to its convergence with Lake Michigan. The main branch of the Lower Grand River is 51 miles long, and the major tributaries flow for a total of 209 miles (see Figure 4 below). The bedrock formations of the Watershed consist primarily of shale, sandstone, limestone, and gypsum. These formations formed from sediments that were deposited from 345 to 370 million years ago, in seas which occupied a depression known as the Michigan basin. The Pleistocene epoch began about 1 million years ago. At least four major glaciers advanced and retreated over Michigan during the Pleistocene epoch. As the last glacier retreated, the load of earthen materials incorporated in the ice was deposited, forming several types of glacial features (till plains, moraines, outwash, lake plains, and spillways). The thickness of the glacial drift overlying bedrock varies from 0 to 500 feet within the river basin.

The topography within the LGRW is influenced by glacial deposition of sediment and the effect of water deposition and drainage over time. The elevations in the Watershed range from 780 feet, at the most eastern edge of the Watershed, to 571 feet at its confluence with Lake Michigan at the City of Grand Haven. Within the 2.2 mile stretch of river in downtown, there exists over 18 vertical feet of drop in the riverbed, making the proposed Project area within this reach a rare and unique restoration opportunity. The LGRW ranges from fairly rugged topography in the entrenched mainstream of the Grand River (in the Grand Rapids area) to a low, flat plains area along the lower reaches of the river toward Grand Haven. Many of the tributary streams in this area flow through steep, walled valleys where they join the entrenched valley of the Grand River.

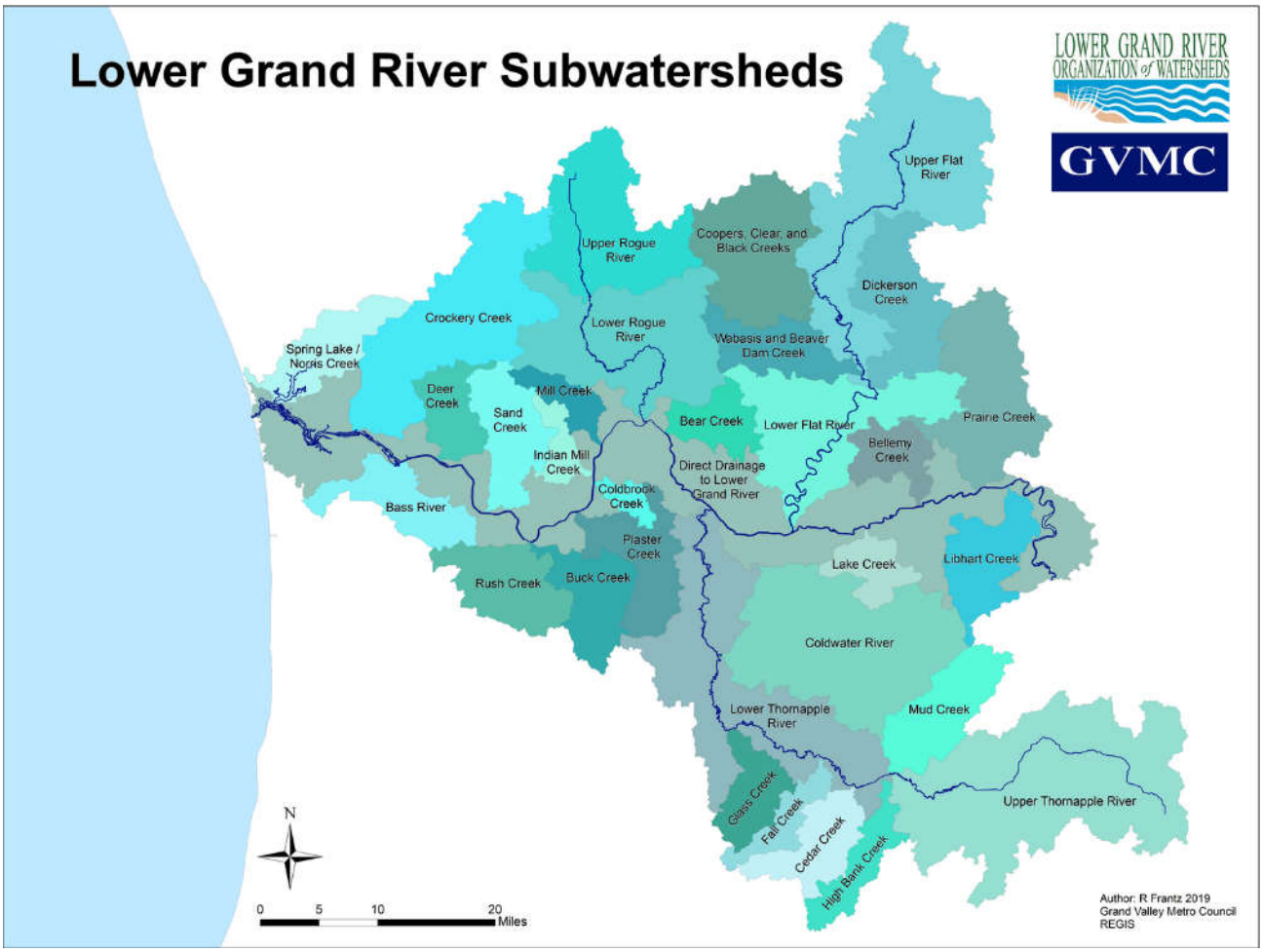

Figure 4. Lower Grand River Watershed and Subwatershed Map

WATER QUALITY

Industrialization in the nineteenth century impacted water quality the Grand River greatly by water-powered, river-dependent industries; large increases in population; stripping of the forests; and discharges of chemical and sewage wastes. In the mid-1960's, the Clean Water Act provided funding for efforts to improve wastewater technologies and sparked environmental efforts to restore aquatic resources within the river. By the end of the 1960s, water quality had improved to the point that recreationists were once again looking to the Grand River for waterskiing, boating, fishing, and swimming opportunities.

The lingering effects of human use within the LGR can be seen to this day. In 2010, the Journal of Great Lakes Research classified 38.6 percent of river miles in the Grand watershed as "impaired" based on fish and invertebrate communities. The City of Grand Rapids has monitored water quality since 1985 using a Modified Water Quality Index. This index does not provide for direct comparison to other rivers, but measurements taken upstream and downstream of the city show a trend of improving water quality over time. The index also shows only a slight decrease in water quality downstream of Grand Rapids, with all values in recent years indicating "Good" water quality and very few limits to recreational use.
As such, seven impairments have been identified as having an impact on designated uses of the Watershed including the following:

Impacts of Sediment on Designated Uses
Impacts of Nutrients on Designated Uses
Impacts of Unstable Hydrology on Designated Uses
Impacts of Thermal Pollution on Designated Uses
Impacts of Chemicals on Designated Uses
Impacts of Habitat Fragmentation on Designated Uses
Impacts of Pathogens/Bacteria on Designated Uses

Within the Project reach, e. Coli has been identified as an impairment, however projects are being implemented throughout the watershed to address these impairments.

NATURAL RESOURCES

Wetlands
Wetland Delineation Reports were performed by Golder Associates in 2015 and Fishbeck (FTCH) in 2019. The 2019 delineation was performed to add to the Golder report because the wetland delineations are only considered valid to the State of Michigan for 3 years after they are performed. FTCH identified 5 delineated wetlands within the RCPP project reach totaling 0.276 acres.

Fish and Wildlife
A diversity of aquatic and terrestrial habitat types is found throughout the LGRW that harbors various amphibian, reptile, avian, mammal, and fish species. Many of these species are important from a recreational and economical perspective. Well-organized conservation and outdoor sporting groups exist throughout the Watershed, such as Ducks Unlimited, Pheasants Forever, Trout Unlimited, and Michigan United Conservation Clubs, to protect and enhance habitat for animals such as whitetail deer, wild turkeys, pheasants, grouse and many species of fish. Many nontarget species are also likely to benefit from these efforts.

Protected, Endangered and Invasive Species

The proposed Project Area includes numerous considerations for protected, endangered and invasive species. Most notably the federally-endangered snuffbox mussel and invasive Sea Lamprey. As such, the preferred alternative provides a specific balance of channel alteration and associated impacts. Through ongoing correspondence with MDNR fisheries division, Michigan Department of Environment, Great Lakes and Energy (EGLE), United States Fish and Wildlife Service (USFWS), and other stakeholders, the preferred configuration was developed that met the project goals of restoring aquatic habitat and enhancing recreational opportunities, and also minimized impacts to endangered snuffbox mussels and existing wetlands. The preferred alternative demonstrates fish passage that considers the range of fish species and life stages in the Grand River as well as preventing the spread of invasive species.

HYDROLOGY

The LGR flows for 51 miles and drains 2,909 square miles. The Watershed is characterized by poor natural drainage, resulting in numerous lakes, swamps, and artificial drains. The LGRW includes three major tributaries that flow into the Grand River: the Thornapple River, the Flat River, and the Rogue River (see Figure 3). Significant alterations have been made to the Grand River and its tributaries since the mid-1800s including a series of low-head dams within the downtown area, see Figure 5 below.

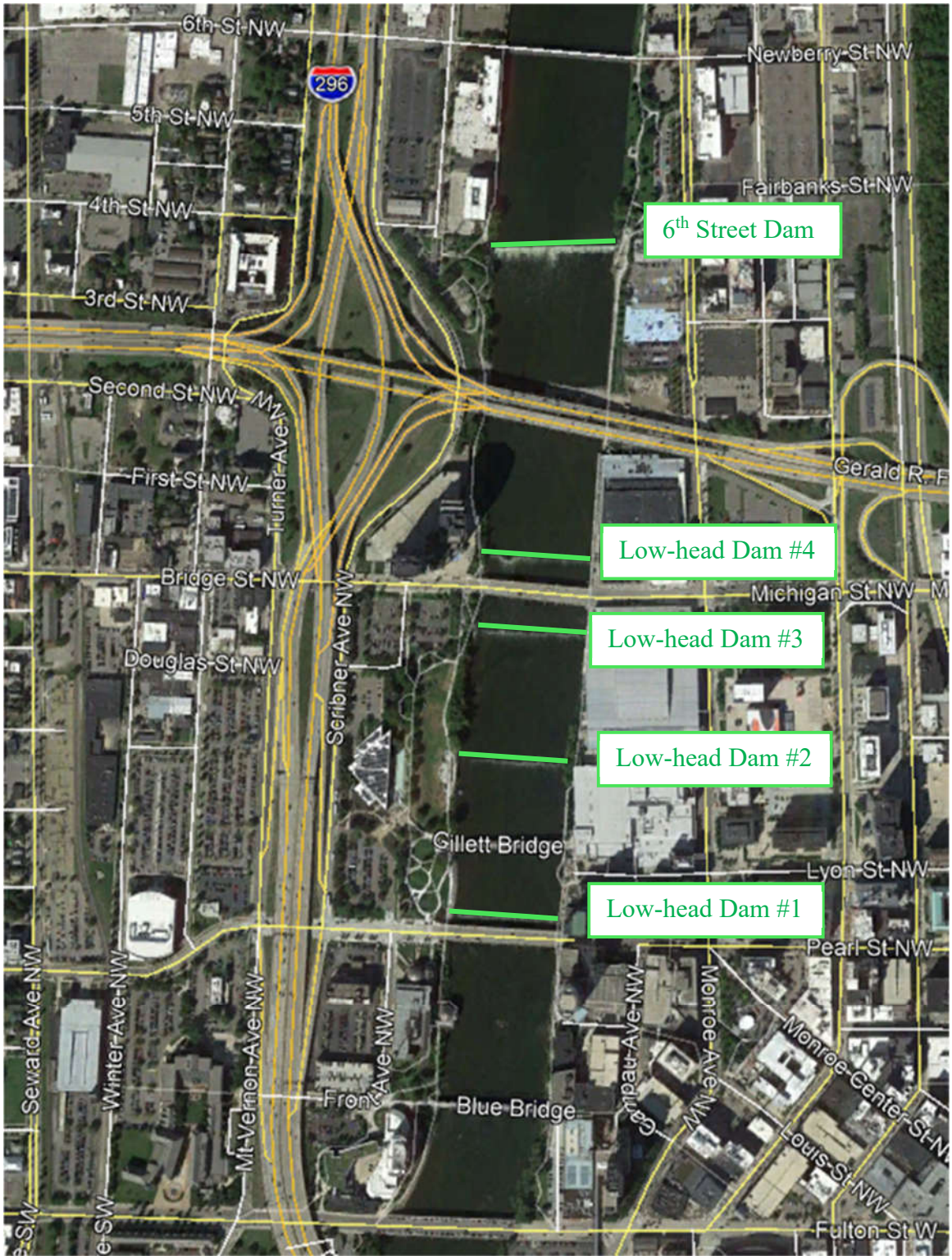

Figure 5. Low-Head Dam Location Map

These low-head dams have drastically affected the ecological and physical conditions of riverine system. Normal high and low water conditions within the riverine system are altered by the low-head dams, resulting in changes in stream channel, fisheries, and other aquatic habitats. In addition, the dams limit the normal movement of fish and other aquatic organisms along the river's length. As such, the proposed Project will demolish the 4 low-head dams and restore the substrate within the proposed Project reach.

Per EGLE guidance, harmful interference and flood risk were evaluated based on the flowrates shown in Table 1 (below). These flow rates were determined through correspondence with EGLE through use of the online 'Request a Flood or Low Flow Discharge Form' as authorized by PA 451 of 1994. This information was used in all model runs. The proposed Project does not change the hydrology of the Grand River through the reach.

Table 1. Lower Grand River Flood Flow Rates

Recurrence Interval	Flow (cfs)
100-yr	55,000
50-yr	48,000
25-yr	42,000
10-yr	33,000
5-yr	27,000
2-yr	18,000

More regular flows which occur throughout a typical summer and fall were used to for evaluating suitable aquatic habitat, fish passage, substrate stability, and recreational hydraulics.

HYDRAULIC ANALYSIS

The most prominent and widespread anthropomorphic hydraulic controls acting on the Grand River systems are constructed dams, such as the four low-head dams within the proposed Project reach. These dams dramatically alter the rivers response to baselevel change. The baselevel lowering occurring within this dam-controlled river system only affects the downstream portion of the river. The upstream portion experiences a "slack-water" effect, causing sediment infilling upstream as the channel adjusts to the decrease in slope. The opposite effect occurs downstream of dams. The downstream reaches have generally become incised due to a sediment deficit below the dam. These low-head dams are the only major anthropomorphic hydraulic controls active in the Lower Grand River. The proposed Project aims to restore the natural rapids (for which the city is named) that once occupied the channel downstream of these controls.

The hydraulic influence of the proposed Project terminates upstream at the 6th Street Dam hydraulic control and downstream immediately above Fulton Street. The four-concrete low-head dams cross the river through the project reach, varying in height from 1.5 feet to 4 feet. A Hydraulics Report (Appendix E) was prepared by the engineers at River Restoration. The hydraulic report analyzes the modeling results for the proposed Project. The hydraulic design of the project targets more regular flows which occur throughout a typical summer and fall. Flowrates used to evaluate these design elements ranged from the 7Q10 low flow (the lowest 7-day average flow that occurs every 10 years) of 890 cfs up to the bankfull flowrate of 13,000 cfs. The HEC-RAS model demonstrates there are no increases to the 100-year water surface elevations, within the project reach or downstream or upstream, as compared to existing conditions. Increases in water surface elevations are present for the 2- through 50-year flood events, but the increases are contained within the City of Grand Rapids' flood projection system and do not result in

Harmful Interference as defined by EGLE.

DESIGN CRITERIA

The design criteria have been established as the preferred alternative for the proposed Project utilizing national, state and local regulatory guidance documents and industry standards. This alternative has been designed and evaluated to a higher level of detail through ongoing coordination with EGLE and MDNR.

The alternatives evaluated represent different channel configurations that result in varying degrees of restoration potential enhancement of the historic rapids and aquatic habitat while minimizing potential environmental impacts. The Project location places constraints on the complete restoration of the rapids to pre-development conditions due to existing infrastructure (e.g., bridges and flood walls) and public uses. The pre-developed channel was significantly wider with multiple side channels and islands and likely covered a much broader area during periods of flooding. The existing encroachments of infrastructure on the river include floodwalls, bridges, properties, and other facilities, which make restoration to pre-development conditions infeasible. Therefore, all alternatives were evaluated to determine the relative benefits and detriments of enhancing the rapid habitat and function within the existing planform

The distribution of water surface gradient and stable grade control provided by the low-head dams will be replaced with four in-channel features. The proposed grading of each of the four in-channel features is unique to the site constraints and existing grade at each location; however, each feature generally follows a typical design. The wave features would be installed on the west side of the channel, constructed from boulder with a gradually sloping boulder wing structure tying into the existing bank.

The dimensions and location of the proposed design has been determined through iterative coordination between the design team and EGLE, MDNR, and other stakeholders to find an optimal balance of achieving project goals and satisfying constraints. The way in which each constraint has generally influenced the locations, elevations, dimensions, and slopes of the grading is described below.

Table 2. Design Criteria

Design Constraint	Design Influence
Flood conveyance	Limited volume and elevations of proposed in-river fill
Public Safety	Location of grading and proximity to existing infrastructure, more gentling sloping areas of proposed grading
Integrity of Existing Infrastructure	Location of grading and proximity to existing infrastructure, avoidance of directing flow into existing piers or floodwalls
Fish Passage	gentling sloped grading of riffles and near-shore grading
Sea Lamprey escapement at the 6th Street Dam	Elevations of features set to avoid decreasing the effectiveness of the 6th Street Dam as a barrier to Sea Lamprey

AGENCY COORDINATION

The Project is being funded by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) under the watershed Protection and Flood Prevention Act (PL-566) and Regional Conservation Partnership Program (RCPP) in combination with private and public funding obtained through project fundraising efforts. The Grand Valley Metropolitan Council (GVMC), in partnership with the City of Grand Rapids (the Sponsoring Local Organization (SLO)), has prepared a Plan-EA pursuant to NRCS PL-566 requirements. In addition, a Biological Assessment was prepared in consultation with the USFWS and Michigan Department of Natural Resources (MDNR); the USFWS subsequently issued a Biological Opinion (BO) (issued October 22, 2020) covering multiple state and federal threatened and endangered species, including freshwater mussels. The BO is included in Appendix E.

During the preliminary scoping period for the project, scoping questions, comments, and concerns were requested from government agencies, both orally at public meetings and via written submittal of comments. A scoping notice was prepared and mailed to interested parties. The scoping comment period was open for 30 days and several comments were received.

A public notice of availability of the Draft Plan-EA will be mailed to interested parties, published in the local newspaper or included in a utility mailer and posted to the NRCS project website. The Draft Plan-EA will be released for public review and comment and a public meeting will be held

Agency coordination and consultation is summarized and documented in the Plan-EA.

ALTERNATIVES EVALUATION

The alternatives evaluated represent different channel configurations that result in varying degrees of restoration potential enhancement of the historic rapids and aquatic habitat while minimizing potential environmental impacts. The proposed Project location places constraints on the complete restoration of the rapids to pre-development conditions due to existing infrastructure (e.g., bridges and flood walls) and public uses. The pre-developed channel was significantly wider with multiple side channels and islands and likely covered a much broader area during periods of flooding. The existing encroachments of infrastructure on the river include floodwalls, bridges, properties, and other facilities, which make restoration to pre-development conditions infeasible. Therefore, all alternatives were evaluated to determine the relative benefits and detriments of enhancing the rapid habitat and function within the existing planform.

Alternatives were considered for the design of dam removals, substrate enhancements, and wave features. The design was generated to avoid and minimize environmental impacts associated with initial construction and long-term repair and rehabilitation to the extent possible while still achieving the project purpose. The Plan-EA evaluates environmental impacts associated with five alternatives. However, three explicit alternatives were considered for this feasible and prudent alternatives analysis. In addition to the no action alternative, two action alternatives have been developed and evaluated against project goals and constraints. The action alternatives range from relatively high degree of alterations and substrate enhancement, with a relatively large area of impact to the riverbed, to removing the low-head dams without substrate enhancement, with relatively less direct impact to the riverbed.

Each action alternative provides a specific balance of channel alteration and associated impacts.

Through ongoing correspondence with MDNR fisheries division, EGLE, USFWS, and other stakeholders, a preferred configuration was developed that met the project goals of restoring aquatic habitat and enhancing recreational opportunities, and also minimized impacts to endangered snuffbox mussels and existing wetlands, demonstrated fish passage that considered the range of fish species and life stages in the Grand River, avoided increased flood risk with conservative modeling parameters, prevented tailwater increases that could allow invasive Sea Lamprey escapement, and minimized public safety concerns. The project purpose is to revitalize a river with a relatively steep gradient where dams and impairments exist in the Grand River in downtown Grand Rapids. Restoring a different river or somewhere else in the Grand River would not address those targeted impairments and would not have sufficient gradient provide functional in-channel hydraulic features. There are no feasible and prudent alternatives based on locations at another location in another river or the Grand River.

The preferred configuration includes the demolition the four low-head dams downstream of 6th Street Dam and construction of a series of proposed in-channel hydraulic features to replace grade control. Three configurations of the preferred alternative were explored, including design, modeling, and agency correspondence, to determine a preferred configuration between Bridge Street and Fulton Street and contains four wave features and four riffle features.

ECONOMICS

The NRCS National Watershed Manual was used as a reference for the economic analysis of the proposed Project. To inform portions of the Plan-EA for the proposed Project, Anderson Economic Group (AEG) was retained to perform a cost-benefit and economic impact analysis of the alternatives proposed RCPP reach. The purpose of the AEG economics reporting was to:

Document the proposed alternatives in terms of their impact on the environment, ecosystem, and recreation;
Catalogue, measure, and categorize costs and benefits for each alternative from the national perspective;
Monetize the estimated costs and benefits, where possible; and
Calculate the net effect of each of the alternatives as compared to the No Action alternative.

The proposed Project is a non-water resource project, meaning that the project is not primarily for flood damage reduction, water supply, water-based recreation, water quality management, nor large scale irrigation or drainage. As such, in comparing alternatives, the Plan-EA is required to identify the “least costly socially and environmentally acceptable method of achieving the agreed-upon level of resource protection.”

AEG followed Principles and Guidelines procedures to identify and quantify the costs and benefits of the project: all costs, including operation, maintenance, and replacement, expected to be incurred over the period of analysis are included in the economic reports. We met and exceeded the expectations outlined by the National Watershed Program Manual by quantifying not only the costs for each alternative, but also added benefits not required for non-water resource plans.

The estimated project costs, totaling $14,485,608 over three years, include a 15% contingency and cover the demolition of the four low-dams and enhancement of the substrate in the Project Area. The costs of future OMRRR maintenance are likely to be negligible.

Overall, AEG findings indicate the net benefit of removing the low-head dams and enhancing the underlying substrate is significant; demolition of the low-head dams with substrate enhancement, yields a

net present value of $17.6 to $22.4 million in net benefits over 25 years on dimensions that we are able to monetize, see Table 3 below. This includes a significant value to the city and surrounding community over the no-action alternative.

Table 3. Net Economic Impact of Construction for the Grand River Restoration and Net Annual Economic Impact of Increased Recreational Activity in Grand Rapids, Earnings and Employment

	Earnings (millions)	Average Annual Employment
Construction Spending	$1.1 to $1.2	5 to 6
Increased Recreational Activity	$6.2 to $8.3	273 to 367

REFERENCES

Anderson Economic Group (AEG) 2019. Cost Benefit Analysis, Economic Impact Analysis, January 8, 2019.

City of Grand Rapids, in partnership with neighbor City of Walker - Freeboard Analysis Report, Closure Evaluation Report, Embankment Protection Analysis Report, Levee/Floodwall Stability and Settlement Report, Interior Drainage Analysis, Operation, Maintenance, and Inspection Manual, and As-Built Drawings to FEMA

EcoAnalysts 2018. Final Biological Assessment: Impact to federal and state threatened and endangered species from rehabilitation of the Grand River between I-196 and Fulton Street in Grand Rapids, Kent County, Michigan

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FTCH 2019. Fishbeck, Thompson, Carr & Huber, Inc. 2019. Updated Wetland Delineation. Grand River Whitewater Restoration Project, City of Grand Rapids, Kent County, Michigan. February 26, 2019.

Golder Associates, Inc. October 14, 2014. Wetland Delineation, Grand River Whitewater Restoration Project, City of Grand Rapids, Kent County, Michigan, Draft Report.

Journal of Great Lakes Research, An ecological assessment of Great Lakes tributaries in the Michigan Peninsulas, Volume 36, Issue 3, September 2010, Pages 505-519 - Authors: Catherine M.Risenga, Michael J.Wileya, Paul W.Seelbachb, R. Jan Stevensonc

Lower Grand River Organization of Watersheds. 2011. Lower Grand River Watershed Management Plan Chapter 3. Available online at https://www.lgrow.org/lgrwmp/. Accessed December 2018.

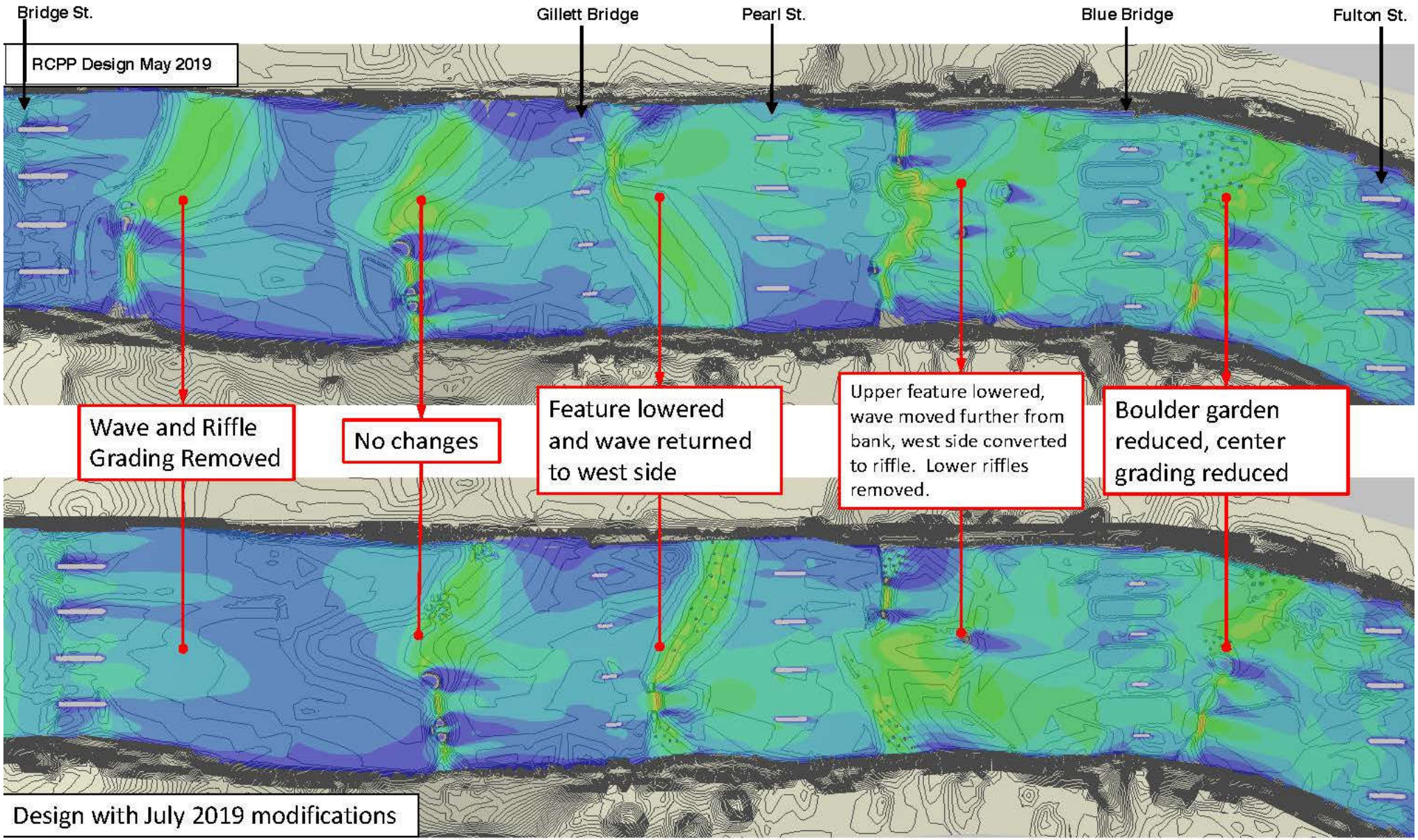
Materials Testing Consultants, Inc. 2017. Summary of Grand River Sediment Sampling Grand River Rapids Restoration.

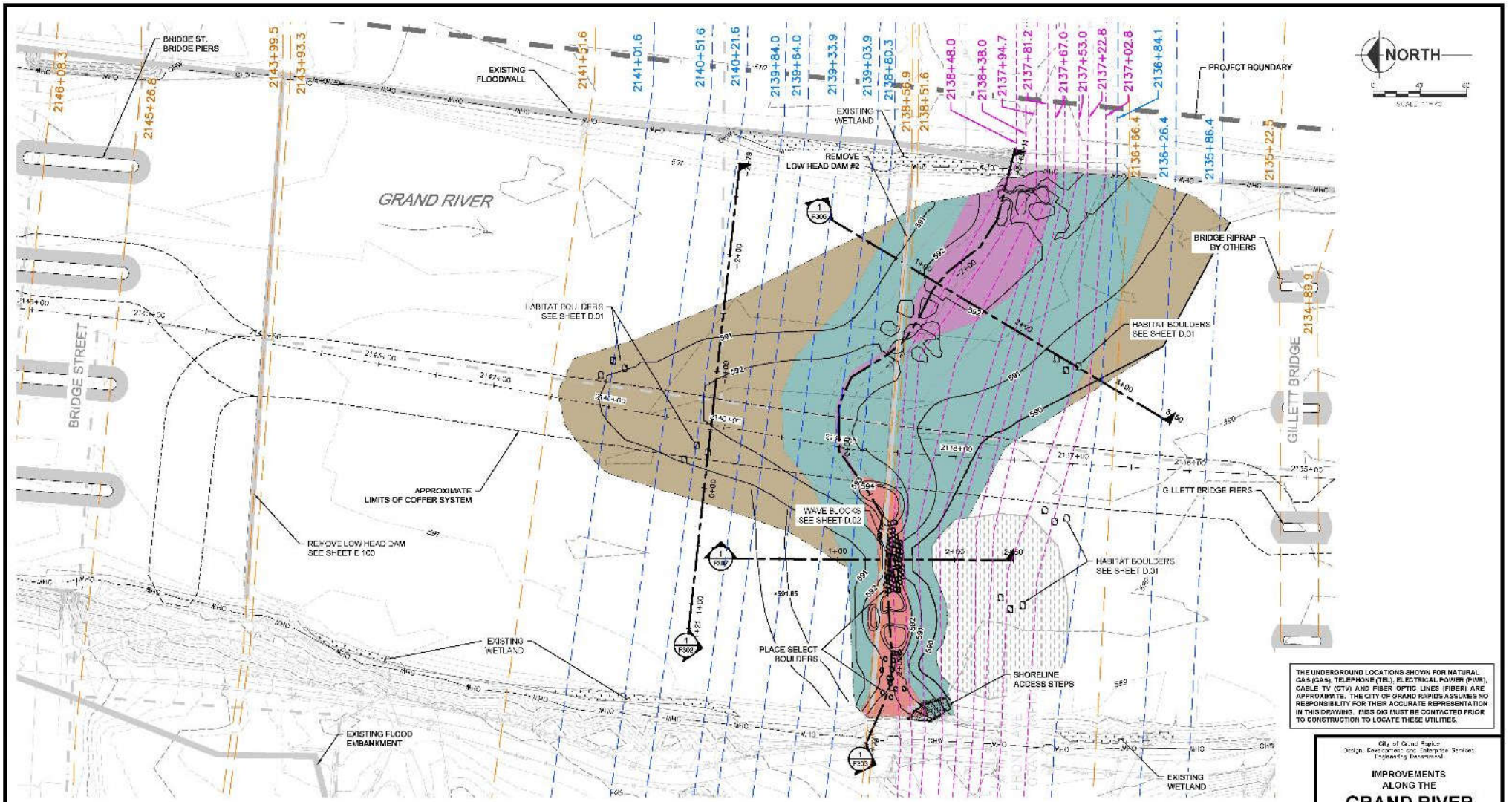
RiverRestoration.org. 2017. Appendix I-3-A - Sediment Transport Analysis – Supplemental Analysis A.

APPENDIX D

Investigation and Analyses Report and Preliminary Investiga on

Basis of Design Attachment 1; Concept Design Drawings


Bridge St.
Gillett Bridge
Pearl St.
Blue Bridge
Fulton St.
RCPP Design May 2019
Wave and Riffle Grading Removed
No changes
Feature lowered and wave returned to west side
Upper feature lowered, wave moved further from bank, west side converted to riffle. Lower riffles removed.
Boulder garden reduced, center grading reduced
Design with July 2019 modifications
N



THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

LEGEND

- FINISHED GRADE BOULDER (SEE SPECIFICATIONS FOR SIZING)
- FINISHED GRADE RIPRAP (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE IMPORTED COARSE ALLUVIUM (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE IMPORTED FINE ALLUVIUM (SEE SPECIFICATIONS FOR GRADATION)
- PLACE OF NATIVE ALLUVIUM
- POOL EXCAVATION
- PROPERTY BOUNDARIES
- EXISTING ORDINARY HIGH WATER LINE
- 596 AVERAGE PROPOSED GRADING - 1' CONTOURS
- LIMITS OF SUB-GRADE BOULDER OR RIPRAP FILL
- CONCRETE BOULDER (SEE DETAIL SHEET D.03)
- HABITAT BOULDERS (SEE DETAIL SHEET D.01)
- SELECT BOULDERS - TO BE PLACED WITH ENGINEER ON SITE (SEE SPECIFICATIONS FOR SIZING)

CONSTRUCTION NOTES:

1) GRADING SHOWN ON PLANS CONTAIN TARGET SLOPES. FINISHED GRADE MAY HAVE A TOLERANCE OF 0.05 FT/FT
2) WAVE FEATURE GRADING HAS A FINISHED GRADE SLOPE TOLERANCE OF 0.01 FT/FT

HEC-RAS CROSS SECTIONS:

- FEMA CROSS SECTIONS
- ADDED CROSS SECTIONS - NO SKEW
- ADDED CROSS SECTIONS - WITH SKEW

ALL ELEVATIONS ARE IN NAVD 88 DATUM

City of Grand Rapids
Design, Development and Enterprise Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

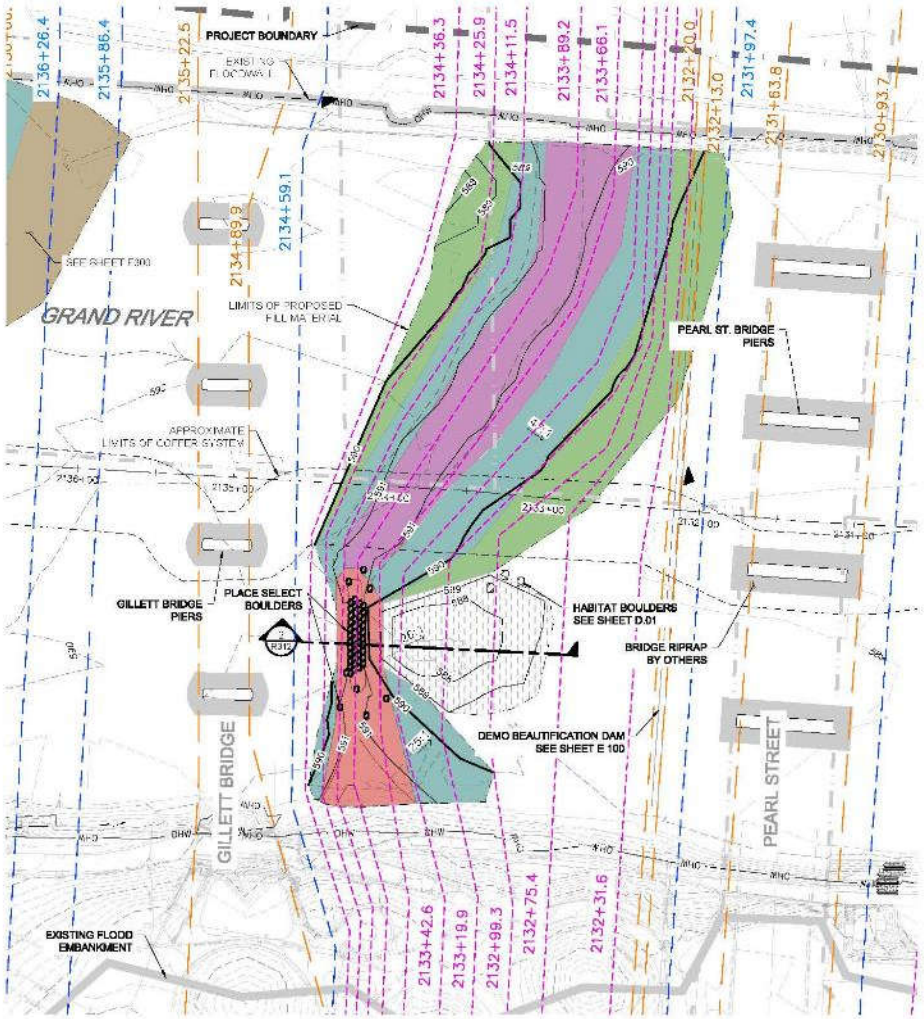
FINISHED GRADE GRADING PLAN
BRIDGE STREET TO GILLETT

Drawn by _____ Notes in _____
Check Field _____ Office _____

Approved: _____ Last Mitchell, Acting City Engineer _____ Date _____

APPROVAL OF SHEET(S) 1 - 87 ONLY

Project No.	GPT No.	Sheet Label	Sheet No.
17014	5315	F300	22 of 87



LEGEND

- FINISHED GRADE BOULDER (SEE SPECIFICATIONS FOR SIZING)
- FINISHED GRADE RIPRAP (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE IMPORTED COARSE ALLUVIUM (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE IMPORTED FINE ALLUVIUM (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE NATIVE ALLUVIUM
- POOL EXCAVATION

- PROPERTY BOUNDARIES
- EXISTING ORDINARY HIGH WATER LINE
- AVERAGE PROPOSED GRADING - 1' CONTOURS
- LIMITS OF SUB-GRADE BOULDER OR RIPRAP FILL
- CONCRETE BOULDER (SEE DETAIL SHEET D.03)
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HEC-RAS CROSS SECTIONS:

- FEMA CROSS SECTIONS
- ADDED CROSS SECTIONS - NO SKEW
- ADDED CROSS SECTIONS - WITH SKEW

NORTH

SCALE: 1" = 50'

ALL ELEVATIONS ARE IN NAVD 88 DATUM

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

City of Grand Rapids
Design, Development and Enterprise Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

FINISHED GRADE GRADING PLAN
GILLETT TO PEARL STREET

Drawn by: _____ Notes by: _____
Checked by: _____ Office: _____

Approved: _____
Jeff McCaul, Acting, City Engineer Date:
APPROVAL OF SHEET(S): 1 - 87 ONLY

Project No.	OPF No.	Sheet Label	Sheet No.
17014	5315	F310	30 of 87



NORTH

SCALE 1" = 40'

LEGEND

- FINISHED GRADE BOULDER (SEE SPECIFICATIONS FOR SIZING)
- FINISHED GRADE RIPRAP (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE IMPORTED COARSE ALLUVIUM (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE IMPORTED FINE ALLUVIUM (SEE SPECIFICATIONS FOR GRADATION)
- FINISHED GRADE NATIVE ALLUVIUM
- POOL EXCAVATION

- PROPERTY BOUNDARIES
- EXISTING ORDINARY HIGH WATER LINE
- 595 AVERAGE PROPOSED GRADING - 1' CONTOURS
- LIMITS OF SUB-GRADE BOULDER OR RIPRAP FILL
- CONCRETE BOULDER (SEE DETAIL SHEET D.03)
- HABITAT BOULDERS (SEE DETAIL SHEET D.01)
- SELECT BOULDERS - TO BE PLACED WITH ENGINEER ON SITE (SEE SPECIFICATIONS FOR SIZING)

CONSTRUCTION NOTES:

1) GRADING SHOWN ON PLANS CONTAIN TARGET SLOPES. FINISHED GRADE MAY HAVE A TOLERANCE OF 0.05 FT/FT
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HEC-RAS CROSS SECTIONS:

- FEMA CROSS SECTIONS
- ADDED CROSS SECTIONS - NO SKEW
- ADDED CROSS SECTIONS - WITH SKEW

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

City of Grand Rapids
Design, Development and Enterprise Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

FINISHED GRADE GRADING PLAN
BLUE BRIDGE TO FULTON STREET

Drawn by _____ Name in _____
Checked by _____ Office _____

Approved: Jeff McCoy, Acting City Engineer Date
APPROVAL OF SHEET(S) 1 - 87 ONLY

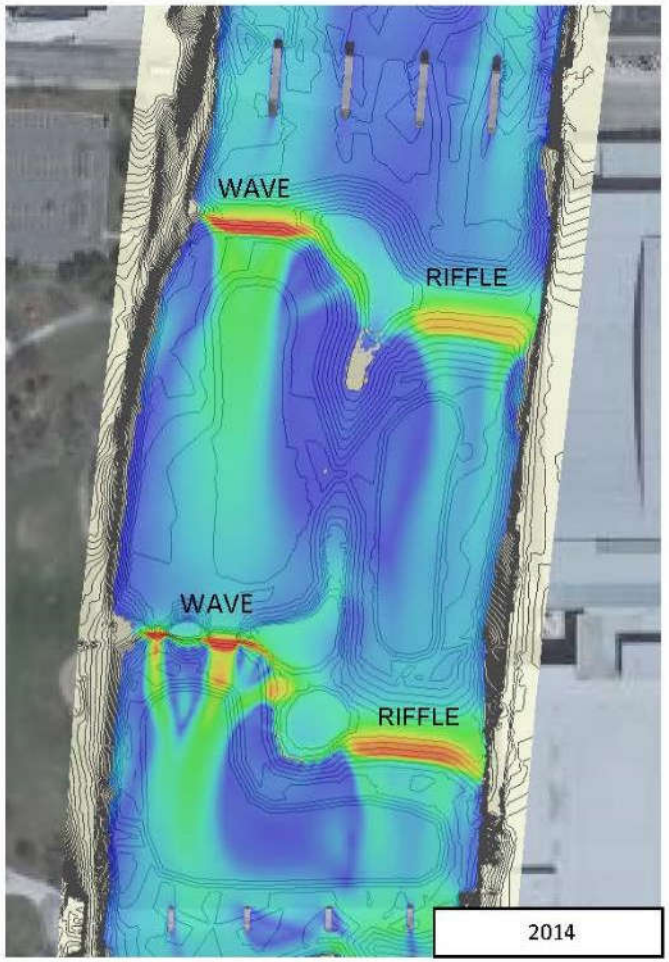
ALL ELEVATIONS ARE IN NAVD 88 DATUM

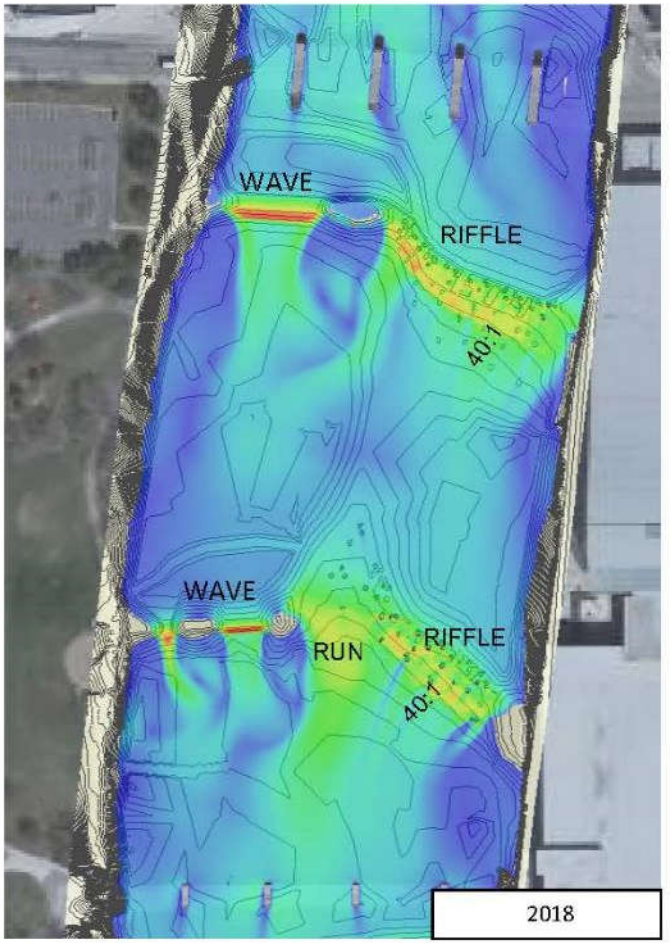
Project No.	GRT No.	Sheet Label	Sheet No.
17014	5315	F330	42 of 87

Design Progression

2014 to 2018

Bridge Street to Gillet Bridge

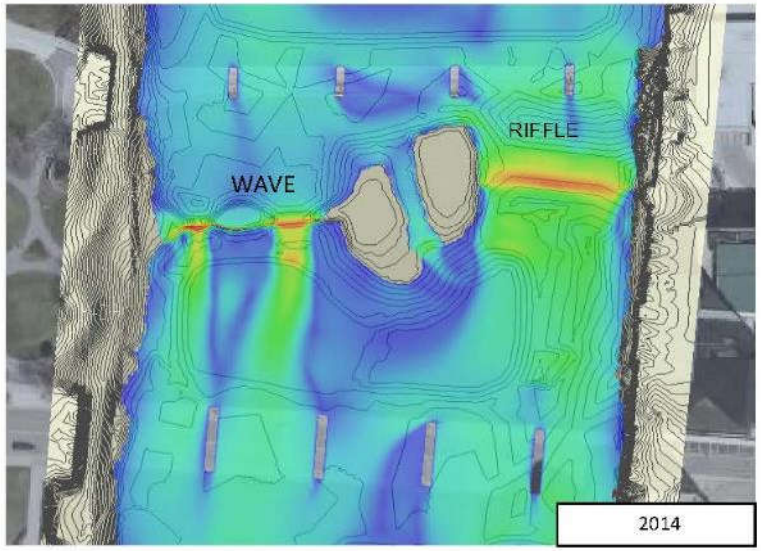


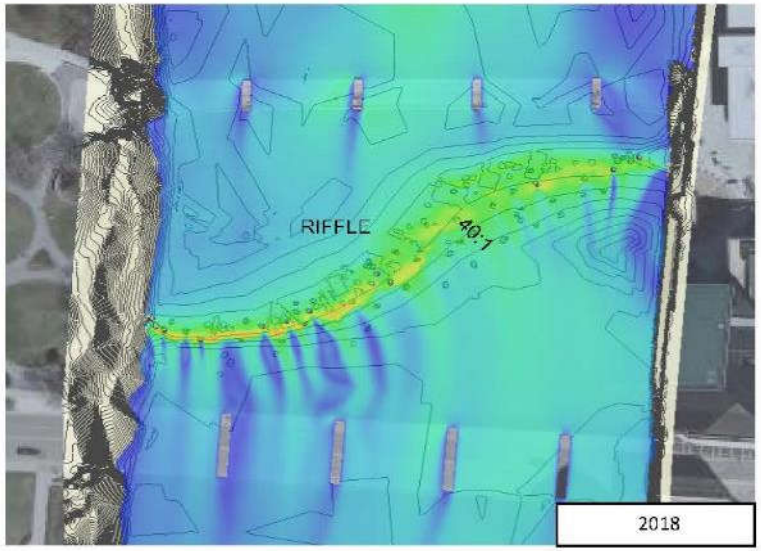


Design Progression

2014 to 2018

Gillet Bridge to Pearl Street

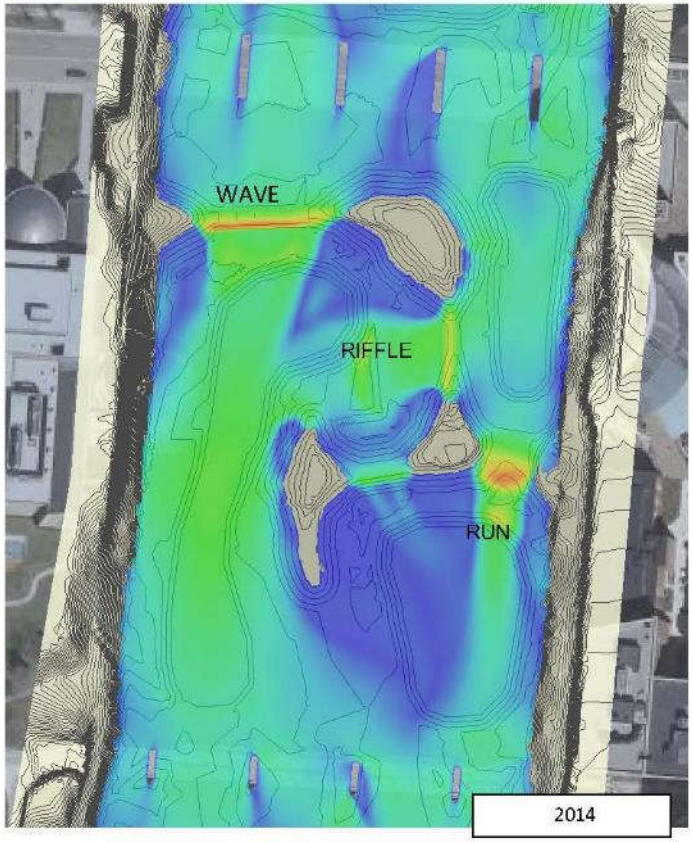


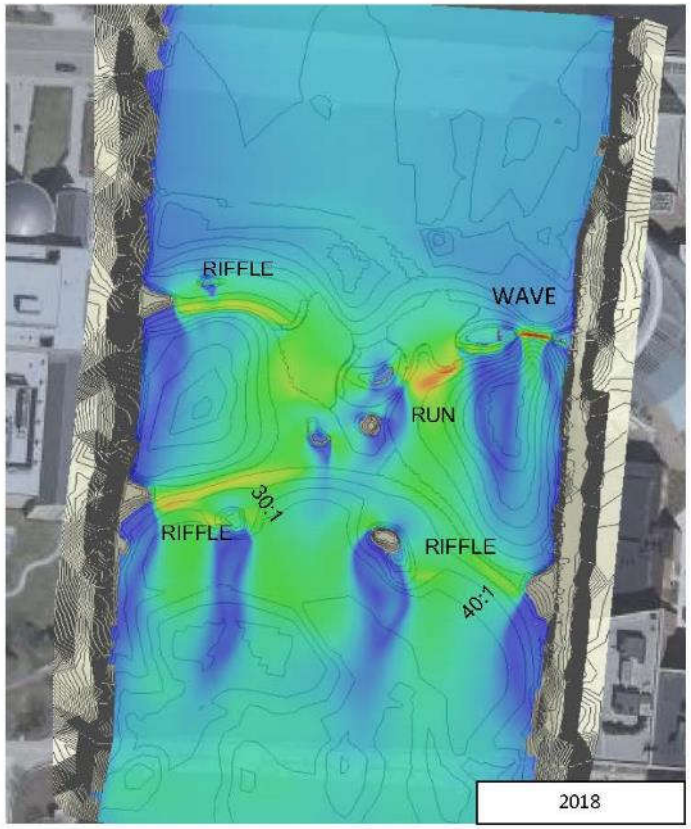


Design Progression

2014 to 2018

Pearl Street to Blue Bridge

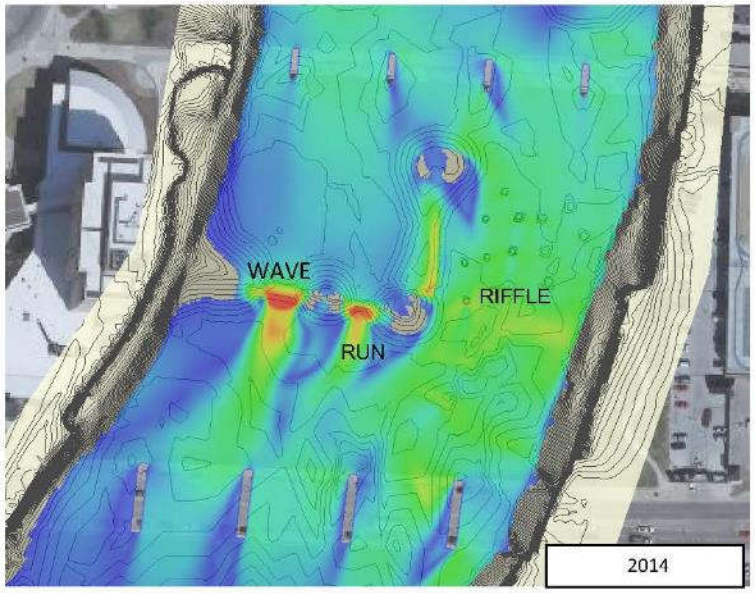


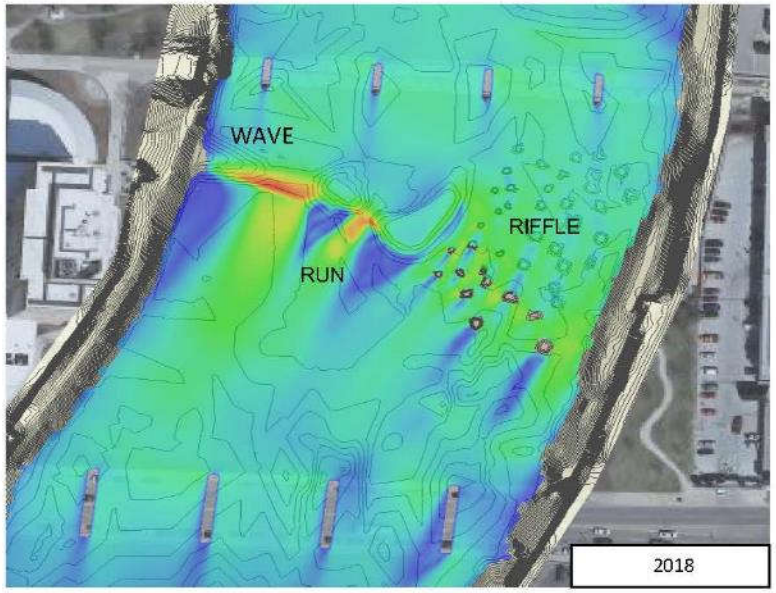


Design Progression

2014 to 2018

Blue Bridge to Fulton Street





APPENDIX D

Investigation and Analyses Report and Preliminary Investiga on

Basis of Design Attachment 2; Cost Estimates

PROJECT BUDGET								
GRAND RAPIDS RIVER REVITALIZATION 2016 COST ESTIMATATION								Sep-15
CATEGORY	**Use of Funds**	**No. of Units**	**UNIT**	**Cost Per Unit**	**Partner**	**Applicant**	**REQUEST**	**Total ($)**
Professional Services RRO & Subs								
	Restoration Survey and Design Phase I/II	3.00	LS	$100,000	$226,000	$74,000	$0	$300,000
	Recreation and Landscape Design Phase I/II	4.00	LS	$50,000	$200,000	$0	$0	$200,000
	Mussel Survey/ BA	1.00	LS	$113,550	$113,550	$0	$0	$113,550
	Permitting/ Coordination Phase II	20.00	LS	$10,000	$124,000	$76,000	$0	$200,000
	Fundraising/ Marketing/Media Phase II	5.00	LS	$10,000	$6,324	$43,676	$0	$50,000
	Flood Plain Mapping Phase II	3.00	LS	$10,000	$30,000	$0	$0	$30,000
	Final Design Phase III	10.00	LS	$50,000	$222,100	$0	$277,900	$500,000
	Plans and Specifications Phase III	3.00	LS	$50,000	$150,000	$0	$0	$150,000
	Structural & Geotechnical Engineering Phase	10.00	LS	$5,000	$50,000	$0	$0	$50,000
	Design Contingency	-	LS	$50,000	$0	$0	$0	$0
Professional Services Others					$0	$0		
	Supervision and Administration	3.00	LS	$10,000	$30,000	$0	$0	$30,000
	Habitat Monitoring &AM	20.00	YR	$50,000	$1,000,000	$0	$0	$1,000,000
	LERRDs Admin/Survey/Legal	193.00	AC	$5,000	$965,000	$0	$0	$965,000
	HTRW Testing	1.00	LS	$27,000	$0	$27,000	$0	$27,000
	Environmental Impact Statement	10.00	LS	$100,000	$1,000,000	$0	$0	$1,000,000
Operations, Maintenance, Repair, Replacement & Rehabilitation (OMRRR)								
	OMRRR (NPV7%)	20.00	YR	$150,000	$1,589,102	$0	$0	$1,589,102
Lands, Easements, ROWs, Relocations, and Disposal Areas (LERRDs)								
	Floodway Easement	127.00	AC	$8,000	$1,016,000	$0	$0	$1,016,000
	Temporary Construction License	30.00	AC	$1,000	$30,000	$0	$0	$30,000
	OMRRR Easements	15.00	AC	$5,000	$75,000	$0	$0	$75,000
					Partner	**Applicant**	**REQUEST**	**Total ($)**
PLANNING	**Soft Costs Subtotal**				**$6,827,076**	**$220,676**	**$277,900**	**$7,325,652**
Downstream of Bridge St.	**Construction Subtotal**				**$176,451**	**$1,000,000**	**$7,843,004**	**$9,019,455**
Use of Funds		**# of Units**		**Cost Per Unit**	**Partner**	**Applicant**	**REQUEST**	**Total ($)**
Site Setup								
Mobilization/demobilization/Bonding/Insurance		4	LS	$70,000.00	$0	-	$280,000	$280,000
Construction Review/Survey/ Stake/ As Built		150	DAYS	$1,440.00	$0	-	$216,000	$216,000
Construction Access Repair		18	EA	$4,500.00	$0	-	$79,200	$79,200
Channel Construction								
Boulder Footer Excavation		16000	CY	$6.00	$0	-	$96,000	$96,000
Channel Grading Excavation		16000	CY	$6.00	$0	-	$96,000	$96,000
Excavation Backfill		8000	CY	$6.00	$0	-	$48,000	$48,000
Excavation Stockpile		24000	CY	$12.00	$0	-	$288,000	$288,000
48” Grade Control Boulders, delivered & placed		32000	TONS	$75.00	$0	-	$2,400,000	$2,400,000
Furnish and Place Gravel/Cobble Fill		25000	TONS	$6.00	$0	-	$150,000	$150,000
Filter Fabric		6000	SY	$4.00	$0	-	$24,000	$24,000

48" Boulder Cluster Field		3325	TONS	$75.00	$0	-	$249,404	$249,404
Precast Structure		15	EA	$15,000.00	$0	-	$225,000	$225,000
Demo Concrete		2	LS	$50,000.00	$0	-	$100,000	$100,000
Protect in Place		9	EA	$2,500.00	$0	-	$22,000	$22,000
Bank Boulder Stabilization/ Terracing		**0**						
Protect in place mature trees		44	EA	$50.00	$0	-	$2,200	$2,200
Excavation		4400	CY	$6.00	$0	-	$26,400	$26,400
Excavation Backfill		2200	CY	$6.00	$0	-	$13,200	$13,200
Excavation Stockpile		2200	CY	$6.00	$0	-	$13,200	$13,200
3" Minus Gravel Bedding		1320	TONS	$20.00	$0	-	$26,400	$26,400
Slab Rock, delivered & placed		4400	TONS	$150.00	$0	-	$660,000	$660,000
Filter Fabric		4400	SY	$4.00	$0	-	$17,600	$17,600
Landscaping								
Native Diciduous B&B		40	EA	$650.00	$0	-	$26,000	$26,000
Thorny Vegetation (clumps)		15	EA	$720.00	$0	-	$10,800	$10,800
Vegetative Understory		2000	EA	$3.75	$0	-	$7,500	$7,500
Park Sign		2	EA	$6,000.00	$0	-	$12,000	$12,000
Navigation Signs		5	EA	$2,500.00	$0	-	$12,500	$12,500
SWPPP and Care of Water								
Mussel Relocation or PIP		9	WEEK	$10,000.00	$0	-	$90,000	$90,000
Mussel Propogation		0	LS	$20,000.00	$0	-	$0	$0
Traffic Control		400	DAYS	$500.00	$0	-	$200,000	$200,000
Care of Water Structures		400	DAYS	$1,000.00	$0	-	$400,000	$400,000
Work Bridges		**7**	**EA**	**$200,000.00**	**$0**	-	$1,400,000	$1,400,000
Care of Water Pumping		400	DAYS	$250.00	$0	-	$100,000	$100,000
Care of Water Filter		400	DAYS	$150.00	$0	-	$60,000	$60,000
Tracking pads and spud barges		5	MONTHS	$25,000.00	$0	-	$125,000	$125,000
Silt Fence		4000	LF	$2.50	$0	-	$10,000	$10,000
Barrier Fence		4000	LF	$2.00	$0	-	$8,000	$8,000
Certified Weed Free Haybales		50	EA	$22.00	$0	-	$1,100	$1,100
Wheel Wash Area		9	EA	$1,500.00	$0	-	$13,500	$13,500
Tracking Pad		9	EA	$500.00	$0	-	$4,500	$4,500
Fueling Area		9	EA	$750.00	$0	-	$6,750	$6,750
Dewatering Area		9	EA	$750.00	$0	-	$6,750	$6,750
Construction Trailer		400	DAYS	$18.00	$0	-	$7,200	$7,200
Porta-potty		36	MONTHS	$225.00	$0	-	$8,100	$8,100
Gravel for Haul Roads/ Graded		2000	TONS	$40.00	$0	-	$80,000	$80,000
Channel Access Roads		2000	TONS	$40.00	$0	-	$80,000	$80,000
Water Truck for Dust Control		44	DAYS	$400.00	$0	-	$17,600	$17,600
BMP Other		9	EA	$10,000.00	$0	-	$88,000	$88,000
Regrade to original Grade		18	DAYS	$1,000.00	$0	-	$17,600	$17,600
Plant Native E.C. Grass with mulch/tackifier		5	ACRE	$3,500.00	$0	-	$17,500	$17,500
FLOODWALL AESTHETICS		0.0	LS	$410,000.00	$0	-	$0	$0

					Partner	Applicant	REQUEST	Total ($)
Downstream of Bridge St.	Construction Subtotal				$0	$0	$7,843,004	$7,843,004
Downstream of Bridge St.	15% Contingency				$176,451	$1,000,000	$0	$1,176,451
Downstream of Bridge St.	Construction Subtotal				$176,451	$1,000,000	$7,843,004	$9,019,455

I196 to Fulton Street (Base Project)

Line #	60% design COST OPINION August 2017	Qty	Unit Issue	Unit Cost	Partner	Applicant	Request	Total ($)
	General							
1	Mobilization/demobilization/Bonding/Insurance	1	LS	$826,595				$826,595
2	Construction Review/Survey/ Stake/ As Built	1	LS	$165,319				$165,319
3	Construction Oversight and Management	1	LS	$247,978				$247,978
4	Care of water / ESC Program Management	1	LS	$40,000				$40,000
5								
6							**Sub-total**	**$1,279,892**
7								
8	SA-06 - Scribner / Fish Ladder Staging Area	SA-06						
9	Project Signage	4	EA	$750				$3,000
10	Fueling Area	1	EA	$750				$750
11	Concrete Washout	1	EA	$1,250				$1,250
12	Wheel Wash Area	2	EA	$1,500				$3,000
13	Job Trailer	200	DAYS	$18				$3,600
14	Sanitation Facility	12	MONTHS	$225				$2,700
15	Water Truck for Dust Control	40	DAYS	$400				$16,000
16	Tree Removal and Replacement	4	EA	$1,200				$4,800
17	Protect in Place Mature Trees	2	EA	$300				$600
18	Remove, store and replace light pole	4	EA	$500				$2,000
19	Project in Place Utilities	10	EA	$300				$3,000
20	Protect in Place Existing Wetland	1	LS	$2,500				$2,500
21	Chain Link Construction Fence	450	LF	$5				$2,250
22	Orange Construction Fence	0	LF	$3				$0
23	Certified Weed Free Haybales	100	EA	$22				$2,200
24	Security Gate	2	EA	$2,000				$4,000
25	Silt Fence	2000	LF	$3				$6,000
26	Miscellaneous Erosion Control BMPs	1	LS	$5,000				$5,000
27	Traffic Control	1	LS	$25,000				$25,000
28	Site Restoration	1	LS	$100,000				$100,000
29							**Sub-total**	**$187,650**
30								
31	SA-07 - North Monroe Lot - Staging Area	SA-07						
32	Project Signage	4	EA	$750				$3,000
33	Fueling Area	1	EA	$750				$750
34	Concrete Washout	1	EA	$1,250				$1,250
35	Wheel Wash Area	2	EA	$1,500				$3,000
36	Dewatering Area	1	EA	$2,500				$2,500
37	Job Trailer	200	DAYS	$18				$3,600
38	Sanitation Facility	12	MONTHS	$225				$2,700
39	Water Truck for Dust Control	40	DAYS	$400				$16,000
40	Tree Removal and Replacement	14	EA	$1,200				$16,800
41	Remove, store and replace light pole	2	EA	$500				$1,000
42	Chain Link Construction Fence	1000	LF	$5				$5,000
43	Certified Weed Free Haybales	100	EA	$22				$2,200
44	Security Gate	2	EA	$2,000				$4,000
45	Silt Fence	1000	LF	$3				$3,000
46	Miscellaneous Erosion Control BMPs	1	LS	$4,000				$4,000
47	Cut and Restore Floodwall	1	LS	$75,000				$75,000
48	Traffic Control	1	LS	$25,000				$25,000
49	Site Restoration	1.00	LS	$5,000				$5,000
50							**Sub-total**	**$173,800**
51	SA-08 - Bridge Street Staging Area	SA-08						
52	Project Signage	4	EA	$750				$3,000
53	Fueling Area	1	EA	$750				$750
54	Concrete Washout	1	EA	$1,250				$1,250
55	Wheel Wash Area	2	EA	$1,500				$3,000
56	Job Trailer	150	DAYS	$18				$2,700
57	Sanitation Facility	12	MONTHS	$225				$2,700
58	Water Truck for Dust Control	40	DAYS	$400				$16,000
59	Remove and Replace Tree	8	EA	$1,500				$12,000
60	Protect in Place Mature Trees	13	EA	$300				$3,900
61	Protect in Place Utilities	0	EA	$300				$0
62	Remove, store and replace light pole	4	EA	$500				$2,000
63	Chain Link Construction Fence	749	LF	$5				$3,745
64	Post Construction Fence	290	LF	$8				$2,320
65	Security Gate	2	EA	$2,000				$4,000
66	Certified Weed Free Haybales	50	EA	$22				$1,100
67	Silt Fence	256	LF	$3				$768
68	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
69	Protect in Place Existing Wetland	1	LS	$2,500				$2,500
70	Site Restoration	1	LS	$100,000				$100,000
71							**Sub-total**	**$163,233**
72								
73	SA-09 - Gillett Bridge West Staging Area	SA-09						
74	Project Signage	4	EA	$750				$3,000
75	Fueling Area	1	EA	$750				$750
76	Concrete Washout	1	EA	$1,250				$1,250
77	Wheel Wash Area	2	EA	$1,500				$3,000
78	Dewatering Area	1	EA	$2,500				$2,500
79	Job Trailer	150	DAYS	$18				$2,700
80	Sanitation Facility	12	MONTHS	$225				$2,700
81	Water Truck for Dust Control	40	DAYS	$400				$16,000
82	Remove and Replace Tree	2	EA	$1,500				$3,000
83	Protect in Place Mature Trees	4	EA	$300				$1,200
84	Protect in Place Utilities	0	EA	$300				$0
85	Remove, store and replace light pole	7	EA	$500				$3,500
86	Chain Link Construction Fence	663	LF	$5				$3,315
87	Security Gate	1	EA	$2,000				$2,000
88	Certified Weed Free Haybales	70	EA	$22				$1,540
89	Silt Fence	380	LF	$3				$1,140
90	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
91	Protect in Place Existing Wetland	1	LS	$2,500				$2,500
92	Site Restoration	1	LS	$100,000				$100,000
93							**Sub-total**	**$151,595**
94								
95	SA-10 - Gillett Bridge East Staging Area	SA-10						
96	Project Signage	3	EA	$750				$2,250
97	Fueling Area	0	EA	$750				$0
98	Concrete Washout	0	EA	$1,250				$0
99	Wheel Wash Area	0	EA	$1,500				$0
100	Job Trailer	0	DAYS	$18				$0

101	Sanitation Facility	2	MONTHS	$225				$450
102	Water Truck for Dust Control	0	DAYS	$400				$0
103	Remove and Replace Tree	1	EA	$1,500				$1,500
104	Protect in Place Mature Trees	2	EA	$300				$600
105	Project in Place Utilities	1	EA	$500				$500
106	Remove, store and replace light pole	1	EA	$500				$500
107	Chain Link Construction Fence	132	LF	$5				$660
108	Security Gate	1	EA	$2,000				$2,000
109	Certified Weed Free Haybales	20	EA	$22				$440
110	Silt Fence	0	LF	$3				$0
111	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
112	Site Restoration	1	LS	$20,000				$20,000
113							**Sub-total**	**$30,400**
114								
115	SA-11 - Blue Pedestrian Bridge	SA-11						
116	Project Signage	6	EA	$750				$4,500
117	Fueling Area	0	EA	$750				$0
118	Concrete Washout	0	EA	$1,250				$0
119	Wheel Wash Area	2	EA	$1,500				$3,000
120	Job Trailer	150	DAYS	$18				$2,700
121	Sanitation Facility	12	MONTHS	$225				$2,700
122	Water Truck for Dust Control	40	DAYS	$400				$16,000
123	Remove and Replace Tree	9	EA	$2,500				$22,500
124	Protect in Place Mature Trees	6	EA	$300				$1,800
125	Protect in Place Utilities	1	EA	$300				$300
126	Protect in Place Concrete stairs	1	ES	$300				$300
127	Temporary relocation and storage of Statue	1	EA	$3,000				$3,000
128	Temporary demo of wall and railing	1	LS	$3,000				$3,000
129	Remove, store and replace light pole	8	EA	$500				$4,000
130	Chain Link Construction Fence	534	LF	$5				$2,670
131	Security Gate	1	EA	$2,000				$2,000
132	Certified Weed Free Haybales	50	EA	$22				$1,100
133	Silt Fence	160	LF	$3				$480
134	Miscellaneous Erosion Control BMPs	1	LS	$1,500				$1,500
135	Site Restoration	1	LS	$150,000				$150,000
136							**Sub-total**	**$221,550**
137								
138	SPlanP and Care of Water	CW06 - CW07 - CW11 -CW12						
139	Traffic Control	1	LS	$120,000				$120,000
140	Care of Water Pumping	400	EA	$250				$100,000
141	Care of Water Filter	1	LS	$60,000				$60,000
142	Turbidity Curtain	1200	LF	$18				$21,600
143	Oil Boom	1200	LF	$10				$12,000
144	Silt Fence	995	LF	$3				$2,985
145	Barrier Fence	2414	LF	$2				$4,828
146	Furnish and Install Stage 3 (River Right) Alluvial Coffer Dam	13000	CY	$42				$546,000
147	Reconfigure Causeway Coffer System	13000	CY	$18				$234,000
148	Furnish and Install Stage 1 Sheetpile (20' lengths	55000	SF	$20				$1,100,000
149	Demo and Dispose Sheetpile	55000	SF	$0				$0
150	Stage 1 Access Ramps	2	EA	$35,000				$70,000
151	Stage 2 Sheetpile re-configuration	1480	LF	$30				$44,400
152	Stage 2 Work Bridges	2	EA	$150,000				$300,000
153	Install Stage 3 (Pearl to Fulton) Sheetpile (re-use stage 1	1408	LF	$30				$42,240
154	Stage 3 (Pearl to Fulton) Access Ramps	1	EA	$35,000				$35,000
155	Stage 4 (Pearl to Fulton) Sheetpile re-configuration	1480	LF	$30				$44,400
156	Stage 4 (Pearl to Fulton) Work Bridges	1	EA	$150,000				$150,000
157	Certified Weed Free Haybales	100	EA	$22				$2,200
158	Rip Rap Scour Protection	1973	TONS	$75				$147,941
159	Temporary Grade Control	785	TONS	$75				$58,874
160	Sediment Removal	5000	TONS	$10				$50,000
161	Filter Area	3	EA	$4,500				$13,500
162	PIP or Maintain Stormwater outfall	4	EA	$2,500				$10,000
163	PIP Existing Wetland	2	LS	$2,500				$5,000
164	PIP Existing USGS Stream Gage	1	EA	$3,000				$3,000
165	Care of water / ESC Program Management	1	LS	$40,000				$40,000
166	Plant Native E.C. Grass with mulch/tackifier	5	ACRES	$3,500				$17,500
167							**Sub-total**	**$3,235,468**
168								
169	Bank Improvements and Access	R300 - R310 - R320						
170	Excavation hauloff and dispose of grouted boulder	40	CY	$45				$1,800
171	Excavation of riprap	35	CY	$12				$420
172	Slab Rock, delivered & placed	200	TONS	$450				$90,000
173	Tie-in boulder (12"-24"), delivered & placed	150	TONS	$156				$23,400
174	Hauloff or stockpile excavated riprap	38	TONS	$20				$759
175	3" Minus Gravel Bedding, furnish and place	14	TONS	$35				$479
176	Excavation backfill with alluvium produced on site	29	CY	$12				$346
177	Filter Fabric	149	SY	$4				$598
178	Tie-in to exisitng path and finish	4	LS	$2,000				$8,000
179							**Sub-total**	**$125,803**
180								
181	In-Channel Earthwork	R300 - R310 - R320						
182	Removal of low Head Existing Dam	2109	CY	65				$137,085
183	Unclassified Excavation	3610	CY	6				$21,658
184	Furnish and Deliver Boulder	11091	tons	75				$831,805
185	Placement Boulder	11091	tons	56				$621,081
186	Furnish and Deliver Riprap Substructure	3883	CY	65				$252,369
187	Placement Riprap Substructure	3883	CY	12				$46,591
188	Grading of Alluvium (Imported)	27583	CY	12				$330,996
189	Grading of Alluvium (Native)	3896	CY	12				$46,752
190	Furnish and Deliver Alluvium (assumes repurposed cut)	23117	CY	42				$970,925
191	Install Grout in Boulder Matrix	200	CY	200				$40,000
192	Precast Structures	17	CY	15000				$255,000
193	Excavate & Dispose Unsuitable non-HTRW	100	CY	45				$4,500
194	Bridge Riprap	6426	CY	65				$417,685
195							**Sub-total**	**$3,976,448**
196								
197							**Construction Soft Costs**	**$1,279,892**
198							**Total for Downstream of Bridge Street**	**$8,265,946**
199							**15% Contingency**	**$1,431,876**
							Total with Contingency	**$10,977,71**

APPENDIX E

Other Supporting Information

- Biological Opinion; USFWS, 8/14/2024
- Biological Assessment Revised; EcoAnalysts Inc., March 2024
- Amendment to Biological Assessment; EcoAnalysts Inc., June 2024
- Basis of Design Report, May 2024; RiverRestoration
- Hydraulics Report, May 2024; RiverRestoration
- Temporary Conditions Hydraulics Report, May 2024; RiverRestoration
- Hydraulic Influence at the 6th Street Dam, June 2024; RiverRestoration
- Sediment Transport Report, June 2024; RiverRestoration
- Bridge Scour Evaluation, June 2024; RiverRestoration
- OMRRR Report, May 2024; RiverRestoration
- Recommended Construction Sequencing and Methods, June 2024; RiverRestoration
- Grand River Revitalization 60% GMP Bid Item Summary Cost Estimate, 4/17/2024
- Impacts to Fish Passage in the Grand River Between Bridge Street and Fulton Street, February 2024; Holtgren, Encompass
- Grand River-Lower Reach Project Monitoring Plan 4-2024
- Cumulative Impacts Analysis; City of Grand Rapids to EGLE, June 2024
- Preliminary Geotechnical Engineering Study, July 2015; Materials Testing Consultants, Inc.
- 141579 Grand River Sediment Sampling Report, March 2017; Materials Testing Consultants, Inc.
- Wetland Delineation Report; Golder Associates, 10/14/2014
- Updated Wetland Delineation Report; Fishbeck, 2/2019
- Wetland Boundary Verification; Fishbeck, 10/18/2023
- Letter to Grand Rapids Fire Department, March 2021
- Ottawa County letter 5/7/2021
- Aquatic Benefits Memo; ERM, 4/16/2021
- Grand River Water Quality
- Water Rescue Activity 2019-2023
- Cultural Resources Memorandum of Agreement, 9/30/2022
- NRHP Evaluation Grand River Beautification Dams GRWW
- Tribal Consultation Outreach and Tribal Consultation Responses, 7/3/2019
- Other potential updated Cultural/Tribal documents/letters/information
- 2020 FEMA Documents

APPENDIX E

Other Supporting Information

Biological Opinion 8/14/2024

United States Department of the Interior

FISH AND WILDLIFE SERVICE

2651 Coolidge Road, Suite 101
East Lansing, Michigan 48823-6360

August 14, 2024

Ms. Ruth Shaffer
Water Quality Specialist
USDA, NRCS
3001 Coolidge Road, Suite 250
East Lansing, MI 48823

Michael Staal, P.E.
Project Manager, Engineering Department
300 Monroe Ave NW
Grand Rapids, MI 49503

Mr. Matt Chapman
Grand Rapids Whitewater
120 Lyon St NW
Grand Rapids, MI 49503

RE: Endangered Species Act Section 7 Consultation for the City of Grand Rapids Watershed Flood Prevention Act grant and associated mussel relocation project. Project #2024-0036384

Dear Ms. Shaffer, Mr. Staal, and Mr. Chapman:

Enclosed is the U.S. Fish and Wildlife Service' (USFWS) Biological Opinion (BO) for the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Watershed Flood Prevention Act (WFPA) grant and the associated City of Grand Rapids and Grand Rapids White Water (City/GRWW) freshwater mussel relocation project in partnership with the USFWS. The BO evaluated the project's effects on the endangered snuffbox mussel (*Epioblasma triquetra*) in accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.).

The NRCS and the USFWS determined that the proposed project was "likely to adversely affect" Snuffbox mussel as well as negatively impact State listed freshwater mussels and fish. The NRCS's request for formal consultation was received on April 23, 2024, with the Biological Assessment (BA) 2024: Impacts to federal and state threatened and endangered species from rehabilitation of the Grand River between Bridge and Fulton Streets in Grand Rapids, Kent County, Michigan Revision 1. The City/GRWW submitted a BA amendment June 20, 2024, with new information on the proposed action, impact areas, and effects of the action on state and federally listed mussels.

This BO is based on information provided in the April 2024 BA, June 2024 BA Amendment, project meetings, conference calls, site visits, survey data, and other sources of information. A

complete administrative record of this consultation is on file at the USFWS Michigan Ecological Services Field Office.

Your BA also contains an analysis of adverse effects on freshwater mussels listed as special concern, threatened, or endangered by the State of Michigan including: Black Sandshell (*Ligumia recta*), Lilliput (*Toxolasma parvum*), Purple Wartyback (*Cyclonaias tuberculata*), Slippershell (*Alasmidonta viridis*), Round Pigtoe (*Pleurobema sintoxia*), Pink Heelsplitter (*Potamilus alatus*), Deertoe (*Truncilla truncata*), Ellipse (*Venustaconcha ellipsiformis*), Elktoe (*Alasmidonta marginata*), Creek Heelsplitter (*Lasmigona compressa*), Fluted Shell (*Lasmigona costata*) and Paper Pondshell (*Utterbackia imbecillis*) mussels. The BA also contains an analysis of effects to state threatened Lake Sturgeon (*Acipenser fulvescens*) and River Redhorse (*Moxostoma carinatum*). Therefore, effects to state listed freshwater mussels and fish are also included in this Opinion.

Additionally, the NRCS used the Michigan All Species Determination Key in the USFWS Information for Planning and Consultation System and received no effect determinations for the following federally listed species: northern long eared bat (*Myotis septentrionalis*); Indiana Bat (*Myotis sodalis*); tricolored bat (*Perimyotis subflavus*); monarch butterfly (*Danaus plexippus*); eastern massasauga rattlesnake (*Sistrurus catenatus*), and Karner blue butterfly (*Lycaeides melissa samuelis*).

Snuffbox

After reviewing the current status of the Snuffbox, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that these actions, as proposed, are not likely to jeopardize the continued existence of the species.

With respect to the ESA's compliance, all aspects of the project description are binding. The Reasonable and Prudent Measures and the accompanying Terms and Conditions provided within the enclosed biological opinion are nondiscretionary and are designed to minimize incidental take of listed species.

We appreciate the opportunity to cooperate with the NRCS, the City of Grand Rapids, and Grand Rapids Whitewater in conserving endangered species. If you have any questions regarding these comments, please contact Jessica Pruden, of this office, at 517-351-8245, or jessica_pruden@fws.gov.

Sincerely,

SCOTT HICKS

Digitally signed by SCOTT HICKS
Date: 2024.08.14 09:21:36 -04'00'

Scott Hicks
Field Supervisor

cc: Michigan DNR (T. Newcomb, J. Kleitch, J. Buszkiewicz, J. Johnson, P. Ertel, J. Wesley)
Michigan EGLE (A. Lounds, L. Trumble)
EcoAnalysts Inc. (H. Dunn)
USFWS (J. Barber, P. Hrodey)

BIOLOGICAL OPINION

Effects to the Snuffbox, *Epioblasma triquetra* from the Grand River Revitalization Project, U.S. Department of Agriculture Natural Resources Conservation Service, Grand Rapids, Kent County, Michigan, and Relocation Efforts by the City of Grand Rapids and Grand Rapids White Water in Partnership with the U.S. Fish and Wildlife Service, East Lansing, Michigan

Prepared by:
U.S. Fish and Wildlife Service
Michigan Ecological Services Field Office
East Lansing, MI

Project #2024-0036384

August 13, 2024

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INTRODUCTION

The City of Grand Rapids (City) is pursuing proposed Watershed and Flood Prevention Act PL83-566 grant funding (WFPA) with the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) (NRCS WFPA Project) to improve aquatic habitat in the Lower Grand River where it flows through downtown Grand Rapids, Kent County, Michigan (GVMC, 2011). The funding would be used for revitalizing the rapids in the NRCS WFPA Project Area (downstream face of the 6th Street Dam to upstream face of Fulton St. Bridge). To reduce the impacts on freshwater mussels resulting from the NRCS WFPA Project, the City and Grand Rapids Whitewater (GRWW) plan to relocate as many freshwater mussels as practicable from direct impact areas (City/GRWW Project). Although NRCS does not anticipate funding the mussel relocation, absent the funding for the revitalization of the rapids the mussel relocation would not be necessary and therefore the relocation is a consequence or effect of the action for the purposes of Section 7 evaluation (50 CFR 402.02). In addition, the U.S. Fish and Wildlife Service (USFWS) has engaged in the planning for this project since Grand Rapids was first selected by the U.S. Environmental Protection Agency (USEPA) to be part of the Urban Waters Federal Partnership (UWFP) in 2013. USFWS plans to assist the City and GRWW during the mussel relocation portion of the action (City/GRWW Project).

This document transmits the USFWS' Biological Opinion (BO) based on our review of the Proposed Actions including NRCS WFPA Project and the associated City/GRWW Project in partnership with the USFWS under the UWFP and these Projects effects on the Snuffbox mussel (*Epioblasma triquetra*) in accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). The NRCS and the USFWS determined that the proposed project was "likely to adversely affect" Snuffbox mussel as well as negatively impact State listed freshwater mussels and fish. The NRCS's request for formal consultation was received on April 23, 2024, with *the Biological Assessment 2024: Impacts to federal and state threatened and endangered species from rehabilitation of the Grand River between Bridge and Fulton Streets in Grand Rapids, Kent County, Michigan Revision 1.* An amendment to this Biological Assessment (BA) was submitted June 20, 2024, with new information on the proposed action, impact areas, and effects of the action on state and federally listed mussels.

This Opinion is based on information provided in the April 2024 BA, June 2024 BA Amendment, project meetings, conference calls, site visits, survey data, and other sources of information. A complete administrative record of this consultation is on file at the USFWS Michigan Ecological Services Field Office.

Consultation History

The Grand Rapids Revitalization Project was initially funded with private funds, prompting the development of a Habitat Conservation Plan (HCP) pursuant to section 10(a)(1)(B) of the ESA in January 2015. Meetings were held each year between 2015 and present to discuss the development of the Project and compliance with various state and federal regulations. In 2017, the USDA NRCS awarded a Regional Conservation Partnership Program (RCPP) grant pursuant to the Watershed Protection and Flood Prevention Act, PL-566 program, to the Grand Valley Metro Council (GVMC) located in Grand Rapids, Michigan.

The GVMC is an alliance of governmental units in the West Michigan area appointed to plan for the growth and development, improve the quality of the community's life, and coordinate governmental services. The City is a member of the GVMC. The GVMC worked with GRWW to implement the RCPP grant. The RCPP grant provided $8 million in funding for the "Lower

Grand River Watershed Habitat Restoration-Farmland Conservation Project." Of the $8 million, $4.1 million was to be used for revitalizing the rapids in Grand Rapids downstream of the face of 6th Street Dam to the upstream face of Fulton Street Bridge. Funding under the RCPP created a federal nexus for the RCPP Project, which transitioned ESA compliance for adverse effects to Snuffbox mussel from Section 10(a)(1)(B) to Section 7 of the ESA. Initially formal consultation pursuant to Section 7 was requested by NRCS on July 3, 2018, accompanied by a BA. The USFWS and Michigan Department of Natural Resources (MDNR) had significant comments on the 2018 BA, which were subsequently addressed by NRCS. A revised draft BA was submitted to the USFWS on November 2, 2018. USFWS and MDNR comments on the draft were received November 29, 2018. These comments were addressed in the revised BA that was submitted to the USFWS in December 2018. Due to concerns with increased tailwater elevation, which could decrease the effectiveness of the 6th Street Dam as a barrier to sea lamprey (*Petromyzon marinus*) migration, significant changes were made to the project design. Most significantly, the upstream construction limit was moved downstream to Bridge Street on April 15, 2019, which reduced the amount of material placement in the river, alleviated the tailwater increase post-construction, and maintained tailwater elevations during construction. A revised BA reflecting changes made to project design was submitted to the USFWS in May 2019. After review of the May 2019 BA, the USFWS and MDNR continued to have concerns with hydraulic modeling, sea lamprey escapement, and fish passage. The project was redesigned and a revised BA was submitted to the USFWS in February 2020. After additional concerns on the February BA were addressed, a final BA was submitted in June 2020 and was submitted along with a request by NRCS to initiate formal consultation. In a letter dated July 9, 2020, formal consultation was initiated with NRCS on June 9, 2020, and the USFWS completed formal consultation through issuance of a BO on October 22, 2020.

The City continued to pursue their permit application to the Michigan Department of Environment Great Lakes and Energy under the Clean Water Act state assumed program for work within the Grand River. During this process the RCPP grant funding was extended, though ultimately they were unable to obtain necessary permits in time to secure the grant funding. The City is now pursing the PL83-566 WFPA funding.

As a result, the USFWS and NRCS are now consulting on the proposed WFPA Project and the City/GRWW Project (mussel relocation project) in partnership with the USFWS.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

As defined in the ESA Section 7 regulations (50 CFR 402.02), "action" means "all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas." The "action area" is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action."

Proposed Action

NRCS proposes to remove four low head dams, construct riffles and boulder arches, bank vane structures, and create emergent habitat boulder fields within a portion of the Grand River between the 6th Street Dam and Fulton Street in downtown Grand Rapids, Kent County, Michigan. The NRCS, the City, and GRWW stated intent of the proposed design is to: 1) restore the rapids; 2)

improve public safety; 3) restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species; and 4) enhance river access and use.

The area that would be affected by project construction includes the area from 91 m (300 ft) upstream of Bridge Street to the upstream face of Fulton Street, an area of 127,600 m2 (31.5 acres). Of the 127,600 m2 (31.5 acres), 47,415 m2 (11.7 acres) would be directly impacted during dam removal, temporary scour protection placement, causeway construction, feature creation, and tracking in the river to construct features (i.e., emergent habitat boulder fields, diversified boulder arches, and rock pile vanes downstream of Pearl Street) (direct impact area). The areas between direct impact areas would be indirectly impacted by temporary increases in turbidity and changes in flow patterns associated with causeways and features constructed in the river. Increased scour potential outside of direct impact areas will be avoided and minimized during construction. Upstream indirect impacts during construction (38,420 m2; 9.5 acres) would be limited to slight changes in depth and velocity depending on what construction and project features are in the river. The area of indirect impact within the construction area is approximately 80,185 m2 (19.8 acres).

The area permanently impacted includes a sum of the habitat area occupied by all structures on the riverbed where that habitat would not be available to freshwater mussels post-construction. This includes areas where boulders and rock are placed to construct riffles, diversified boulder arches, emergent habitat boulder fields, rock vanes, and transient sand. Scour protection would be removed when the Dam 2 construction area is no longer isolated. This area is not considered a permanent impact area.

Prior to construction of the NRCS WFPA Project, the City/GRWW Project will be implemented and consists of collecting as many mussels as possible from the NRCS WFPA Project area in partnership with the USFWS and translocating them to three recipient sites.

A survey was conducted in 2015 to identify suitable recipient sites for mussels that would be translocated from the NRCS WFPA Project impact areas (ESI, 2016). Five potential sites were identified: Ionia, Saranac, Chief Hazy Cloud, Ada, and Site 7.

Collection and translocation of mussels would occur when water temperature is above 10° C (50° F) and air temperature is between 10 and 32° C (50 and 90° F) unless permission is obtained from USFWS and MDNR to salvage and relocate outside of these temperature windows.

As many unionids as practicable would be translocated from direct impact areas before construction in 2024 to minimize these impacts. However, unsafe diving/collection conditions may prevent some unionids from being removed. Unionids not relocated from direct impact areas could be crushed by construction activities. The river bottom would not be physically modified in approximately 80,185 m2 (19.8 acres) of the NRCS WFPA Project Area, but could be affected by turbidity and changes in local hydraulic conditions. Staging and access areas would primarily be from Ah-Nab-Awen Park.

The following is a list of the major components of the proposed project in the Action Areas:

- Between Blue Bridge and Fulton Street
    - Augmented boulder vane structure with a reduced footprint and surrounding scattered boulders.
- Between Pearl and Blue Bridge
    - Placement of emergent habitat boulder field and a series of bank vane structures to provide slack water near designated access points on the bank.

- Between Gillett and Pearl Street (Location of Dam 1)
    - Installation of a single constructed riffle with emergent habitat boulders.
- Between Bridge and Gillett Street (Location of Dam 2)
    - Installation of a hydraulic feature that combines constructed riffles on either side of a series of boulder arches located near the center of the channel. The new hydraulic feature has a reduced footprint.
    - Small scour pools are included directly downstream of the boulder arches with .
- Between Bridge Street and Gillet (Location of Dam 3)
    - Re-grading of the channel upstream of Dam 3.
    - Emergent habitat boulders are proposed to be placed within the dam removal footprint.
- Upstream of Bridge Street (Location of Dam 4)
    - The dam removal limits include re-grading of the channel upstream of Dam 4.

Equipment staging would be primarily within Ah-Nab-Awen Park. Some equipment may be staged on the east bank between I-196 and the 6th Street Dam, but the river would only be accessed from Ah-Nab-Awen Park. Erosion and sediment control measures would be used in accordance with the Michigan Unified Keying System and approved by the City's Stormwater (Michigan Natural Resources and Environmental Protect Act Part 91) reviewers.

General construction best management practices (BMPs) to be implemented for the NRCS WFPA Proposed Action are outlined below.

- Vegetation removal will only occur within the staging areas and will be minimized as much as practicable to provide access and limit any safety concerns.
- Vegetation removal in staging areas will be limited to smaller shrubs and urban trees.
- Construction staging and stockpile areas will be established.
- Areas for storage of spare oil booms, designated oiling, and petroleum handling areas, will be established outside of the riparian zone and will be isolated from the river using silt-fences, straw wattles, and berms.
- The contractor will establish and post protocols for potential oil spill cleanup and emergency response.
- Construction equipment such as excavators, loaders, cranes, and haul trucks, will be maintained and stored in areas in accordance with guidelines prescribed by EGLE.
- Runoff from equipment maintenance and storage areas will be directed to stabilized outlets designed to adequately convey the volume discharged.
- Heavy equipment would be well maintained to prevent leaks.
- Vehicles or other equipment will not be washed at locations where the runoff could flow directly into a watercourse or separate storm sewer.
- Construction materials, including topsoil and chemicals, will be stored, covered, or isolated to prevent runoff of pollutants and contamination of groundwater.
- Empty canisters, cans, or other chemical containers (e.g., hydraulic fluids, etc.), scrap wood, scrap metal, and all other waste materials would be disposed of daily or kept in sealed waste containers until they can be properly disposed of off-site, such as in a landfill.

- Waste materials will not be buried on-site.
- Prior to entering the watercourse, all equipment will be washed under high-pressure water with a nonharmful and biodegradable degreaser.
- Equipment in the watercourse will be inspected frequently and maintained properly to ensure no grease, oils, or chemicals are entering the watercourse.
- If equipment is leaking such fluids, it will be removed from the water course and repaired prior to reentering.
- Equipment regularly traversing in and out of the watercourse will be cleaned under high pressure water (i.e., wheel washing station) at a minimum once per week.
- Biodegradable hydraulic fluid fuel will be used in any equipment entering the water.
- Oil booms may be placed downstream of any equipment working in the wet as necessary.
- All in-river construction work is expected to be conducted with river conditions approximately ≤3,900 CFS. However, the construction crew on site would ultimately decide on conditions they can safely work under.
- Construction in the wet would be restricted to lower flow rated with suitable flow depths for tracking in the river .
- Causeways of imported clean coarse aggregate will be installed along the west bank to access the Dam 1, 3, and 4 construction areas, as well as the bank vane structures and the emergent habitat boulder fields downstream of Pearl Street.
- The Dam 2 construction area would be accessed directly from the staging area. Temporary scour protection at the Gillett Bridge piers would be accessed by tracking on the river bottom.
- The contractor will be required to have construction equipment equipped with Global Positioning Systems (GPS) to ensure all construction and in river tracking is within the direct impact areas outlined in this BA.
- Wetlands that are within direct impact areas would be covered with timber mats before any causeway construction or tracking on the river occurs.

To maintain flow conditions for in-river work and avoid and minimize potential temporary increases in tailwater elevations at 6th Street Dam, the following construction sequencing has been developed.

Causeways would be installed before removal of dams or construction of proposed improvements. Construction of proposed improvements could then occur at any location downstream of Dam 3 as the first construction activities, with the Dam 2 feature being prioritized first (if construction begins in spring/early summer). Installation of the access causeway and construction of proposed improvements to Dam 3, including the removal of the dam, would not occur until the cofferdam within the Dam 2 construction area is removed and the contractor is confident the Dam 2 feature will be completed within the same construction season. The installation of the access causeway and the removal of Dam 4 would not occur until the Dam 2 feature has been fully constructed.

Flow velocity may increase when the Dam 2 cofferdam is in place, potentially increasing scour around the Gillett Bridge piers. Therefore, temporary scour protection has been included at the

eastern three bridge piers. Access to these piers would extend from the causeway along the west bank. Scour protection would extend around the three eastern most piers to twice the pier width (4.4 m; 14.4 ft). Scour protection would be installed before the Dam 2 area is isolated in July/August (after sea lamprey (*Petromyzon marinus*) spawning season). The temporary causeway and scour protection would be removed before the end of the construction season at the latest (not left in over winter). The additional material in the river has been modeled to have minor (0.01 ft) impact on tailwater elevation at 6th Street Dam and would not be in the river during sea lamprey spawning season.

Isolation measures at Dam 2 would be installed when the water temperature is > or = to 20°C and no earlier than July 1st, which corresponds to when the sea lamprey migration season ends. The NRCS, the City, and GRWW, will coordinate installation activities with the USFWS Sea Lamprey Control Program. Isolation measures would be removed immediately following the completion of the work on the west side of Dam 2. Construction within the isolation measures is anticipated to require approximately three weeks. The isolation measures would not be left in the river overwinter. The modeled impacts to tailwater at 6th Street Dam were evaluated and considered at length during the development of the construction sequencing and modeled increases in tailwater have been avoided and minimized to the greatest extent practicable. The Dam 2 construction area would be accessed from the Ah-Nab-Awen Park staging area via an access ramp. Temporary causeways of clean imported aggregate would be constructed around the outside of the area to be isolated for construction of the diversified boulder arches, and around the construction area for the east side riffle feature. A cofferdam constructed of aggregate bags filled with clean imported material would be installed inside the causeways. The causeways cannot be used to isolate the area, as the rock used for the causeway is too permeable. Aggregate bags cannot be used for the causeway, as they are not designed to hold construction equipment.

Fish would likely move out of this area during construction of the causeway. However, once the area is isolated, it will be electrofished and/or seined to remove as many fish that remain as practicable. Unionid mussels would be collected and translocated (the City/GRWW Project). Water would then be pumped out. A screen would be placed around the pump and a net around the pump area to limit entrainment of fish. During pumping, if fish remain in the area, a crew would be on site to collect and remove fish from the isolated area. Because the lack of flow and potentially increased water temperature may stress unionid mussels inhabiting the isolated area, sufficient personnel would be on site to limit the unionid collection time to less than 10 days.

Once mussels are removed from the isolated area, Dam 2 would be removed, and a diversified hydraulic structure would be constructed at its location. The proposed structure would include constructed riffles with emergent habitat boulders on either side of a series of boulder arches and scour holes. Once the west side is complete, the cofferdams would be removed and the proposed improvements on the east side would be constructed, using previously installed causeways to access.

On the east side of the river, Dam 2 would be demolished and removed, and the proposed riffle structure would be constructed. The riffle would be constructed of stable imported alluvium and stabilized with imported riprap with a D50 of 30 cm (12 in), with large emergent habitat boulders placed throughout. Riffle slope would be 50:1. The isolation measure and causeways would be removed following the completion of Dam 2 feature construction. Temporary causeways would be removed following construction.

Causeways to, and along, Dams 3 and 4 would be installed and the dams demolished and removed. The channel upstream of the dams would be regraded after dam removal. Emergent

habitat boulders would also be placed within the Dam 3 removal and regraded area. Dam 3 would be accessed from the north end of Ah-Nab-Awen Park, and Dam 4 would be accessed from a temporary causeway extending from the park to Dam 4. Temporary causeways would be removed following construction.

Dam 1 would be demolished and removed and replaced with a riffle. The Dam 1 construction area would be accessed via a causeway that would run from Ah-Nab-Awen Park along the west bank to the Dam 1 construction area. Temporary causeways would be constructed on the upstream and downstream sides of the proposed riffle feature. The low-head dam would be demolished and removed. The riffle would be constructed with stable imported alluvium, and stabilized with imported riprap (D50, 30 cm [12 in]), and have a slope of 50:1. Emergent habitat boulders would be placed throughout the riffle. Temporary causeways would be removed following construction.

Two emergent habitat boulder fields would be constructed between Pearl and Fulton Streets. Both areas would be accessed from a causeway extending from Ah-Nab-Awen Park to the construction areas. Emergent habitat boulders on the west side would be placed from the causeway, while boulders on the east half of the river would be placed while tracking in the river. Boulder vanes would be constructed upstream and downstream of Grand Rapids Public Museum Carousel and on the east bank to create slack water for public access to the river.

Between Blue and Fulton Street, diversified boulder arches would be created on the west side of the river and emergent habitat boulder field on the east side. Access would be provided by extending the causeway along the west bank downstream of Blue Bridge. The emergent habitat boulder field would be constructed by tracking in the river.

Once features are in place, some changes in depth and flow would result. Depths upstream of Bridge Street would be faster and shallower than existing conditions. Tailwater elevations at 6th Street Dam are expected to be lowered, maintaining the existing sea lamprey barrier effectiveness (June 2024 BA Table 2-3 and 2-4). The regraded area and emergent habitat boulder field in the area of Dams 3 and 4 would be deeper and slower. Flow velocity would also be slower between the Dam 3 and Dam 2 features. Downstream of the Dam 2 features, the area near the bank would be slower, with some deeper holes developing downstream of the diversified boulder arches. However, these scour holes are all within the direct impact area. The area between Dam 2 and Dam 1 features would be slightly deeper and slower. Throughout the project reach, flow conditions would be more diversified than under existing conditions. Flow depths downstream of Pearl Street would be similar to existing conditions.

The Project was designed to minimize long-term Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRRR). Operation includes regular monitoring, inspections, data collection and reporting. These activities would not require any tracking of equipment into the riverbed and would therefore not affect unionid mussels. Maintenance includes routine, planned and scheduled upkeep of project features, equipment, or supplies necessary to maintain proper functionality of project elements. The proposed grading is anticipated to adjust to post-construction hydraulics and some localized scour and deposition may result, along with slight shifts in boulder and riprap. This is expected, and features would be left alone to adapt to river conditions. No routine maintenance is anticipated.

Repair is for currently unanticipated corrections resulting from unforeseen circumstances that are outside the design assumptions of the project. Rehabilitation is to correct anticipated shifting, wear and tear, weathering, or materials degradation by resetting features, augmenting features with additional materials, or refurbishing of features or components. Replacement includes

removal, demolition and disposal, and replacement of project features or components that cannot be repaired or rehabilitated.

Repair, rehabilitation, and/or replacement that could require instream activity would be scour or deposition that threaten public safety (flood threats, bank access, or adverse hydraulics for recreation) or infrastructure (flood wall, bank, or bridge scour). Whenever possible, repair, rehabilitation or replacement of structures would be conducted from the riverbank or, if flows and depths allow, from floating work platforms floated upstream from the Butterworth ramp with minimal impacts to the river bottom. Any debris that might hang up on riffles, bridge piers, diversified boulder arches, or rock vanes would be removed by chain sawing in place and allowing debris to float downstream, or floating debris to the riverbank for removal.

Action Area

The Action Area is defined (50 CFR 402.02) as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action."

The Grand River is Michigan's longest river, with a drainage area of 14,256 km^2 (5,504 mi^2). It begins in northern Hillsdale County as a series of lakes and ends at Grand Haven, MI in Lake Michigan. Hanshue and Harrington (2017) divided the river into five mainstem valley segments based on common channel and landscape features; headwaters, upper, middle, lower, and mouth segments. The headwaters flow 87 km (54 miles) to the confluence with Sandstone Creek, the upper river flows 68 km (42 miles) from Sandstone Creek to Eaton Rapids upstream of Red Cedar River, the middle river extends 97 km (60 miles) down to the mouth of the Maple River, the lower river flows 113 km (70 miles) from the Maple River to the Village of Lamont, and the mouth of the river continues for 40 km (25 miles) from Lamont to Lake Michigan.

Table 1. Action Area Description Reference Summary

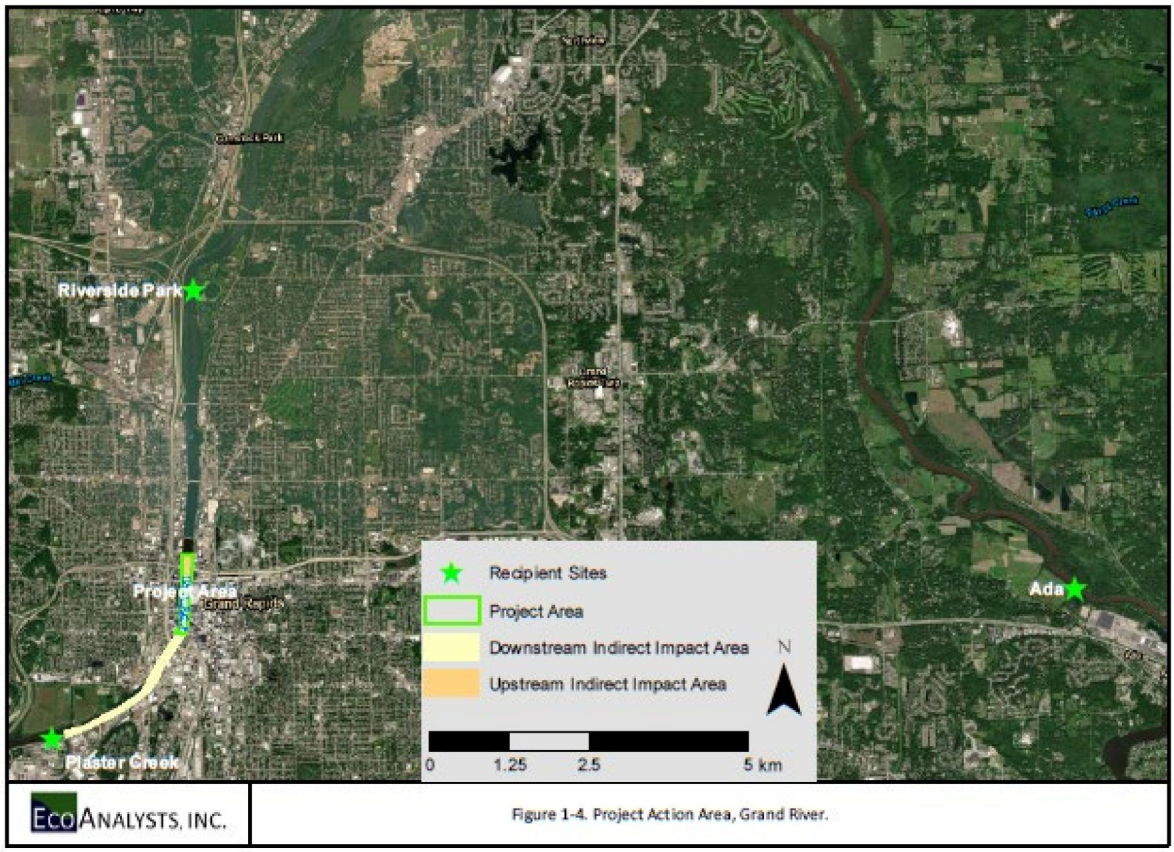
Reference Name	Location	Notes/Subcategory	Area (m^2) within Grand River
Upstream indirect impact area	Upstream edge of the Construction Area upstream to the 6th Street Dam	May experience nominally altered local hydraulics	38,420 m^2
Construction Area	300 ft upstream of Bridge Street Bridge downstream to the upstream edge of the Fulton Street Bridge	Construction indirect impact area (may experience temporary increases in turbidity during construction and altered local hydraulics)	80,185 m2
		Construction Direct impact area (physically disturbed by construction)	47,415 m^2
Downstream	Upstream edge of	Impacted by	282,600 m^2

indirect impact area	Fulton Street Bridge to the mouth of Plaster Creek	increased turbidity during construction	
Mussel Relocation Recipient Sites	Ada, Riverside Park, Plaster Creek	Sites where translocated mussels would be placed	12,050 m^2
Staging and access areas	Ah-Nab-Awen Park and some equipment may be staged north of I-196 on the east side of the river	Access to the river will only be from the park.	N/A

The USFWS has determined that the Action Area for the NRCS WFPA Project begins at Plaster Creek, 2.5 km (1.5 miles) below Fulton Street and will extend to the 6th Street Dam. The Action Area for the City/ GRWW Project includes all direct impact areas where mussels will be salvaged as well as 3 recipient sites for relocated mussels. The direct impact areas generally can be described as within the portion of the NRCS WFPA Project Action Area between Fulton Street and extending just upstream of Bridge Street. The portion of the NRCS WFPA Project Action Area from the mouth of Plaster Creek to the upstream edge of the Fulton Street Bridge will be indirectly impacted by turbidity increases during construction. The actual in river construction area for the NRCS WFPA Project is within the wetted channel of the Grand River between Bridge and Fulton Street bridges in Grand Rapids, Kent County, Michigan. Of this area (127,600 m2 (31.5 acres), 47,415 m2 would be directly impacted during construction (direct impact area). This is approximately a 50% reduction in construction impact area from the previous design, 89,195 m2 (22 acres). The river bottom would not be physically modified in approximately 80,185 m2 of the construction area (Construction Indirect Impact Area) but could be affected by turbidity and changes in local hydraulic conditions. Staging and access areas would primarily be from Ah-Nab-Awen Park. Some equipment may be staged north of I-196 on the east side of the river, but access to the river will only be from the park. The downstream indirect impact area that could be affected by turbidity increases during construction is conservatively estimated as 2.5 km (1.5 miles) from Fulton Street to Plaster Creek. The upstream indirect impact area between the 6th Street Dam and just upstream of Bridge Street would be affected by slight changes in hydraulics includes approximately 38,420 m2 (9.5 acres).

The three recipient sites for relocated mussels are also included within the Action Area. One site is downstream of Fulton Street between Plaster Creek and the M-11 Bridge. The other two sites are upstream of the 6th Street Dam; one is in Ada, 0.6 miles downstream of the Thornapple River on the left descending bank and the other is at Riverside Park on the left descending bank, 1 mile upstream of Ann Street in Grand Rapids.

Figure 1: WFPA and the City/GRWW Action Area (Source: Ecanalysts Inc. 2024 BA, Figure 1-4)



Conservation Measures

Conservation Measures are part of the proposed action; therefore, we consider them in the analysis of effects. The BA includes a list of Conservation Measures outlined below summarized for both proposed actions. Several Conservation Measures are described in greater detail following outlined measures:

1. NRCS WFPA Project - The project has changed from most of the Project Area being isolated and impacted directly (89,195 m2 direct impact Area; EcoAnalysts, 2020) to direct impact area of only 47,415 m2, a 50% reduction in area affected by the project. Rather than the river being constrained by isolation measures during construction, construction would occur in the flowing river. Only a small area (3,285 m2) at Dam 2 would be isolated during construction (June 2024 BA Table 2-9), and the area would not be isolated during sea lamprey migration season.
2. NRCS WFPA Project - Causeways have been removed from the isolated area construction design for less impact on unionid mussels, allowing more mussels to be translocated from within the isolated area.
3. NRCS WFPA Project - The footprint of causeways have been moved to overlap with proposed grading limits where possible to further reduce impacts to the river bottom.
4. NRCS WFPA Project -The number of habitat boulders has been reduced, reducing the construction impact area.
5. NRCS WFPA Project and the City/GRWW Project - Construction sequencing has been

postponed to 2025 to allow the most time possible for unionid translocation under the City/GRWW Project in 2024. In 2025, if needed, the translocation team would work with construction managers to allow mussels to be translocated before an area is under construction.

6. NRCS WFPA Project - Wetlands have been avoided to the greatest extent possible. Those that fall within direct impact areas would be covered with timber mats before any causeway construction or tracking on the river occurs.
7. NRCS WFPA Project - Construction sequencing has been changed to maintain the river grade and prevent scouring, but still maintain existing tailwater elevations during sea lamprey migration season.
8. The City/ GRWW Project - To reduce impacts to fish, fish would be salvaged from the isolation area before it is dewatered.
9. The City/GRWW Project - To prevent fish entrainment while dewatering the isolated area, a screen would be placed around the pump and a net around the pump area.
10. The City/GRWW Project - Mussels would be removed from the isolated area after water levels are reduced. Sufficient personnel would be on site to ensure mussels are removed within a 10-day period to prevent stress due to lack of flow and increased water temperatures.
11. The City/GRWW Project - Mussels in direct impact areas would be translocated under the City/GRWW Project.
12. The City/GRWW Project - Mussels not relocated would be compensated through a mitigation fund.
13. NRCS WFPA Project - Constructed features would be allowed to adjust to post-construction hydraulics, and no operation or maintenance would be required, reducing impacts to the river bottom post construction.
14. NRCS WFPA Project - Erosion and sediment control measures would be used in accordance with the Michigan Unified Keying System and approved by the City's Stormwater (NREPA Part 91) reviewers.
15. NRCS WFPA Project - Vegetation removal would only occur within the staging areas and would be minimized as much as practicable to provide access and limit any safety concerns.
16. NRCS WFPA Project - Construction staging and stockpile areas would be established, as well as areas for storage of spare oil booms and designated oiling and petroleum handling areas outside of the riparian zone.
17. NRCS WFPA Project - These areas would be isolated from the river using BMPs such as silt-fences, straw wattles, and berms. The contractor would also establish and post protocols for potential oil spill cleanup and emergency response.
18. NRCS WFPA Project - Runoff from equipment maintenance and storage areas would be directed to stabilized outlets designed to adequately convey the volume discharged. Heavy equipment would be well maintained to prevent leaks. Vehicles or other equipment would not be washed at locations where the runoff would flow directly into a watercourse or separate storm sewer.

19. NRCS WFPA Project - Construction materials, including topsoil and chemicals, would be stored, covered, or isolated to prevent runoff of pollutants and contamination of groundwater. Empty canisters, cans, or other chemical containers (e.g., hydraulic fluids, etc.), scrap wood, scrap metal, and all other waste materials would be disposed of daily or kept in sealed waste containers until they can be properly disposed of off-site, such as in a landfill. Waste materials would not be buried on-site.
20. NRCS WFPA Project - Prior to entering the watercourse, all equipment would be washed under high-pressure water with a non-harmful and biodegradable degreaser. Once in the watercourse, equipment would be inspected frequently and maintained properly to ensure no grease, oils, or chemicals are entering the watercourse. If equipment is leaking such fluids, it would be removed from the water course and repaired prior to re-entering. Equipment regularly traversing in and out of the watercourse would be cleaned under high-pressure water (i.e., wheel washing station) at a minimum once per week. Biodegradable hydraulic fluid fuel would be used in any equipment entering the water. If needed, oil booms may be placed downstream of any equipment working in the wet.
21. NRCS WFPA Project - Construction equipment would be equipped with Global Positioning Systems (GPS) to ensure all construction and in river tracking is within the direct impact areas outlined in this BA.
22. NRCS WFPA Project - Silt curtains would be used downstream of construction areas within the Project Area to reduce downstream turbidity.
23. NRCS WFPA Project - Turbidity would be monitored downstream of construction areas and in the downstream indirect impact area.

Conservation measure #8 the City/GRWW Project: Fish Salvage Plan

A small area (3,285 m2) at the Dam 2 diversified boulder arches needs to be isolated for construction. Without fish salvage, fish would be trapped in the isolated area and would die during construction. Some fish would leave the area due to construction activity disturbance during construction of causeways. Once the area is isolated, a team of biologists would electrofish and/or seine the area to remove as many remaining fish as practicable. To protect any remaining fish from impingement or entrainment by pumps, a screen would be placed over the pump and a net would be placed around the pump area. A biologist team would remain on site to collect and remove any fish that remain trapped during the water drawdown. All live fish would be identified, counted, and released into the flowing channel.

Conservation measure #10 and 1, the City/GRWW Project: Mussel Salvage Plan

Collection and Translocation Safety Limitations and Timing

The mussel collection and translocation effort would be limited by flow velocity. Safe diving/snorkeling areas would be determined based on the evaluation of the dive crew on site. If a diver/snorkeler cannot hold position, conditions would be considered unsafe. Attempts to maximize translocation efforts and efficiencies would occur if divers/snorkelers and the dive supervisor deem the hydraulic conditions safe. Portions of the direct impact area that are predicted to be ≤0.6 m/sec (2 ft/sec) at 2,500 CFS would be used a guide for dive safety, but use judgement to determine if they could work safely further riverward. The area worked would be as large as possible while maintaining diver/snorkeler safety. Divers/snorkelers would prioritize areas based on mussel abundance (highest abundance areas first), and secondly areas that that would be constructed first (Dam 1 and 2 construction area and access causeways). Additional areas would be worked as flow

conditions and time permit. One translocation crew would mobilize once flow rates are predicted to remain below 3,000 CFS for 7 days or more; a flow rate with a higher probability of occurring and at least some area being safe for collecting mussels. The mussel translocation crew would evaluate safe diving conditions at 3,000 CFS and determine the amount of area that could safely be worked. If more than 7 days of area is available, additional crews would be mobilized and mussels would be removed from as much of the direct impact areas as possible. As flows decline and additional area is workable, up to four crews would be mobilized to maximize the area that mussels could be translocated from before construction. Once translocation begins, if flows are predicted to remain above safe diving conditions as determined by the translocation crew (approximately 3,000 CFS) for 7 days or more, translocation crews would demobilize and plan to return to the site once flows are predicted to be at or below safe levels for 7 days or more. In 2025, construction would be prioritized. If mussels in parts of the direct impact areas were not collected and translocated in 2024 and river conditions are determined to be safe for collecting in 2025, the translocation crew would coordinate closely with the construction manager to determine areas where mussel collection could occur safely without interfering with construction. Mussel translocation would occur within the isolated area around Dam 2 unless flows and time allow mussel translocation to occur prior to construction of the isolation structure. Mussels would be collected after isolation and before water is drawn down. Sufficient personnel would be on site to remove as many mussels as practicable within 10 days.

Collection and Translocation Methods

Collection and translocation of mussels would occur when water temperature is above 10° C (50° F) and air temperature is between 10 and 32° C (50 and 90° F) unless permission is obtained from USFWS and MDNR to translocate outside of these temperature windows. Water temperature and water clarity would be recorded within each collection area and at the recipient sites. Each direct impact area would be divided into 5 x 10 m blocks within workable flow areas as determined by divers/snorkelers on site. Workable flow would be defined as current velocity in which the diver/snorkeler can maintain position (not be swept downstream) within the block and collect mussels. Blocks would be further divided into smaller 2 m x 1 m grids using a 3/8-inch metal that would lay flat on the river bottom grid. Each 2x1 grid is split into 1m x 1m cells and would be searched individually. Use of smaller blocks rather than a moving transect would allow collectors/snorkels to systematically search an area, but also stay within irregular search areas. Each of the 1 m x 1 m cells would be visually searched for habitat and mussels (visual search). If no habitat (i.e., bedrock or entirely non-movable rock) is found, then that 1 m2 is clear. If habitat and/or mussels are found, that 1 m2 would be excavated down to 15 cm (6 inches), collecting any mussels that are found (first pass) within an average search effort of 2 min/m2. Excavation would include moving cobble and woody debris and moving away silt, sand, and small detritus, then digging the substrate down at least 15 cm (6 inches). That 1 m2 would be excavated a second time (second pass) for an average of 2 min/m2, and if <5% of the mussels are collected on the second pass compared to the completed first pass and no state and federally listed species are found, then the 1 m2 would be declared clear. If not, it would be searched again until the <5% criteria and no state and federally listed species found threshold is reached. Searching would require an average of 2 min/m2. Once the entire 2 m x 1 m grid is clear, the 2 m x 1 m grid would be moved to the next 2 m x 1 m.

“Clear” would be defined as

1. Area is bedrock or non-diggable rock on the visual search;

2. No mussels >0.5 inches are found on the completed first dug up pass (divers/snorkelers would strive to collect all mussels, but can only have high confidence that mussels >0.5 inches would be collected);

3. Mussels are found after digging up the area (first pass), but <5% of the total number of mussels >0.5 inches found on the first pass are found after the area is dug up again (second pass) AND no State and federally listed species are found;

4. Passes continue until <5% criteria of the completed first pass is met and no state and federally listed species are found.

All areas within the direct impact areas that are deemed safe by the snorkeler/diver will be searched as above. Once an area is deemed unsafe it would not be worked unless river conditions improve. Collected unionids would be held in flowing water or in flow through tanks (under ambient water conditions) while awaiting processing and/or translocation. Unionids would be processed within a few hours of collection. All collected state and federally listed mussels would be tagged, measured (length in mm), and aged (external annuli count). State listed species would be tagged with shellfish tags, and Snuffbox will also be tagged with Passive Integrated Transponder (PIT) tags. Common species would be identified, counted, and marked with a Dremel tool (slash on the anterior ventral edge of the shell to assess growth).

Unionids would be translocated to recipient sites at the end of each day or beginning of the following day wrapped in moist towels within coolers. Once at the site, common species would be spread on the bottom by a diver/snorkeler within a defined area at a density not to exceed 1 unionid/m2 (either marked with buoys or GPS points). State and federally listed species would be hand placed on the substrate within their assigned area at a density of 1 unionid/m2. Hand placing unionids on the substrate rather than in holes dug by the diver/snorkeler allows the animal to select where it wants to be burrowed and previous studies indicate no difference in mortality or recovery with this method (Dunn et al., 2000). Based on previous translocations (H. Dunn, personal communication), 80% of the unionids within each collected area should be collected and survive translocation (estimated 15% not collected and 5% mortality of those collected). A report would be prepared within 45 days of completion of each year's translocation.

Recipient Site Selection

A survey was conducted in 2015 to identify suitable recipient sites for mussels that would be relocated from within the proposed action area (ESI 2016).

Five potential sites were identified; Ionia, Saranac, Chief Hazy Cloud, Ada, and Site 7. Of these, Ada is the largest (23,480 m^2 [5.8 acres]) site, and most of the state and federally listed species were found at this site. The best habitat within the Ada bed is 3,400 m^2 (0.8 acres) mid channel. Thirty-four (34) 10 m x 10 m areas would be established using corner markers driven into the substrate and either PVC pipe or ropes between the corner markers within this section of the site for the placement of state and federally listed species. State and federally listed species would be randomly placed 1 mussel/m^2 into the 10 x 10 areas. A PVC grid with 1 m^2 cells would be used to locate each random position within the 10 x 10 area. The remainder of the site would be used to place common species. Density within this site averaged 2.8 mussels/m^2. If density is increased no more than 50%, the site can accommodate 4,760 state and federally listed individuals and 21,000 common individuals.

Species that were not found at Ada include Pink Heelsplitter, Lilliput, Deertoe, Paper Pondshell. Pink Heelsplitter was not found at any of the investigated sites, and Deertoe was only found at Saranac. Freshwater Drum is the host for both Pink Heelsplitter and Deertoe and is sparse upstream of the 6th Street Dam (Hanshue and Harrington 2017). These species should be moved to a site just downstream of Plaster Creek. JFNew (2013d) found both of these species at the I-

196 Bridge project site. A 10 m x 10 m grid will be established, and these species will be placed in the grid within the Plaster Creek recipient site. Permanent corner markers and additional markers between the corner markers.

Animals will be able to move freely within and outside of the grid. Lilliput and Paper Pondshell are both species that occur near the bank in siltier habitat. Neither of these species were found in the Construction Direct Impact Area, but they could occur at a low frequency. Several Lilliput were collected at Riverside Park, and habitat suitable for Paper Pondshell is available. If these species are found in the Construction Direct Impact Area they will be moved to Riverside Park. A grid will be established, and these species placed in the grid.

Monitoring

Translocated unionids would be monitored within one year following each year's translocation (2024 and if needed 2025) between June and October 15 when water temperature is greater than 10° C (50° F), and air temperature is between 10 and 32° C (50 and 90° F). Up to 100, 1 m2 cells in each recipient site would be randomly selected for monitoring. A PIT tag wand would be first used to find and collect Snuffbox. A diver/snorkeler would systematically search each selected 1 m2 area. A PVC grid with 1 m2 cells would be used to facilitate searching. Since excavating all cells may destabilize substrate and render habitat unsuitable for mussels, at least 10 1-m2 cells within each area would be excavated to calibrate surface to buried ratio. The remainder would be surface searched (visual, tactile, moving rocks, logs, probing the top inch) for at least 1 minute/m2. All collected unionids would be checked for tags, recorded as tagged or not tagged, measured (length in mm), and aged (external annuli count), and Lampsilini would be checked for gravidity.

Conservation Measure 12, the City/GRWW Project: Mitigation Fund

Snuffbox and state listed species, will be negatively impacted by the NRCS WFPA Project and the City/ GRWW Project even if all direct impact areas are salvaged at 85% collection efficiency with less than 5% mortality. An additional number of Snuffbox and state listed species would be negatively impacted during repair, rehabilitation, or replacement operations, if necessary. The intended design of the proposed action to enhance habitat for aquatic species. However, there is a significant amount of uncertainty regarding creation of aquatic habitat. The actual project impacts and benefits to state and federally listed mussels cannot be anticipated given the complexities affecting the presence of mussel communities. It is uncertain what the actual as-built river features performance will be in terms of suitability for mussel-host fish presence and movements, substrate changes, maintenance activities, impact of new hydraulics on habitat, and influence of the project on sea lamprey escapement.

A fund for conservation measures that have significant benefits for mussels in the lower Grand River will be established to mitigate the loss of state and federally listed species. The purpose of the fund will be to support conservation measures that significantly benefit state and federally listed mussels after completion of the NRCS WFPA Project.

A mitigation fund would be established to offset the take for the mussels that were unable to be translocated under the Grand Rapids/GRWW Project. As many mussels as possible would be collected from direct impact areas and translocated to one of the three recipient sites under the Grand Rapids/GRWW project. The estimated area of direct impacts is 47,415 m2. Using an average unionid density of 0.3 unionids/m2, approximately 14,224 unionids occur within direct impact areas. Mussels would at least be collected and translocated from within the isolated area for Dam 2. Up to 15% of those mussels may be missed during collection, and up to 5% might die due to handling.

The maximum mitigation fund contribution would be based on $34.10/mussel (2020 BA $28.50/mussel escalated for inflation) and would not exceed $456,743 (Table 2-13 in the 2024 BA updated). This fund would be reduced by the amount of mussels that are translocated multiplied by the cost per mussel as stated above. This fund would be reduced by the amount of mussels that are expected to survive translocation (i.e., relocated minus the 5% of relocated animals anticipated to be lost due to handling stress). The mitigation fund contribution may not be reduced by a percent greater than the percent of area cleared (i.e., area of quadrats cleared from the total area of the direct impact areas). Prior to reducing the funding, the proportion of areas cleared as result of a determination of non-diggable rock must be compared to prior survey efforts to help ensure that estimates of mussels impacted are consistent with the 2024 BA. The objective of the mitigation fund would be to fund projects that provide a direct benefit to mussels to achieve the USFWS "no net loss" policy and offset any potential impacts from mussels that were unable to be translocated. The work performed through the mitigation fund would help inform future conservation and habitat restoration efforts. The USFWS, NRCS, and MDNR, would act as decision makers for the mitigation fund to determine what mitigation projects are selected for implementation. Priority would be given to projects that provide a direct benefit to mussels within the NRCS WFPA Proposed Action Area or the Lower Grand River Watershed. Specific mitigation activities, and mitigation fund management protocols would be developed in coordination with appropriate regulatory agencies.

The City and GRWW are interested in the long-term success of these habitat restoration efforts and would like to continue to partner with the USFWS, NRCS, and MDNR, on potential future projects that benefit mussels in the NRCS WFPA Project Area. The City and GRWW would advance the goals of the mitigation fund by encouraging local scientific partners including, but not limited to, the Grand Valley Metropolitan Council, Grand Rapids, Public Museum, John Ball Zoo, Grand Valley State University, and Trout Unlimited, to apply to the mitigation fund for projects that directly benefit mussels and the advancement of habitat restoration efforts in the Lower Grand River Watershed. An initial deposit would be made to the mitigation fund following the completion of the 2024 mussel translocation efforts based on the collection efficiency. A second and final deposit to the fund covering the balance of the required mitigation fund would be made following any mussel translocation activities that occur during the 2025 construction season. Any excess funds of the initial deposit would be returned if the mussel translocation exceeds the estimated collection efficiency. The financial assurance shall take the form of proof of funding deposited into an escrow account, City of Grand Rapids Commission Resolution, proof of deposit and an executed agreement with a Non-Government Organization, or another agreed upon form of financial assurance documentation.

STATUS OF THE SPECIES

Per ESA section 7 regulations (50 CFR 402.14(g)(2)), it is the USFWS's responsibility to "evaluate the current status and environmental baseline of the listed species or critical habitat." The USFWS listed the Snuffbox mussel as endangered on February 14, 2012 (77 FR 8632). Critical habitat has not been designated for this species. The following is a summary of Snuffbox general life history, distribution and status, and threats to the species.

Species Description and Life History

Snuffbox is a small- to medium-sized mussel, with males reaching lengths up to 7 cm (2.8 in) and females reaching only 4.5 cm (1.8 in; USFWS 2022). Snuffbox are sexually dimorphic. The shell is triangular (males) to ovate or oblong (females) with solid thick and inflated valves (USFWS 2022). The beak sculpture consists of three or four faint double looped bars. The

periostracum is typically yellowish, becoming darker with age, and is marked with dark green rays, blotches, or chevron-shaped markings (Carman and Goforth 2000; USFWS 2012; Ecoanalysts Inc. 2020).

Snuffbox typically occur in small- to medium-sized streams and rivers in higher flow areas of riffles and shoals (Cummings and Mayer 1992; Parmalee and Bogan 1998; Ecoanalysts Inc. 2020). Snuffbox are often observed deeply buried in the substrate, except during spawning periods (Parmalee and Bogan 1998; Ecoanalysts Inc. 2020). Adults are suspension-feeders, spending their entire lives partially or completely buried within the substrate feeding on algae, bacteria, detritus, microscopic animals, and dissolved organic material (USFWS 2022). Juvenile mussels utilize foot (pedal) feeding, consuming algae and detritus (USFWS 2022).

Reproduction starts with males releasing sperm into the water. The sperm enter the female through the incurrent siphon tube, and the eggs are fertilized internally, larvae are called glochidia (USFWS 2022). Female Snuffbox are bradytictic (long-term brooders), which means they hold the glochidia in their marsupial gills from approximately September-May (USFWS 2022). Snuffbox spawning and fertilization has been documented from mid-July to August. Unionids require a host species to complete reproductive life cycle. The Snuffbox preferred host is logperch, though in the laboratory setting they have used other darter and sculpin species (USFWS 2022). The Snuffbox's life cycle includes a brief, parasitic stage on logperch, glochidia are released by the female and encyst on the gills of logperch until they drop off as newly transformed juveniles. Glochidia typically encyst on logperch from approximately mid-May through July. Data from the Clinton River observed glochidia release starting on May 17th with a water temp of 62ºF, continuing through early-mid July (Sherman 1994; USFWS 2013).

Logperch adults prefer relatively shallow, swift riffles or raceways with gravel substrate, which corresponds with habitat where Snuffbox often occurs, but are also common in lakes and impoundments.

Distribution and Status

The Species Status Assessment (SSA) for Snuffbox was completed by the USFWS in 2022. The SSA summarizes the best available scientific information on the biological condition and viability of the species. The analysis of the current condition of Snuffbox in the SSA was conducted at the U.S. Geological Survey hydrologic unit scale (HUC) of HUC8, which is at the subbasin scale. Demographic population condition was assessed as high, moderate, low, or verylow/functionally extirpated based on specific criteria and estimated a probability of persistence over 2 lifespans of Snuffbox (40 years) (USFWS 2022). Five primary risk factors were also evaluated including water quality/contaminants, hydrological regime, landscape, connectivity, and invasive species (USFWS 2022). Risk factors were assigned a category of high, moderate, or low, and assigned a probability of persistence over 50 years (USFWS 2022).

Snuffbox was historically known from 211 streams and lakes in 18 states and Canada (USFWS 2018). Snuffbox is currently considered to be extant in 83 streams in 14 states (Alabama, Arkansas, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Wisconsin) and Ontario, Canada (USFWS 2018, USFWS 2022). The current condition is summarized at the HUC8 scale as following: Great Lakes basin has 11 extant populations; of these, 4 are at high risk, 5 are at moderate risk, and 1 is at low risk (one population in Canada was not able to be fully analyzed); Ohio basin has 30 extant populations; 13 of which are at high risk, 15 are at moderate risk, and 2 are at low risk; Tennessee basin has five populations, three at high risk and two at moderate risk; Upper Mississippi basin has four populations, and the Lower Mississippi basin has one population, and

all populations in these basins are at high risk (USFWS 2022). The Arkansas-White-Red basin has four populations, two are at high risk, one is at moderate risk, and one is at low risk (USFWS 2022).

Threats

The conservation needs of Snuffbox are summarized in the table below taken directly from the Snuffbox SSA (i.e., "Table 2.1 Individual Needs for the snuffbox") (USFWS 2022):

Table 2.1. Individual Needs for the snuffbox.

Life Stage	Resources Needed to Complete Life Stage	Source
Fertilized eggs - spring	• Clean, flowing water • Sexually mature males upstream from sexually mature females • Appropriate spawning temperatures.	Berg et al. 2008, p. 397 Haag 2012, pp. 38–39
Glochidia - late fall to spring	• Clean, flowing water • Presence of host fish for attachment.	Strayer 2008, p. 65 Haag 2012, pp. 41–42
Juveniles - excystment from host fish to approx. age 3-4	• Clean, flowing water • Host fish dispersal • Appropriate interstitial chemistry; low salinity, low ammonia, low copper and other contaminants, high dissolved oxygen. • Appropriate substrate (clean gravel/sand/cobble) for settlement	Dimmock and Wright 1993, p. 188–190 Sparks and Strayer 1998, p. 132 Augspurger et al. 2003, p. 2,574 Augspurger et al. 2007, p. 2,025 Strayer and Malcom 2012, p. 1,787–1,788 Schwalb et al. 2011, entire
Adults - greater than ~ age 4	• Clean, flowing water • Appropriate substrate (stable gravel and coarse sand free from excessive silt) • Adequate food availability (phytoplankton and detritus) • High dissolved oxygen • Appropriate water temperature	Yeager et al. 1994, p. 221 Nichols and Garling 2000, p. 881 Chen et al. 2001, p. 214 Spooner and Vaughn 2008, p. 308

As described in the USFWS Snuffbox 5 Year Review (USFWS 2018), at the time of listing, destruction, modification, and curtailment of the species range was considered to be a threat to the species, primarily due to the construction of impoundments. While dam removals and other habitat restoration projects have improved habitat suitability on some Snuffbox streams, habitat loss and degradation continue to be one of the major threats to Snuffbox (USFWS 2018). Water quality degradation from point and non-point sources including agricultural runoff, municipal effluents, industrial sources, and spills continue to contribute sediment, organic compounds, heavy metals, pesticides, and a wide variety of newly emerging contaminants to the aquatic environment. Other factors contributing to the reduction in range include dredging and channelization, oil and gas production (including water withdrawal), and sand and gravel mining, and development. Exotic species pose a threat to Snuffbox and the host, including the zebra mussel, corbicula, round goby, and black carp, because of habitat modification, competition, and predation (USFWS 2018).

Zebra Mussels (*Dreissena polymorpha*) are native to the Baltic Sea and were introduced to the Great Lakes through the discharge of ballast water from ocean-going cargo ships. Zebra Mussels have rapidly colonized the Great Lakes, inland lakes, and rivers, which has resulted in

significant ecological impacts (Ecoanalysts Inc. 2020). Survival rates of native freshwater mussels have been shown to decline significantly with the increase in Zebra Mussel colonization (Hart et al. 2001a and 2001b).

In addition, there are other emerging threats such as disease and climate change. Little is known about diseases in freshwater mussels (Grizzle and Brunner 2009; USFWS 2018). However, mussel die-offs have been documented in Snuffbox streams, and some researchers believe that disease may be a factor contributing to the die-offs (USFWS 2018). Since listing, mussel die-offs have occurred in three Snuffbox streams including the Elk River (WV), Big Darby Creek (OH), and the Clinch River (TN) (USFWS 2018). The causes of these recent die-offs are not known. It is also not known if any Snuffbox were affected during these events (USFWS 2018). Factors associated with climate change are likely to affect regional mussel populations including changes in stream temperature regimes and precipitation levels that may indirectly result in reduced habitat and declines in host fish stocks (USFWS 2018).

Climate change has the potential to affect aquatic organisms and habitat in the Grand River. Climate change alters water temperatures, precipitation, streamflow patterns, water quality, and sediment loads (Jimenez Cisneros et al. 2014 as referenced in Ecoanalysts Inc. 2020). Climate predictions vary depending on the model used, though there are some shared similarities across models with respect to future predictions including a shift in precipitation from snow to rain (Jyrkama and Sykes 2007, Stewart 2009, Christensen et al. 2004 all as referenced in Ecoanalysts Inc. 2020), earlier snowmelt (Stewart 2009, Kunkel and Pierce 2010, as referenced in Ecoanalysts Inc. 2020), an increase in overall precipitation (Angel and Kunkel 2010, NOAA Technical Report NESDIS 142-3 2013, Stewart 2009, Pryor et al. 2014 as referenced in Ecoanalysts Inc. 2020), and warmer water temperatures (Jyrkama and Sykes 2007, Angel and Kunkel 2010, Kunkel and Pierce 2010, NOAA Technical Report NESDIS 142-3 2013, as referenced in Ecoanalysts Inc. 2020). Changes in streamflow, water quality, and temperature could alter mussel distribution, composition, abundance over time, and habitat as well as host fish habitat, distribution, and abundance (Ecoanalysts Inc. 2020). It is also possible that expansion of invasive species communities could result based on these climatic shifts expanding the threat posed currently to certain populations.

STATUS OF CRITICAL HABITAT

No critical habitat has been designated for this species.

ENVIRONMENTAL BASELINE

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

Status of the Grand River within the Action Area

The Grand River is the longest river in the State of Michigan, stretching approximately 248 miles through an approximately 5,575 square mile basin in the southwestern portion of Michigan's

Lower Peninsula before draining into Lake Michigan near Grand Haven (Hanshue and Harrington 2017). The River runs through the center of the City of Grand Rapids, located in Kent County, Michigan. The River stretches approximately eight miles through the city. Historically the rapids in Grand Rapids stretched for a little more than one mile with a nearly uniform decent. The rapids resulted from a bedrock outcropping (an approximately 20 to 50ft thick formation named "Bayport Limestone") with scattered granitic boulders and cobble (moved by glaciers from the Canadian Shield) (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). This bedrock formation appears to angle deeper underground as you move upriver; within the outcropping are layers that may have given the rapids a step-down appearance (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018).

The bedrock outcropping extends from about where, today, the water treatment plant is located through to Lyon Street (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). Below Lyon Street the river channel included several small islands. Downstream of the bedrock outcrop additional boulders and cobble likely continued to approximately where Fulton Street is today (near Fulton Street the river grade drops and sand and gravel may have accumulated over larger material) (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018).

Prior to modifications of the bedrock outcrop and rapids, in low water levels the river likely shallowly spread across this bedrock outcropping (e.g., the bedrock was noted to be above low water in many locations) and portions of the channel likely dried out occasionally as the width of the river contracted during extended dry periods (e.g., during the summer months) (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). Four of the City's dams were constructed to spread the river out during low water keeping the river bed always wet during the time when untreated sewage was discharged into the river (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). In high water levels, the river would have spread out beyond the current banks to side channels and out into the river's historically forested flood plain (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018).

At several locations in the river channel, limestone was quarried from the bedrock outcropping. A long linear quarry on the westside of the river from start upstream in-between Webster St NW/Myrtle St NW to about 10th St NW; another quarry was located just below the current 6th Street dam on the east-side of the river, and was approximately .5 acres in size (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). Additionally, large scattered glacial origin boulders that may have been in the channel would have likely been removed for construction purposes (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). The Grand River's channel in the downtown reach has been reduced by approximately 30% through fill, development, and building of flood walls (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018). Additionally, bridge piers and scour protection around the piers also affect the flow of water through the downtown reach (USFWS Michigan Field Office and Michigan Department of EGLE Lansing Pers. Comm. 2018).

The historical channelization of the Grand River and the construction of dams in Grand Rapids have limited the connectivity of the Grand River above and below the 6th Street Dam. These structures have also limited the abundance of boulders and riffles, which are considered habitat for host fish species necessary for the reproductive success of many native mussels in the Grand

River. The lack of contiguous habitat within and through the Project Area may have a negative impact on the distribution and reproduction of mussels throughout the project reach.

In general, the water quality in the Grand River has been degraded over time due to municipal, stormwater, and industrial discharges, Confined Animal Feeding Operations, nonpoint discharge, airborne deposition of pollutants, and localized degradation from contaminated sediments (Hanshue and Harrington 2017). These factors have created a need to monitor the Grand River for environmental and human health parameters, including: water temperature, sediment and water chemistry, bacteria and pathogens. Within the lower reach of the Grand River, including Grand Rapids, there were 152 identified sites of environmental contamination, four solid waste landfills, 30 hazardous waste operations, and 123 oil and gas operations (Hanshue and Harrington 2017).

Status of Invasive Species in the Action Area

Sea Lamprey

Sea lamprey are native to the Atlantic Ocean and entered into the Great Lakes in the 1800's via manmade locks and shipping canals. Sea lamprey were first observed in Lake Ontario in the 1830s, but Niagara Falls served as a natural barrier preventing sea lampreys from entering the other Great Lakes (https://www.fws.gov/midwest/SeaLamprey/index.html). However, modifications to the Welland Canal in the early 1900s provided sea lampreys access to the other Great Lakes. In 1921 sea lampreys were first observed in Lake Erie and spread into Lakes Michigan, Huron and Superior (https://www.fws.gov/midwest/SeaLamprey/index.html). Adult Sea lamprey affix to prey fish and feed on their body fluids and tissues; often resulting in death of the host fish (Ecoanalysts Inc. 2020). Sea lamprey prey on most species of large Great Lakes fish such as lake trout, salmon, lake sturgeon, whitefish, burbot, walleye and catfish. The Great Lakes experienced a drastic decline in lake trout, whitefish and chub populations in the 1940s and 1950s brought on by overfishing, habitat degradation and the invasion of parasitic sea lampreys (https://www.fws.gov/midwest/SeaLamprey/index.html).

Adult sea lamprey do not feed during migration. Sea lamprey spawning habitat is characterized by steady, unidirectional water flow, and suitable gravel substrates with minimal sand (0.9 to 5.1 cm diameter; 0.4 to 2 inches), water velocity (0.5 to1.5 m/sec; 1.6 to 4.9 ft/sec), depth (13 to 170 cm; 5 to 67 inches), and temperature (10.0 to 26.1° C; 50 to 79° F) (Ecoanalysts Inc. 2020). Nest building begins when water temperature warms to 15° C (59° F) (Ecoanalysts Inc. 2020). Larval habitat is characterized by sandy areas with organic matter. Once larvae metamorphose, they swim out to the Great Lakes to feed.

In the Grand River the 6th Street Dam represents a barrier to sea lamprey at low flows and occurrence in the mainstem is restricted to the stretch of river downstream of the dam. Most of the Grand River downstream of Fulton Street has a sand substrate that could be used by sea lamprey, larvae have not been reported in the Grand River proper (Sullivan and Mullett, 2018, Ecoanalysts Inc. 2020). However, larval sea lamprey have been documented in tributaries upstream of Grand Rapids including Lowell Creek in 1962 and Rogue River in 2008, and 2022, and in Prairie Creek in 2022 (Barber and Steeves 2023; Hrodey et al. 2022). Rogue River was treated with lampricide in 2009 (Sullivan and Adair 2009). Larval lamprey were found in the Rogue River in 2022, and the area is expected to be treated with lampricide (Barber and Steeves 2023). The source of these escapement events is unknown (Barber and Steeves 2023). However, in 2006 the stop logs in the fish ladder stop log with lip were reconfigured to increase the drop for a more effective barrier (Barber and Steeves 2023). Several years after 2006, the steel lip at the top of the P. marinus barrier came loose and was replaced (Barber and Steeves 2023).

However, the loss of vertical drop needed for a sea lamprey barrier in the fish ladder still occurs at a lower river stage height than the main spillway (Barber and Steeves 2023). The 2022 larvae in Rogue River and Prairie Creek could have occurred in 2020 during a high discharge event (30,000 CFS in May 2020; Hrodey et al. 2022).

A two-year evaluation of larval and juvenile sea lamprey production potential was conducted in 2014 and 2015 to evaluate the production potential upstream of the 6th Street Dam (GLFC, 2015). The survey focused on finding native lamprey, which occupy the same habitat as P. marinus. Native lamprey were found in 463 km (287 mi) of the Grand River watershed upstream of the 6th Street Dam. Within that area there is approximately 2,957,701 m2 (730 acres) of Type I habitat (preferred mix of sand and fine organic matter) and 6,396,646 m2 (1,580 acres) of Type II habitat (acceptable shifting sand with no fine organic matter). Areas with Type I and II habitat include Bear Creek, Bellamy Creek, Crooked Creek, Fish Creek, Grand River, Honey Creek, Libhart Creek, Lowell Creek, and Maple River. If sea lamprey managed to successfully pass the 6th Street Dam, the Grand River could become one of the most productive sea lamprey tributaries to Lake Michigan (GLFC 2018, Ecoanalysts Inc. 2020). The chemicals used for sea lamprey control have the potential to significantly impact mussel communities and their hosts due to the lethal and sublethal effects caused by lampricides in both freshwater mussels and host fish (details included in the Sea Lamprey section below).

Zebra Mussels

Zebra Mussels (*Dreissena polymorpha*) are native to the Baltic Sea and were introduced to the Great Lakes through the discharge of ballast water from ocean-going cargo ships. Zebra Mussels have rapidly colonized the Great Lakes, inland lakes, and rivers, which has resulted in significant ecological impacts (Ecoanalysts Inc. 2020). Survival rates of native freshwater mussels have been shown to decline significantly with the increase in Zebra Mussel colonization (Hart et al. 2001a and 2001b). Zebra Mussels are found in the lower Grand River near the mouth and in the bayous. Woolnough (2015) reported Zebra Mussels only as weathered shells below Lyons Dam. Live Zebra Mussels were found at all sites sampled from Ionia though the Action Area, though at the time these sites were surveyed, infestation of native freshwater mussels was low (only a few freshwater mussels had attached Zebra Mussels) and only a few large Zebra Mussels (<10 per individual) were attached to native individuals (ESI, 2014, 2016, 2017, 2018; EcoAnalysts Inc. 2018). Flow regimes of the mainstem may prevent Zebra Mussels from becoming more established, as all dams on the mainstem are operated as run of the river dams and the variable flow that exists in this system is not conducive to colonization. However, recreational boating may represent a constant input of more Zebra Mussels into the river. The Flat River and lower Thornapple River, as well as many inland lakes within the basin, have also been invaded.

Status of Climate Change in the Action Area

Climate change has the potential to affect aquatic organisms and habitat in the Grand River. By altering the hydrological cycle, climate change alters water temperatures, precipitation, streamflow patterns, water quality, and sediment loads (Jimenez Cisneros et al. 2014). Climate predictions vary depending on the model used, though there are some shared similarities across models with respect to future predictions including a shift in precipitation from snow to rain (Jyrkama and Sykes 2007, Stewart 2009, Christensen et al. 2004, as referenced in Ecoanalysts Inc. 2020), earlier snowmelt (Stewart 2009, Kunkel and Pierce 2010, as referenced in Ecoanalysts Inc. 2020), an increase in overall precipitation (Angel and Kunkel 2010, NOAA Technical Report NESDIS 142-3 2013, Stewart 2009, 3rd US national climate assessment 2014, as referenced in Ecoanalysts Inc. 2020), and warmer water temperatures (Jyrkama and Sykes

2007, Angel and Kunkel 2010, Kunkel and Pierce 2010, NOAA Technical Report NESDIS 142-3 2013, as referenced in Ecoanalysts Inc. 2020). Changes in streamflow, water quality, and temperature could alter mussel distribution, composition, and abundance over time (Ecoanalysts 2020).

Average annual precipitation is expected to increase over time, and in some regions, precipitation may trend toward less frequent but more intense rainfall (USFWS 2014), with a resulting increase in frequency of extreme discharge levels. Increases in precipitation may increase river flows, changing patterns of sediment scour and deposition, and hydraulic conditions. Precipitation increases may also affect water quality and/or sediment loading in rivers. Greater runoff may carry more pollutants from urban areas, nutrients from the soil into the water, and sediment, reducing water quality. Changes in hydraulic conditions, flow, water quality, and substrate condition, have the potential to alter mussel habitat, distribution, and species composition (Goodding et al. 2019, Ecoanalysts Inc. 2020).

Precipitation may also be more dominated by rainfall events instead of snow melt, which may also impact water temperature (Ecoanalysts Inc. 2020). Increasing water temperatures themselves may affect mussels by influencing factors such as growth, burrowing behavior, byssus production, metabolic rates, and reproductive success (Hastie et al. 2003, Pandolfo et al. 2009, Archambault et al 2014, Ganser et al. 2015, as referenced in Ecoanalysts Inc. 2020). Studies have also shown that certain groups of freshwater mussels may be more thermal tolerant or sensitive. Thermally tolerant species (Threeridge (*A. plicata*), Wabash Pigtoe (*F. flava*), Washboard (*Megalonaias nervosa*), Threehorn wartyback (*O. reflexa*)) had increased clearance rates and were still able to assimilate energy at 35° C (95° F) (Spooner and Vaughn 2008, Ecoanalysts Inc. 2020). In contrast, thermally sensitive species (Mucket (*A. ligamentina*), Plain Pocketbook (*L. cardium*), Deertoe (*T. truncate*), and Pimpleback (*C. pustulosa*)) decreased clearance and depleted their energetic stores at 35°C (95° F) (Spooner and Vaughn 2008, Ecoanalysts Inc. 2020). All four of the thermally sensitive and two of the thermally tolerant species occur in the construction area for the WFPA Project and have the potential to be impacted if water temperatures increase in the future.

Alterations in temperature and flow patterns caused by climate change would similarly impact fish species in the Grand River and may potentially impact the timing of spawning, migration, habitat use, and distribution (Ecoanalysts Inc. 2020, Lynch et al. 2016). The lower Grand River mainstem and tributaries are currently home to 10 species of fish considered cold water preferential (Hanshue and Harrington 2017). As water temperatures increase, the thermal microhabitats created from inputs of cold, cold-transitional, and warm-transitional tributaries would likely decrease in size and suitability to these species (Ecoanalysts Inc. 2020). Both Lake Sturgeon (*A. fulvescens*) and River Redhorse (*M. carinatum*) use temperature cues to initiate spawning behavior, therefore changes in water temperature due to climate change has the potential to directly impact the timing of spawning events (Ecoanalysts Inc. 2020). Additionally, changes in distribution and behavior of fish host also has the potential to impact interactions between host species and freshwater mussels.

Literature suggests that invasive species would persist, and current ranges may expand under the predicted warmer conditions. Both Round Goby and Zebra Mussel may experience range expansion as water temperatures warm perpetuating the negative effects of these invasive species on aquatic ecosystems including competition for resources, displacement, and in the case of Zebra Mussels direct mortality of native freshwater mussels. Climate change may also indirectly impact mussel assemblages of the Grand River by increasing the probability of sea lamprey

escapement at the 6th Street Dam. The potential for reduced effectiveness of low-head barriers currently serving as sea lamprey barriers, could result from increased flood events and increased water temperatures during upstream migrations that influence swim performance of sea lamprey (Hansen et al. 2016, Ecoanalysts 2020). Under its current configuration, sea lamprey is most likely to breach the 6th Street Dam during high flows, which typically occur between March and April when water temperatures are below 10° C (50° F). The swimming performance of sea lamprey is relatively poor at water temperatures below 10° C (50° F). However, sea lamprey swimming performance is dramatically improved at temperatures above 15° C (59° F). Given the expected increase in water temperatures caused by climate change, high water events would be more likely to occur at warmer temperatures; if high water events occur at temperatures optimal for sea lamprey swimming performance, sea lamprey would be more likely to pass through the 6th Street Dam (Ecoanalysts Inc. 2020). Increased escapement may result in treatment of the Grand River watershed with lampricides as one potential control method. If the Grand River were treated with lampricides, freshwater mussels and their hosts could suffer direct mortality as well as sub-lethal effects.

Status of Federally Listed Species in the Action Area

Snuffbox (Epioblasma triquetra)

In the Grand River, Snuffbox occurs in the middle (Red Cedar River to Maple River) and lower (Maple River to Grand Rapids) sections of the Grand River proper and its tributaries (Hanshue and Harrington 2017). Very little mussel survey data is available downstream of Grand Rapids, as a result there is uncertainty regarding the presence of Snuffbox, though there are areas that have potentially suitable habitat for the species. There is a significant population in the vicinity of the former Lyons Dam, Village of Lyons, Ionia County (Woolnough and Barnett 2013). A large population also occurs in the Flat River, in the east channel between the dam and the confluence with the Grand River (ESI 2016).

Adult and juvenile Snuffbox were recently collected alive during surveys and relocation efforts within the Action Area. Evidence of recruitment has been observed within the Grand River, as juvenile Snuffbox have been collected throughout their range within the watershed. Snuffbox occur at a low density throughout the Action area and highly suitable habitat for Snuffbox is limited. This species comprised 0.9% of the total number of mussels recently collected between 6th Street Dam and Fulton Street.

Logperch, the primary host of Snuffbox, prefer relatively shallow, swift riffles or raceways with gravel substrate, which corresponds with habitat where Snuffbox often occurs, but are also common in lakes and impoundments. Adults (spawning and non-spawning) seem to prefer depths <1 m (<3.3 ft) and current velocity near 1 m/sec (3.3 ft/sec) over substrates of sand, gravel, and cobble, whereas young of the year prefer slightly shallower, slower waters over similar substrate (Becker, 1983; Luttrell et al., 1994; Aadland and Kuitunen, 2006). In Winter, adult logperch tend to use deeper water. In Wisconsin, logperch begin spawning in April, with the spawning season extending into June or July (Becker, 1983).

Logperch have been observed throughout the NRCS WFPA Action Area, although their preferred habitat is limited. Although preferred habitat for this species has been reported as faster flowing deeper areas, logperch was incidentally collected in a slower flowing area adjacent to a wetland during a 2013 mussel survey in the NRCS WFPA Action Area. It was also collected downstream of low-head dams in 2018-2022. Although some gravel substrate is present, substrate consists primarily of armored/compacted cobble and boulder (Figure 2-1). Softer substrate, slower flowing areas occur near the banks where in-stream or near stream vegetation is

present. Logperch represented 4.4% of the fish recently collected (2018 to 2022) in the Lower Grand River. They appear to be recruiting, as age 0 to 3 were collected in 2018 and 2022, 1 to 3 in 2020 and 2021 (M. Holtgren, Encompass, personal communication).

Status of Michigan Freshwater Mussels of State Special Concern (SC), State Threatened (ST), and State Endangered Species (SE)

Thirteen state listed mussels have the potential to occur in the action area.

Lilliput (Toxolasma parvum) (SE)

Lilliput is a small elliptical, cylindrical mussel with a shell that is relatively solid and inflated with rounded posterior and anterior ends, and a length of up to 3.8 cm (1.5 in). The periostracum has a cloth-like texture and ranges in color from dark green to dark brown with no rays. Lilliput is braydtictic, glochidia are released in July in club shaped conglutinate packets (Ecoanalysts Inc. 2020). Spawning likely occurs sometime around July, though gravid individuals have been observed throughout the year. Hosts include several Sunfish (*Centrarchidae*) species and Johnny Darter *(Etheostoma nigrum*) (Watters et al. 2009, Ecoanalysts Inc. 2020). Most of these host species have been observed within the Action Area (Ecoanalysts Inc. 2020).

Lilliput occurs in lakes, ponds, and slow flowing reaches of streams and rivers (Parmalee and Bogan 1998, Mulcrone 2005, Williams et al. 2008, Ecoanalysts Inc. 2020). It is most commonly found in soft substrates such as mud, sand, or fine gravel (Parmalee and Bogan 1998, Watters et al. 2009, Ecoanalysts Inc. 2020). In Michigan, it has been reported from only 10 counties, primarily in the southern half of the state (MNFI 2018). Live individuals have been detected during the Lyons Dam Removal surveys and relocation (Woolnough and Barnett 2013, Woolnough 2015), and at Ionia, Flat River, and Riverside Park, and as a weathered shell at Peace Park by Ecoanalysts Inc. (Ecoanalysts Inc. 2018). Ecoanalysts Inc. (2020) also detected juveniles at Riverside Park. Lilliput has not been detected between the 6th Street Dam and Fulton Street, lack of detection may be more attributed to its small size and that suitable habitat is generally siltier slow flowing areas on the margins of mussel assemblages (Ecoanalysts 2020).

Black Sandshell (Ligumia recta) (ST)

Black Sandshell is a solid, elongate and moderately compressed mussel reaching lengths up to 20 cm (7.9 in). The shell has a smooth, shiny surface that is dark green, brown, or black, with green rays visible on some individuals. Black Sandshell is bradytictic and glochidia are released in white conglutinates (Watters et al. 2009, Ecoanalysts Inc. 2020). Black Sandshell has been found to be fairly non-specific when it comes to fish host and include Rosyface Shiner (*Notropis rubellus*), Yellow Perch (*Perca flavescens*), several *Centrarchidae* species, and Sauger (*S. vitreus*, and *Sander canadensis*).

Black Sandshell occurs in rivers, lakes, and large streams in sandy mud to coarse sand or gravel at depths from a few centimeters to 2 m (6 ft) or more (Parmalee and Bogan 1998, Watters et al. 2009, Ecoanalysts Inc. 2020). In Michigan, Black Sandshell has been reported from several counties in the southern two-thirds of the state, as well as five counties in the Upper Peninsula (MNFI 2018). In the Grand River, it has only been found in the middle and lower river from Portland downstream to Grand Rapids. This species likely occurs in low abundance throughout the lower Grand River. Live adult and juvenile Black Sandshell have been detected in the Action Area (Ecoanalysts Inc. 2020).

Purple Wartyback (Cyclonaias tuberculata) (ST)

Purple Wartyback have shells that are round, heavy, and compressed to moderately inflated and reach a length of 12.7 cm (5 in). The shell surface is covered with bumps or tubercles that are an extension of the beak sculpture. The periostracum is yellowish-brown or greenish-brown in younger individuals, becoming darker brown in older individuals. Purple Wartyback are tachytictic (short-term brooders) and glochidia are released in white oblong conglutinates (Watters et al. 2009, Ecoanalysts Inc. 2020). Glochidia are present in the gills between May and late August. All reported hosts for Purple Wartyback are from the Catfish family (*Ictaluridae*), and include Black Bullhead (*Ameiurus melas*), Yellow Bullhead (*Ameiurus natalis*), Channel Catfish (*Ictalurus punctatus*), and Flathead Catfish (*Pylodictis olivaris*). Yellow Bullhead, Channel Catfish, and Flathead Catfish, have all been found in the Action Area.

Purple Wartyback is found in large creeks to large rivers, typically in coarse sand or gravel substrate (Parmalee and Bogan 1998, Watters et al. 2009, Ecoanalysts Inc. 2020). Although it is often found in moderate to swift current, it may inhabit slower-flowing areas (Parmalee and Bogan 1998, Watters et al. 2009, Ecoanalysts Inc. 2020). In Michigan, Purple Wartyback was historically found in the St. Joseph, Kalamazoo, Grand, Huron, Raisin, and Detroit Rivers, as well as Lake St. Clair (Badra 2010). Live adults and juveniles have been detected within the Action Area (Ecoanalysts Inc. 2020).

Slippershell (Alasmidonta viridis) (ST)

Slippershell are thin shelled as juveniles, becoming thick, inflated, and quadrate with age, reaching a maximum length of 60 mm (2.4 in). The periostracum is a waxy yellow, green, or tan that darkens with age. Notable bold green rays appear at all ages, are varied in width, and commonly cover the entire periostracum. Slippershell is bradytictic that keep their glochidia in their gills over the winter, then release them in the spring. Glochidia are released in a broadcast manner and connect with their host passively. Reported potential host fish include Mottled Sculpin (*C. bairdi*), Banded Sculpin (*C. carolinae*), and Johnny Darter (*E. nigrum*), both Mottled Sculpin and Johnny Darter have been reported in the lower Grand River (Clarke and Berg, 1959; Zale and Neves, 1982; Ecoanalysts Inc. 2020).

Slippershell is a small mussel typically found in small creeks and headwaters of larger rivers and occurs in a wide variety of substrate (Watters et al. 2009, Haag 2012, Ecoanalysts Inc. 2020). In Michigan, it is found throughout the state (MNFI 2018), and has been reported from the Au Gres-Rifle, Au Sable, Case, Clinton, Huron, Kalamazoo, Little Calumet-Galien, Manistique, Maple, Muskegon, Pigeon-Wiscoggin, Pine, Raisin, Shiawassee, St. Clair, St. Joseph (Maumee River and Lake Michigan drainage), St. Mary's, Thornapple, Tiffin, and Upper and Lower Grand Rivers (Badra and Goforth 2001, Carman, 2002, Badra 2010, Ecoanalysts Inc. 2020). Shells have been found in the upper and middle Grand River and one live individual was detected within the Action Area in 2017 (Ecoanalysts Inc. 2020). This is the only recent live record in the Grand River that has been detected (Ecoanalysts Inc. 2018). Given, that only one live individual was found recently, it is unclear as to whether there is a population in the mainstem.

Round Pigtoe (Pleurobema sintoxia) (SC)

Round Pigtoe have shells that are generally triangular to nearly round that are stout and thicker anteriorly and are 9.5 cm (3.7 in) in length. The periostracum is light reddish-brown becoming dark brown with age and usually without rays. Round Pigtoe are tachytictic and are gravid from approximately May through July when they then release their glochidia in conglutinate packets. Reported host fish include Central Stoneroller (*Campostoma anomalum*), Spotfin Shiner (*Cyprinella spiloptera*), Northern Redbelly Dace (*Phoxinus eos*), Southern Redbelly Dace

(*Phoxinus erythrogaster*), Bluntnose Minnow (*Pimephales notatus*), and Bluegill (*L. macrochirus*) (Hove, 1995; Watters et al., 2005 *in* Watters et al., 2009, Ecoanalysts Inc. 2020). Spotfin Shiner and Bluegill have recently been collected between 6th Street Dam and Fulton Street.

Round Pigtoe are found in medium to large rivers in mixed mud, sand, and gravel (Cummings and Mayer, 1992). It has been observed in the Cass, Clinton, Huron, Kalamazoo, Muskegon, Pine, Raisin, Shiawassee, St. Clair, St. Joseph (Lake Michigan and Maumee), Thornapple, Tiffin, and Upper and Lower Grand watersheds (Badra 2010, Ecoanalysts Inc. 2020). Live individuals have been found from Lyons Dam downstream through Grand Rapids. Live juveniles were found within the Action Area as well (Ecoanalysts Inc. 2020).

Pink Heelsplitter (Potamilus alatus) (SC)

Pink Heelsplitter has a rectangular, laterally compressed shell that becomes thicker with age, and is up to 20 cm (8 inches) in length. The periostracum varies in color from dark green to dark brown to black in older individuals and younger individuals commonly have green rays that fade with age. Pink Heelsplitter is bradytictic, gravid females have been reported from June to October and again from May to July. Freshwater Drum (*Aplodinotus grunniens*) was recently confirmed as the fish host and was collected between the 6th Street Dam and Fulton Street.

Pink Heelspiltter typically occurs in medium to large rivers, lakes, and impoundments, but rarely in smaller systems (Watters et al. 2009, Ecoanalysts Inc. 2020). It is most often found in silty sand and mud but can be found in mixed mud, sand, and gravel (Cummings and Mayer 1992, Ecoanalysts Inc. 2020). In Michigan, Pink Heelsplitter is found at the lower stretches of rivers in the lower peninsula, Lakes Erie, and Lake St. Clair (Ecoanalysts Inc. 2020). A few individuals were collected between 6th Street Dam and Fulton Street during 2013 and 2016 sampling, under the I-196 Bridge (Cardno, 2017), and between Fulton Street and the M-11 Bridge, but not at any of the sites upstream of the 6th Street Dam given that the 6th Street Dam is a barrier to passage for Freshwater Drum. The limited distribution of Pink Heelsplitter is likely attributed to the lack of passage for its host species, Freshwater Drum (*Aplodinotus grunniens*), at the 6th Street Dam (Hanshue and Harrington 2017, Ecoanalysts Inc. 2020).

Deertoe (Truncilla truncata) (SC)

Deertoe has a triangular shell that is somewhat inflated, thick, with a shallow sulcus anterior to the posterior ridge, and only reaches lengths up to 5 cm (2 in). The periostracum varies in color from yellow or green to dark brown with numerous green rays of varying width that may be broken or chevron shaped markings. Recently it was determined that Deertoe are tachytictic with gravid females reported from April or May to July (Sietman et al. 2018, Ecoanalysts Inc. 2020). Freshwater Drum is confirmed as a host for Deertoe and as mentioned above, are present in the Action Area downstream of the 6th Street Dam.

Deertoe typically occurs in medium to large rivers, though they may be found in smaller rivers and creeks as well as lakes (Parmalee and Bogan 1998, Williams et al. 2008, Watters et al. 2009, Ecoanalysts Inc. 2020). It occurs in a variety of substrates, including sand, gravel, and mud (Cummings and Mayer 1992, Parmalee and Bogan 1998, Williams et al. 2008, Ecoanalysts Inc. 2020). In Michigan, Deertoe occurs in the Detroit, Huron, Kalamazoo, Pere Marquette-White, St. Clair, St. Joseph (Lake Michigan), Tittabawassee, and the Lower Grand (Badra 2010, Ecoanalysts Inc. 2020). Live individuals have been recently found in the Grand River at the former Lyons Dam site in the Village of Lyons as well as within the Action Area where live juveniles were also documented (Woolnough and Barnett 2013, Ecoanlysts Inc. 2018,

Ecoanalysts Inc. 2020).

Ellipse (Venustaconcha ellipsiformis) (SC)

Ellipse has a shell that is solid, moderately compressed, elliptical in shape, and is up to 7.5 cm (3 in) in length. The periostracum is yellow, green, or dark tan, with dark green rays that become wavy toward the posterior end of the shell. Ellipse is bradytictic, with spawning occurring in July and August. Potential host fish include Sculpin (*Cottus* spp.), Logperch (*Percina caprodes*), and Darters (*Etheostoma* spp).

Ellipse is typically found in small to medium streams in sand and gravel substrate (Cummings and Mayer 1992, Watters et al. 2009, Ecoanalysts Inc. 2020). In Michigan, Ellipse has been reported from the Cass, Kalamazoo, Maple, Pigeon-Wiscoggin, Raisin, Shiawassee, St. Joseph (Lake Michigan and Maumee drainage), Thornapple, and Grand River basins (Badra 2010, Ecoanalysts Inc. 2020). One live individual was found near the former Lyons Dam, as well as Peace Park, Ada, Roselle Park, and in the Flat River they were the dominant species (Ecoanalysts Inc. 2018, Woolnough 2015). Mostly weathered shells have been found, but two live individuals have been collected within the Action Area (Cardno 2017, EcoAnalysts Inc. 2018, Ecoanalysts Inc. 2020).

Elktoe (Alasmidonta marginata) (SC)

Elktoe has a triangular/ trapezoidal, inflated, thin shell, and is up to 10 cm (3.9 in) in length. The periostracum is smooth, greenish yellow in color, with numerous dark green rays and dots (Cummings and Mayer, 1992; MNFI, 2018; Ecoanalysts 2020). Elktoe are bradytictic with spawning occurring in June. Glochidia are found in September and overwinter until May or June the following spring (Watters et al. 2009). Potential host fish include White Sucker (*C. commersonii*), Nothern Hogsucker (*H. nigricans*), Shorthead Redhorse (*Moxostoma macrolepidotum*), Rock Bass (*Ambloplites rupestris*), and Warmouth (*Lepomis gulosus*) (Howard and Anson, 1923 *in* Watters et al., 2009). All but Warmouth were recently collected within Grand Rapids.

Elktoe is found in large creeks to medium rivers. In Michigan, Elktoe is found in both the Upper and Lower Peninsulas, though it appears to be absent from the northern portion of the Lower Peninsula (MNFI 2018, Ecoanalysts Inc. 2020). In the Grand River, it has been collected live or as a fresh shell from Lyons Dam downstream to Fulton Street in Grand Rapids (Ecoanalysts Inc. 2018, Ecoanalysts Inc. 2020).

Creek Heelsplitter (Lasmigona compressa) (SC)

Creek Heelsplitter has an elongate shell that is thin and becomes thicker with age and is up to 8 cm (4 in) in length (Cummings and Mayer, 1992; Watters et al. 2009). The periostracum is yellow, tan, and/or greenish, frequently with rays in young individuals, turning brown to black with age (Watters et al., 2009; Cummings and Mayer, 1992). Creek Heelsplitter is bradytictic, with spawning occurring in June and July in Michigan. Creek Heelsplitter has more than 20 host fish species from several families, including Gar (*Lepisosteus* sp.), Carp family (Cyprinidae), Sucker family (Catostomidae), Catfish family (Ictaluridae), Sunfish (*Lepomis* sp.), and Darters (*Percidae*), many of which are present in the Grand River within Grand Rapids.

Creek Heelsplitter can be found throughout a watershed but is usually in creeks and headwaters of small to medium rivers (Cummings and Mayer, 1992). It was found in pools above and below riffles with compact sand and gravel, or mud patches near shore on the Huron River (Mulcrone 2018b, Ecoanalysts Inc. 2020). In larger rivers it occupies soft mud bottoms in slow-

moving currents near the edge of the river (Cummings and Mayer 1992, van der Schalie 1938, Watters 1995, Ecoanalysts Inc. 2020). In Michigan this species is found in creeks, headwater streams and small rivers throughout drainages in the lower and upper peninsula (Burch 1975, van der Schalie 1938, Ecoanalysts Inc. 2020). In the Grand River, live individuals and juveniles have been found in the Flat River and at Roselle Park, but not downstream of the 6th Street Dam through Fulton Street (Ecoanalysts 2018, Ecoanalysts Inc. 2020).

Flutedshell (Lasmigona costata) (SC)

Fluted Shell is elongate in shape with a moderately thick shell and is up to 18 cm (7 in) in length. The shell's posterior slope has prominent sculpturing consisting of about 10 – 12 heavy, rounded ridges or folds while more sculpturing is present on the lateral surface near the middle of the shell (Cummings and Mayer, 1992). The periostracum is smooth, and younger individuals often have green and brown rays while aged individuals lose color and become browner (Mulcrone, 2018c). Fluted Shell is bradytictic and likely spawn from June to July in Michigan (Lefevre and Curtis, 1912; Watters, 1995). Two glochidia forms have been observed for Fluted Shell with one presumably being able to forego the parasitic stage (Watters et al., 1998). Over 25 host fish species from several families have been reported, of which many are present in the Grand River within Grand Rapids.

In Michigan, it generally occurs in small to medium sized rivers in both the upper and lower peninsulas (van der Schalie, 1938, Burch 1975, Watters 1995, Ecoanalysts Inc. 2020). Live individuals including juveniles have been collected in the Flat River and the Grand River within the Action Area (Ecoanlysts Inc. 2020).

Paper Pondshell (Utterbackia imbecillis) (SC)

Paper Pondshell has an elongate shell that is very thin to transparent in younger individuals, reaching up to 10 cm (3.9 in) in length. The periostracum is smooth, yellow in younger individuals becoming brownish green in older individuals. Paper Pondshell is bradytictic and gravid females have been observed from April through September (Watters et al. 2009). Potential hosts are mainly from the Sunfish family, which are present within the Grand River thorough Grand Rapids.

Paper Pondshell typically occurs in slow-flowing pools and impoundments in soft sand and mud substrate (Parmalee and Bogan 1998, Williams et al. 2008, Watters et al. 2009, Ecoanalysts Inc. 2020). In Michigan, Paper Pondshell is found in the Kalamazoo, Manistique, Pere Marquette-White, St. Claire, and St. Joseph (Lake Michigan) (Badra 2010, Ecoanalysts Inc. 2020), as well as in Lake Erie (Mulcrone 2016, Ecoanalysts Inc. 2020). In the Grand River, live individuals and dead shells have been found from Lyons through Grand Rapids (Ecoanalysts Inc. 2018).

Status of Michigan State Threatened (ST) Fish

Lake Sturgeon (Acipenser fulvescens) (ST)

Lake Sturgeon the only native sturgeon species that inhabits Michigan. It is characterized by a large, torpedo-shaped body covered by rows of bony plates (scutes), a heterocercal tail, and a single dorsal fin (Auer 1999, Ecoanalysts 2020). Lake Sturgeon have a ventral, protrusible mouth with four barbels (Auer 1999, Ecoanalysts 2020). Lake Sturgeon range in color from dark slate to light brown or yellowish-olive (Smith, 1979; Pflieger 1997, Ecoanalysts 2020). Individuals greater than 40 years old are common, with individuals reported to be up to 150 years old (Scott and Crossman 1973; Pflieger 1997; Ecoanlaysts 2020).

Males mature between 12 - 16 years and females mature at 20 - 26 years. Spawning is initiated

when water temperatures reach 9 to 20° C (48 to 68° F) and spawning occurs between 11 and 18° C (52 and 64° F) (Scott and Crossman 1973; Ecclestone 2011; Chiotti et al. 2008); in the Grand River, the temperature range for initiation of spawning occurs between mid-March and early May. They spawn in or before rapids and at the base of dams (Hanshue and Harrington, 2017). Spawning sites are characterized by depths of 0.2 - 4.6 m (2 - 15 ft) with water current up to 3 m/sec (10 ft/sec) (Scott and Crossman 1973; Bruch and Binkowski 2002; Hanshue and Harrington, 2017) over clean rocky substrate in turbulent streams or rocky shoals in lakes in areas of sufficiently oxygenated water (Scott and Crossman 1973; Kempinger 1988; Pflieger 1997; Bruch and Binkowski 2002; Ecclestone 2011). The black, adhesive eggs hatch between 5 - 18 days depending on water temperature and young-of-year occupy their river of origin during the first few months of life and use shoal, run, and pool areas of large rivers with gravel and sand substrate (Holtgren and Auer 2004; Mann et al. 2011; Hanshue and Harrington, 2017). Juveniles in the Grand River seem to prefer shallow areas with sand substrate and moderate flow along river edges (Hanshue and Harrington, 2017).

The current range of Lake Sturgeon includes Arkansas, Indiana, Iowa, Kentucky, Missouri, Nebraska, Pennsylvania, Tennessee, Vermont, Michigan, Wisconsin, Minnesota, and South Dakota, though their status varies throughout their range. In Michigan, Lake Sturgeon occurs in the Great Lakes (Lake Michigan, Lake Superior, and Lake Huron), and several inland lakes and rivers. In Michigan it is known from 23 counties in Michigan's upper and lower peninsulas (MNFI 2018). Self-sustaining populations are found in the Sturgeon River, Menominee River, Black River, St. Clair River, and Detroit River (Hayes and Cafoffino 2012). An additional 19 populations are known to occur in Michigan, at population sizes of <25 adults to over 15,000 adults.

A small Lake Sturgeon population is known to occur in the mainstem of the lower Grand River and the mouth of the Grand River, but they are only believed to spawn near Plaster Creek and possibly near 6th Street Dam (M. Holtgren Encompass, pers. comm.). The Grand River population has been placed into the 'small declining' category based on a low estimated adult population size (n = 103) and declining population trajectory over the past 15 years (Hayes and Carrofino 2012). The 6th Street Dam is a barrier to spawning grounds of several Lake Michigan fish species, including Lake Sturgeon (Hanshue and Harrington 2017). MDNR biologists have reported adult and juvenile Lake Sturgeon, and incidental catch by fishermen has occurred near the 6th Street Dam. A population of between 66 and 130 fish of primarily older (>36 years) adults is estimated to occur in the lower Grand River (Hanshue and Harrington 2017).

River Redhorse (Moxostoma carinatum) (ST)

River Redhorse is a large-bodied sucker with a brown or olive coloration dorsally to brassy sides and white ventrally (Pflieger 1997; COSEWIC 2006). Crescent shaped dark spots are present on each dorso-lateral scale, caudal and dorsal fins are bright red in color, with pelvic and pectoral fins orange to red (Etnier and Starnes 1993; Pflieger 1997; COSEWIC 2006). Adults commonly reach 500 mm (1.5 ft) and up to 2 kg (4 lbs) (Pflieger 1997; Campbell 2001) and can weigh up to 7.7 kg (17 lbs) (Pflieger 1997).

River Redhorse reaches sexual maturity between three and five years (Etnier and Starnes 1993; Huston 1999) with northern populations reaching maturity later (COSEWIC 2006). Adults spawn each year, at temperatures between 18 and 24° C (64 and 75° F) (Mongeau et al. 1992; Jenkins and Burkhead 1993), which occurs between mid-May and late July in the Grand River. Evidence suggests that males excavate spawning redds tended by individual males (Hackney et al. 1967; Etnier and Starnes 1993; Pflieger 1997). Hatching occurs between five and six days post-fertilization (Jenkins

1970).

River Redhorse is found throughout the central and eastern Mississippi River system north from the Great Lakes Basin to the Gulf Slope from Florida to Louisiana (Etnier and Starnes 1993; COSEWIC 2006). This species is known from 24 states and two Canadian provinces (COSEWIC 2006). River Redhorse is known to inhabit lakes and rivers, but generally occurs in rivers with moderate to swift current and clean, rocky substrates needed for spawning (Scott and Crossman 1973; Becker 1983; Etnier and Starnes 1993; Pflieger 1997; Reid 2002; Reid 2003), with spawning individuals commonly collected within 100 m (325 ft) of rapids (Campbell 2001). River Redhorse inhabits rivers in 14 counties in Michigan's Lower Peninsula (MNFI 2018). In the Grand River, River Redhorse occurs throughout the entire Lower segment, from near Lyons to Grand Haven near the mouth of Lake Michigan and upstream into the Maple River (Hanshue and Harrington 2017). They were recently collected between 6th Street Dam and Fulton Street and were recently observed in spawning condition within the Action Area (S. Hanshue MDNR, pers. comm.). They also spawn in the Flat River, Maple River, and Fish Creek (S. Hanshue MDNR pers. comm.).

EFFECTS OF THE ACTION

The effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR 402.02). The following effects analysis analyzes both the effects of both of the proposed actions considered in this BO, the NRCS WFPA Project and the City/GRWW Project. All indirect effects are attributed to the NRCS WFPA Project, while direct effects will result from both proposed action and are described specifically for each project.

Direct Effects

The construction area for the NRCS WFPA Project spans from 91 m (300 ft) upstream of Bridge Street to Fulton Street (127,600 m2 (31.5 acres)). Of this 47,415 m2 (11.7 acres) would be directly impacted during construction. The direct impact area includes impact from causeways constructed in the river for access, construction of the cofferdam for Dam 2, substrate placement, grading, temporary scour protection, and general equipment tracking on the river bottom.

While the goal of the City/GRWW Project is to salvage and relocate animals from all direct impact areas within the NRCS WFPA Project direct impact areas, diving conditions may prove challenging depending on conditions within the Grand River that make such activity unsafe. At a minimum mussels will be salvaged and relocated from the isolation area for Dam 2 (3,285m2). Any fish including state listed fish within this isolated area will be released alive. The construction team would wait for fish and mussels to be moved from within the isolation area before construction could begin. This would require approximately 10 days of salvage effort.

Success of mussel relocations, in terms of conservation and survival of mussels, depends on several factors, including substrate stability, microhabitat requirements, methods of relocation, and timing (Cope and Waller 1995; Cope et al. 2003; Dunn and Sietman 1997; Dunn et al. 2000; Hamilton et al. 1997, EcoAnalysts 2020). Relocations with low mortality (< 1%) after one year have been linked to relocation sites with stable or consolidated substrate, species-specific habitat requirements, and careful handling of mussels (Dunn and Sietman 1997; EcoAnalysts 2020, 2024). The relocation will be conducted in accordance with the collection and translocation

procedures outlined in the BA and summarized in this Opinion (EcoAnalysts Inc. 2024) and the Michigan Mussel Survey Protocols and Relocation Procedures (Hanshue et al. 2019).

Despite conducting salvage and relocation activities in accordance with survey and relocation protocols, mussels still have the potential to be negatively impacted by relocation activities. Cope and Waller (1995) reported low recovery (51%) and survival (43%) following relocation due to extreme air and water temperatures, improper collection methods, handling, and transport, and a poor recipient site. Relocation studies conducted since then have demonstrated that proper handling protocols and relocation conditions such as air and water temperatures, play a significant role in reducing mortality during relocation (Ecoanalysts 2020; Dunn et al. 2000; Cope et al. 2003; Tsakiris et al. 2017). In addition to looking at survival, other studies have also looked at growth, body, condition, and movement in relocated animals versus resident animals and found no difference (Dunn et al. 2000; Tsakiris et al. 2017). However, Roznere et al. (2017) did find difference in metabolites between mussels moved to their captive facility and to Big Darby Creek from the Muskingum River, and suggested that the differences in these metabolites were consistent with physiological processes that would result in reduced growth, and mortality. The translocations analyzed in Tsakiris et al. 2017 and Dunn et al. 2000 moved mussels within the same river, whereas Roznere et al. (2017) moved mussels to a captive facility and a different river system. Results from studies looking at growth due to handling also differed. Dunn et al. (2000) and Tsakiris et al. (2017) handled mussels that remained in the recipient site and those relocated to the recipient site similarly and did not observe any change in growth that could be attributed to handling. In contrast, Haag (2009) reported a reduction in growth when mussels were only handled once a year for two years, whereas Ohlman and Pegg (2020) did not see any changes in growth and survival with no handling, handling every other week, once a week, and twice a week for 85 days. These studies used different species with different growth rates, which could influence study results. Regardless, it is clear that activities associated with relocation including air and water temperature during relocation, handling, transport, and relocation site conditions, could result in elevated stress levels in mussels, resulting in reduced growth rates and mortality in some species.

The capture, handling, temporary holding, and transport, of Snuffbox and state listed mussels during salvage and relocation have the potential to cause increased physiological stress, resulting in disruption of spawning and fertilization, growth, and feeding. While stress associated with salvage and relocation is reduced due to proper handling, the salvage effort within the isolation area presents some unique conditions including potentially elevated water temperatures and exposure due to dewatering. Due to increased physiological stress during relocation, we expect any Snuffbox and state listed mussels relocated will suffer harm in the form of impairment of essential behavior patterns. Of the freshwater mussels relocated, a small subset that are relocated may be harmed and killed (5%).

During salvage operations not all mussels are detected (e.g., juveniles, small bodied mussels, deeply burrowed individuals). Incidental take has been calculated at salvage rate of 85% for the isolated area, typically we estimate 80% detection rate, but given proposed salvage approach the City/GRWW anticipates a slightly higher detection rate. This accounts for up to 5% of the 85% collected, suffering mortality due to handling stress. Mussels that are not detected during salvage efforts in the isolated area will be killed due crushing, injury, smothering due to fill, or desiccation from exposure in unwetted areas (15%).

Snuffbox and state listed mussels that are not salvaged and relocated from any of the NRCS

WFPA Project direct impact areas will suffer direct harm or be killed due to direct mortality from crushing, injury, smothering due to construction activities, fill, or desiccation from exposure in unwetted areas. There is some uncertainty as to when NRCS WFPA Project in river construction activities will begin. Therefore, gravid females of Snuffbox and state listed mussels may be present. Species that are bradytictic (e.g., long term brooders), such as Snuffbox and state listed species including Paper Pondshell, Fluted Shell, Creek Heelsplitter, Elktoe, Ellipse, Pink Heelsplitter, Slippershell, Lilliput, and Black Sandshell, may have glochidia present in themarsupial gills of brooding females. Any glochidia present are likely to be injured, crushed, killed or experience decreased survival if released prematurely. The City/ GRWW Mitigation Fund would be adjusted according to the actual salvage efficiency.

River Redhorse and Lake Sturgeon are expected to vacate the NRCS WFPA Project construction area prior to commencement of construction activities and therefore will not suffer any direct impacts as a result of construction. Small species that are less mobile (e.g., *Cyprinidae, Percidae*), some of which serve as hosts for state and federally listed mussels, have the potential to suffer direct mortality through crushing, injury, and stranding, if they do not move out of the construction areas. Additionally, any species that use the area where construction is planned for spawning, have the potential to suffer reduced recruitment if construction activities coincide with spawning either resulting in disruption of spawning behavior or mortality of eggs and larvae. It is thought that River Redhorse spawning habitat may be present within the construction area. However, construction would be limited to lower water levels and therefore project construction should not overlap with spawning given that it occurs during higher water months such as April-early June. If construction does extend into early spring, the construction area will be unavailable for spawning and could result in a temporary loss of recruitment.

Operation, Maintenance, Repair, Rehabilitation, or Replacement

Operation, Maintenance, Repair, Rehabilitation, or Replacement (OMRRR), of structures post NRCS WFPA Project construction and project completion could require the tracking of equipment into the wetted channel. Mussels within these areas will be killed due to crushing, injury, and smothering due to fill. River Redhorse and Lake Sturgeon should be impacted by this work given that they are likely to simply move out of the area. Other smaller species that are less mobile, may suffer direct mortality as well due to injury or crushing. The maximum area potentially affected by OMRRR, is 10,000 m^2 (2.5 acres).

Indirect Effects

Mussels have the potential to be indirectly affected by the NRCS WFPA Project outside of all direct impact areas (80,185 m2 (19.8 acres)) within the construction area (upstream buffered area of Dam 4 downstream to Fulton Street) (Construction Indirect Impact Area). These areas would be indirectly impacted by temporary increases in turbidity and changes in hydraulic conditions associated with in river construction between Dam 4 and Fulton Street. Scouring of the existing riverbed outside of direct impact areas within the Construction Indirect Impact Area is not anticipated during construction. Upstream of Dam 4 to the 6th Street Dam (Upstream Indirect Impact Area, 38,420m2) is unlikely to be significantly impacted by increased turbidity and hydraulic changes given that the construction area is immediately around Dam 4. Downstream of Fulton Street (Downstream Indirect Impact Area) will likely result in increased turbidity during construction and may cause nutritive stress and potentially reproductive failure in mussels during construction. Turbidity plumes would be temporary and are not expected to cause mortality.

The majority of construction activities will be conducted within the wet and flowing channel

including: demolition of low-head dams (1,3, and 4), construction/removal of causeways, construction/removal of cofferdam for Dam 2, substrate placement, grading, temporary scour protection, and general equipment tracking on the river bottom. The work would be performed with excavators, loaders, dump trucks, and other common earth moving equipment. A total area of 80,185 m2m^2 within in the Construction Indirect Impact Area and 282,600 m2 downstream of the construction area (Downstream Indirect Impact Area, Fulton Street to Plaster Creek) will be indirectly impacted as a result of these construction activities and may experience significant hydraulic changes, increased turbidity, and changes in host fish distribution.

Intermittent exposure to inorganic Total Suspended Solids (TSS) at high levels (>600 mg/L) can cause nutritive stress, resulting in decreased growth and reproduction (Ecoanalysts 2020, Aldridge et al., 1987). Feeding of some species declined as organic TSS increased, with a threshold at 8 mg/L over a seven-month period (Gascho Landis et al., 2013; Gascho Landis and Stoeckel, 2016; Tuttle-Raycraft et al., 2017), and reproduction was affected at TSS >20 mg/L (Gascho Landis and Stoeckel, 2016). M ussels within these indirect impact areas within the Indirect Impact Area and Downstream Indirect Impact Area (Fulton Street to Plaster Creek) may experience disruption of normal respiration, feeding, growth, and reproduction, impairing essential behavior patterns resulting in harm. Snuffbox are present within the Construction Indirect Impact Area and will be harmed. Snuffbox were found at the I-196 bridge but were not detected in surveys between Plaster Creek and Fulton Street. Therefore, we do not expect Snuffbox to be impacted within the Downstream Indirect Impact Area.

Mussels outside of the area where construction is planned that are upstream (from Dam 4 to the 6th Street Dam) will also likely be indirectly affected by changes in hydraulic conditions. These individuals may be temporarily stressed. However, the severity of these effects is likely to be less given that these areas are further from direct impact areas and are unlikely to experience significant elevated levels of turbidity, thus mussels in this upstream indirect impact area are unlikely to adverse effects that rise to the level of harm.

Lake Sturgeon and River Redhorse may be present within the downstream indirect impact area (Fulton Street to Plaster Creek) and may experience temporary increases in turbidity. Both species spawn within this area near the mouth of Plaster Creek. Given that the mouth of Plaster Creek is 2.5 km (1.6 miles) downstream of the Construction Area, turbidity should be minimal, and spawning should not be significantly impacted Small species that are less mobile such as log perch, may not be able to move out of the Construction Area and may remain within indirect impact areas within the Construction Area and downstream. Behavioral changes and increased physiological stress may result (Ecoanalysts 2020).

The NRCS WFPA Project Construction Indirect Impact Area includes a total area of 80,185 m2 and the Downstream Indirect Impact Area is 282,600 m2.

Sea Lamprey

One of the primary concerns of the USFWS is the ability to maintain the 6th Street Dam as an effective sea lamprey barrier for the Grand River Watershed during and after the proposed construction of the NRCS WFPA Project. Sea lamprey treatment and survey activities using lampricides could negatively impact freshwater mussels and host fish in the upper Grand River if an escapement event occurs during or post-construction. The Sea Lamprey Control Program (SLCP) uses the lampricides TFM (3-trifluoromethyl-4-nitrophenol) and Bayluscide® [active ingredient:
5-Chloro-N-(2-chloro-4-nitrophenyl)-2-hydroxybenzamide] to control sea lampreys in the Great Lakes. TFM and the TFM/1% niclosamide mix is applied to streams to kill larval sea lampreys

The granular formulation of Bayluscide [Bayluscide 3.2% Granular sea lamprey Larvicide, granular Bayluscide (gB)] is applied in lentic and lotic systems that are too large to be treated economically with the liquid lampricide formulations, and to survey for larval sea lampreys in areas that are too deep to effectively electrofish with AbP-2 backpack electrofisheing gear (C. Kaye, SLCP Risk Assessment pers. comm. 2020). Niclosamide, the active ingredient in Bayluscide, was first developed as a molluscide to kill snails. The granular form of Bayluscide, targets benthic larval sea lamprey habitat and therefore freshwater mussels can be particularly at risk when present within the vicinity of Bayluscide applications.

Boogaard et al. (2015) tested the toxicity of TFM on multiple life stages of the Snuffbox mussel. The study evaluated the effects of TFM on glochidia, one week old juveniles, and logperch, as well as glochidia, one week old juveniles, and adults of the ellipse (*Venustaconcha ellipsiformis*) mussel as a surrogate to the snuffbox for direct toxicological comparison. The study also evaluated juvenile recruitment success from glochidia (larval) infested logperch exposed to multiple levels of TFM. This work demonstrated that there was minimal toxicity to the larval and juvenile stage of both the ellipse and snuffbox mussels, as well as the adult stage of the ellipse mussel at concentration ratios greater than what is required or typically used to kill larval sea lampreys in streams (USFWS 2013). A comparison of the results to snuffbox glochidia indicates the life stage of the two species respond similarly to TFM. Survival was high among both species at concentrations greater than what would be encountered during treatments suggesting the risk from direct exposure to TFM is low (USFWS 2013). In the natural stream environment, glochidia are distributed directly on the gills of logperch by female snuffbox (USFWS 2013). Glochidia that are inadvertently distributed into the water column (free-floating) have almost a 100 percent chance of dying (USWFS 2013). The viability test conducted during 2011 on free-floating snuffbox glochidia demonstrated that viability decreased rapidly beginning at 12 hours after extraction (USFWS 2013). These results suggest, along with the recruitment tests where juvenile fall-off was not significantly different between the exposed and control fish, that there would be greater survival of glochidia encysted on gills (as opposed to free-floating) at concentrations tested (USFWS 2013). Results from toxicity tests on 1 week old juveniles suggest that there is no risk up to the highest concentration ratios for the snuffbox mussel and that ellipse juveniles may be more at risk at higher concentrations, although these concentrations would not be applied in the field (USFWS 2013).

Boogaard et al. (2015) also looked at the toxicity of TFM to adult logperch. Logperch were exposed to concentration levels of TFM that are typically used in the field to kill sea lampreys in streams. Exposure duration was 12 hours followed by a 12-hour post-exposure period after which mortality of logperch was assessed. Minimum lethal concentrations (MLC) for sea lampreys in this study were 2.1 mg/L. MLC values are based on concentrations of TFM required to kill 99.9% of sea lamprey larvae calculated from the pH and alkalinity of the test water (Adair and Sullivan 2009). Mortality of logperch was 15% at 2.1 mg/L TFM, but 65% at 2.7 mg/L TFM (1.3 x MLC). However, several field studies and non-target mortality observations differ from these lab results including a study by Langdon and Fiske (1991) where logperch were captured at the same rate during 2 pre-treatment surveys and 1post treatment survey in an area that had the highest mean concentration of TFM (4.7 mg/L TFM) and exposure time (11h). Another long-term study (Schuldt et al. 1996) reported 100% logperch survival in a cage study during five lampricide treatments. Kirkeeng et al. (in review) reported 90 – 100% survival of logperch between 1.0 and 1.4×MLC TFM (USFWS SLCP 2024). Survival then dropped to 55% at 1.7×MLC TFM (USFWS SLCP 2024). Until further test are conducted and prove otherwise, logperch are considered sensitive to TFM, having the potential for high levels of mortality (85%

mortality at treatments levels of 1.5 MLC) based on laboratory results. Given their critical role in snuffbox reproduction as the primary host fish, direct mortality or sub-lethal effects to logperch have the potential to impact snuffbox reproduction, which may thereby impact abundance and distribution of the mussel.

A study conducted by Newton et al. (2017) investigated the risk of mortality and sub-lethal effects (probability and duration) as a function of exposure duration among adult and sub-adult mussel species exposed to environmentally relevant concentrations of Bayluscide. Eight species of mussels were chosen based on availability and potential overlap with sea lamprey larval habitat. At each exposure duration, mortality was estimated, and a suite of sub-lethal responses including siphoning activity, gaping valves, production of mucus, and rigid foot extension was recorded. Mortality, over all exposure durations, 21 days after exposure, averaged 42% in sub-adults (range, 23-54%) and 20% in adults (range, 3-44%). For those species tested (*O. olivaria and V. iris*) as both sub-adults and adults, mortality was similar between life stages for *O. olivaria* (~23%) but more than twice as high for sub-adult (mean, 38%) compared to adults (mean, 14%) for *V. iris* . There were positive associations between duration of Bayluscide exposure and mortality in all four species exposed as sub-adults and in four of the six species exposed as adults. These results were the same positive associations seen between duration of exposure and sub-lethal responses in all four species of exposed sub-adults and four of the six species exposed as adults. Bayluscide results in mortality of mussels and indicates that the duration of exposure plays a significant role in the magnitude of mortality among mussels. This study demonstrated the longer mussels are exposed to Bayluscide the greater the mortality and sub-lethal effects. Both adults and sub-adults were sensitive to exposure, but sub-adults were affected by Bayluscide sooner (Newton et al. 2017).

While unionids absorb lampricides and experience narcotization (gaped shell and sometimes foot extended), toxicity studies have indicated that TFM exposure would not result in acute mortality at concentrations required to kill sea lamprey during stream treatments (Kaye 2021 pp. 1–50). Boogaard and Waller (2004 p. 12). Bills et al. (1992) reported that 90% of Pink Heelsplitter survived when exposed to 3.5 mg·L-1 TFM (1.0 × MLC) for 12 hours. However, only 30% survived a 12-hour exposure of 5.25 mg·L-1 TFM (1.5 × MLC). The authors noted that static tests are a worst-case scenario and surmised that survival would be higher in a stream environment. Waller et al. (1998 pp.116–118) stated that both Threehorn Wartyback and Wabash Pigtoe would survive stream treatments at TFM concentration ratios of 1.3 and 1.4 × MLC. A study conducted to test several compounds for the potential control of zebra mussels (*Dreissena polymorpha*; Bills and Waller unpublished data) found no mortality of the Pimpleback (*Cyclonaias pustulosa*), Three Ridge (*Amblema plicata*), and Pink Papershell (*Potamilus ohiensis*) held in TFM concentrations up to 8.4 mg·L-1 (3.4 × MLC) for 12 hours, and 20% mortality of the Deertoe (*Truncilla truncata*) in 6.7 mg·L-1 (2.7 × MLC; MLC = 2.5 mg·L-1). These concentrations were much greater than what would typically be applied to a stream (1.1–1.8 × MLC; Kaye 2021 pp. 5–6; L. Crieger personal communication, 2020).

Boogaard et al. (2004 pp. 1–17) reported that TFM and TFM-1% niclosamide did not produce substantial mortality among three unionid mussel species [Giant Floater (*Pyganodon grandis*), Fragile Papershell (*Leptodea fragilis*), Pink Heelsplitter (*Potamilus alatus*)] tested at concentrations typically applied during stream applications to kill larval sea lamprey. Both lampricides were more toxic to larval sea lamprey than to any of the unionid species tested. The giant floater experienced the highest mortality, which the authors attributed to the added stress of handling and holding conditions in river water at temperatures as high as 27 °C. They stated that the species can often experience a natural die off during mid to late summer (Boogaard & Waller

2004 pp. 1–17).

Waller et al. (2003 pp. 546–550) found that acute mortality did not occur when Eastern Elliptio (*Elliptio complanata*) and Eastern Floater (*Pyganodon cataracta*) juveniles and adults were exposed to TFM up to 1.6 × MLC in a mobile bioassay trailer at the White River, tributary to the Bad River (Ashland County, Wisconsin). Acute mortality of Eastern Elliptio juveniles and adults did not occur when exposed to TFM-1% niclosamide up to 1.9 × MLC. Concentrations routinely applied in the Bad River system range from 1.0–1.7 × MLC (C. Gagnon personal communication, 2020). Even at the highest concentrations, mortalities were not significantly different from the controls. However, survival was greater for Eastern Elliptio than for the Eastern Floater, and for adults relative to juveniles. Waller et al. (2003 p. 550) also found that trials conducted at lower water temperatures (13 °C versus 21 °C) resulted in higher mussel survival.

To date, no toxicological data exists on the effects of lampricide for the state listed fish species of concern with the exception of Lake Sturgeon. If the upper Grand River were proposed for a lampricide treatment, the presence of Lake Sturgeon in the mainstream would be a factor in scheduling the dates of treatment. Young Lake Sturgeon are quite sensitive to lampricide in high alkalinity streams like the Grand River. At the risk of killing larval and juvenile Lake Sturgeon during treatment, the SLCP has been asked by the State of Michigan DNR-Fisheries, Little River Band of Ottawa Indians, and USFWS-Lake Sturgeon restoration teams to treat high alkalinity Lake Sturgeon streams with significant populations, late in the season, preferably after August 15, but before the beginning of the salmon spawning run in September. This provides for a narrow window in which to treat the stream. Mitigation efforts would include the removal of young Lake Sturgeon prior to treatment, aerated tank holding, and release after the treatment to reduce the risk of mortality from lampricide. Communication and coordination of this effort begins in May of the treatment year since there is a large amount of equipment required (boats, sturgeon removal equipment and aerated tanks/trailers) and people to conduct the work.

A two-year evaluation (2014 and 2015) was conducted to determine the larval and juvenile sea lamprey production potential upstream of the 6th Street Dam (GLFC 2015; Ecoanlaysts 2020). The survey focused on documenting native lamprey as an indicator because they prefer the same habitat as sea lamprey and also quantifying suitable larval rearing habitat. Native lamprey were found in 463 km (287 mi) of the Grand River watershed upstream of the 6th Street Dam. Within that area there is approximately 2,957,701 m^2 (730 acres) of Type I habitat (preferred mix of sand and fine organic matter) and 6,396,646 m^2 (1,580 acres) of Type II habitat (acceptable shifting sand with no fine organic matter). Areas with Type I and II habitat include Bear, Bellamy, Crooked, Fish, Honey, Libhart, and Lowell Creeks, and Grand and Maple rivers. If sea lampreys managed to successfully pass the 6th Street Dam, 3,058 km (1,900 miles) could potentially be infested which would make the Grand River one of the most productive tributaries to Lake Michigan (GLFC 2018, Ecoanalysts Inc. 2020).

Infested stream reaches would need to be treated with lampricides every three to four years. Given the size of the Grand River and the volume of water that would require treatment, the most reasonable choice of treatment options would be the use of the TFM/1% niclosamide mixture. There are no data, however, on the effects of the TFM/1% niclosamide mixture to adult Snuffbox. All aspects of the previous study would need to be repeated with the TFM/1% niclosamide mixture to further assess the risk to the snuffbox if this treatment approach is to be considered. Treatment in tributaries generally involves applying lampricides from upstream of a known larvae distribution to the mouth of a streams with 1.5 x MLC for 12 hours. If larvae were found in the Grand River proper, treatment would extend from upstream of the larval habitat to

the nearest barrier, the 6th Street Dam.

The potential risk of sea lamprey escapement at the 6th Street Dam and the subsequent ecological risk that lampricides pose to the watershed, specifically freshwater mussels and their host fish, caused significant concern about the project. The NRCS WFPA Proposed Action reflects significant modification in project design and construction based on these ecological concerns from partners. The ability to maintain a significant difference between the barrier crest and tailwater elevation during springtime flows is a key component of the blockage criteria considered at sea lamprey barriers. Water temperature and velocity are also important factors. Literature indicates that sea lamprey is blocked by endurance swimming limits of 2.5 m/second (sec) (8.2 ft/sec) for 3 m (10 ft), burst speed limit of 4 m/sec (13.1 ft/sec), or a jumping barrier of at least 46 centimeters (cm) (18 in) (Hansen 1980; Hunn and Youngs 1980; McAuley 1996) and impeded at velocities >1 m/sec (3.28 ft/sec) (Almeida et al. 2007; Quintella et al. 2009). Water temperature also affects passage; burst speed and endurance is substantially reduced at water temperatures <10○ C (50○ F) (Applegate 1950; McAuley 1996).

The tailwater velocity and jumping pool barrier at the 6th Street Dam are primarily a function of tailwater elevation during the time of sea lamprey migration. Tailwater elevations were modeled over a range of typical flow rates through a given year and compared under existing, temporary, and 2024 Project conditions. Scour protection would be installed before the Dam 2 area is isolated in July/August (after sea lamprey spawning season). The temporary causeway and scour protection would be removed before the end of the construction season at the latest (not left in over winter). The additional material in the river has been modeled to have minor (0.01 ft) impact on tailwater elevation at 6th Street Dam and would not be in the river during sea lamprey spawning season. Changes to project design and construction sequence resulted in decreases or negligible changes in tailwater elevation with low probability of occurrence and were determined to have no adverse impacts to sea lamprey blockage effectiveness at the 6th Street Dam (P. Hrodey USFWS, personal communication, October 10, 2019, and 2024, Ecoanalysts 2020, 2024). Blockage criteria for sea lampreys at 6th Street Dam would be maintained through construction and post-construction for the NRCS WFPA Project.

Mitigation

The intended design of the NRCS WFPA Proposed Action is to enhance habitat for aquatic species. If aquatic habitat within the construction area improves from the current baseline condition, it is possible that long term, mussels will reseed this area, perhaps at higher densities than are currently there. If mussels are restored within this area, it is possible that the mussel community as a whole will be more abundant and diverse. However, there is a significant amount of uncertainty regarding creation of aquatic habitat suitable for freshwater mussels. The actual project impacts and benefits to state and federally listed mussels cannot be anticipated given the complexities affecting the presence of mussel communities. It is uncertain what the actual as-built river features performance will be in terms of suitability for mussel-host fish presence and movements, substrate changes, maintenance activities, impact of new hydraulics on habitat, and influence of the project on sea lamprey escapement. As a result, of the impacts resulting from the NRCS WFPA Project and the uncertainty around the successful creation of suitable mussel habitat, a Mitigation Fund will be established as part of the proposed action to fund conservation measures that have significant benefits for mussels. Priority will be given to projects that provide a direct benefit to mussels in the NRCS WFPA Project Area and/or in the lower Grand River. This fund is being established to mitigate the loss of state and federally listed species within the NRCS WFPA Project Action Area.

The purpose of the fund will be to support conservation measures that significantly benefit state and federally listed mussels into the future after completion of the NRCS WFPA Project. The intent of the Mitigation Fund would be to off-set impacts as a result of incidental take. The amount of the Mitigation Fund would vary based on salvage and relocation efficiency and essentially the total amount provided would vary with changes in mussel take. The Mitigation Fund will be used to continue efforts to conserve mussels in the Grand River such as improving and restoring aquatic habitat to benefit freshwater mussels in the Lower Grand River, performing surveys to locate other freshwater mussel populations, potentially a propagation effort, as well as other conservation actions that may improve water quality and riparian corridors, all of which will benefit Snuffbox, state listed species, and the freshwater mussel community as a whole. Therefore, while the intent of the Mitigation Fund is to offset impacts to Snuffbox and state listed mussels, the effects of this part of the proposed action will be wholly beneficial in the form of mussel conservation actions within the Grand River into the future.

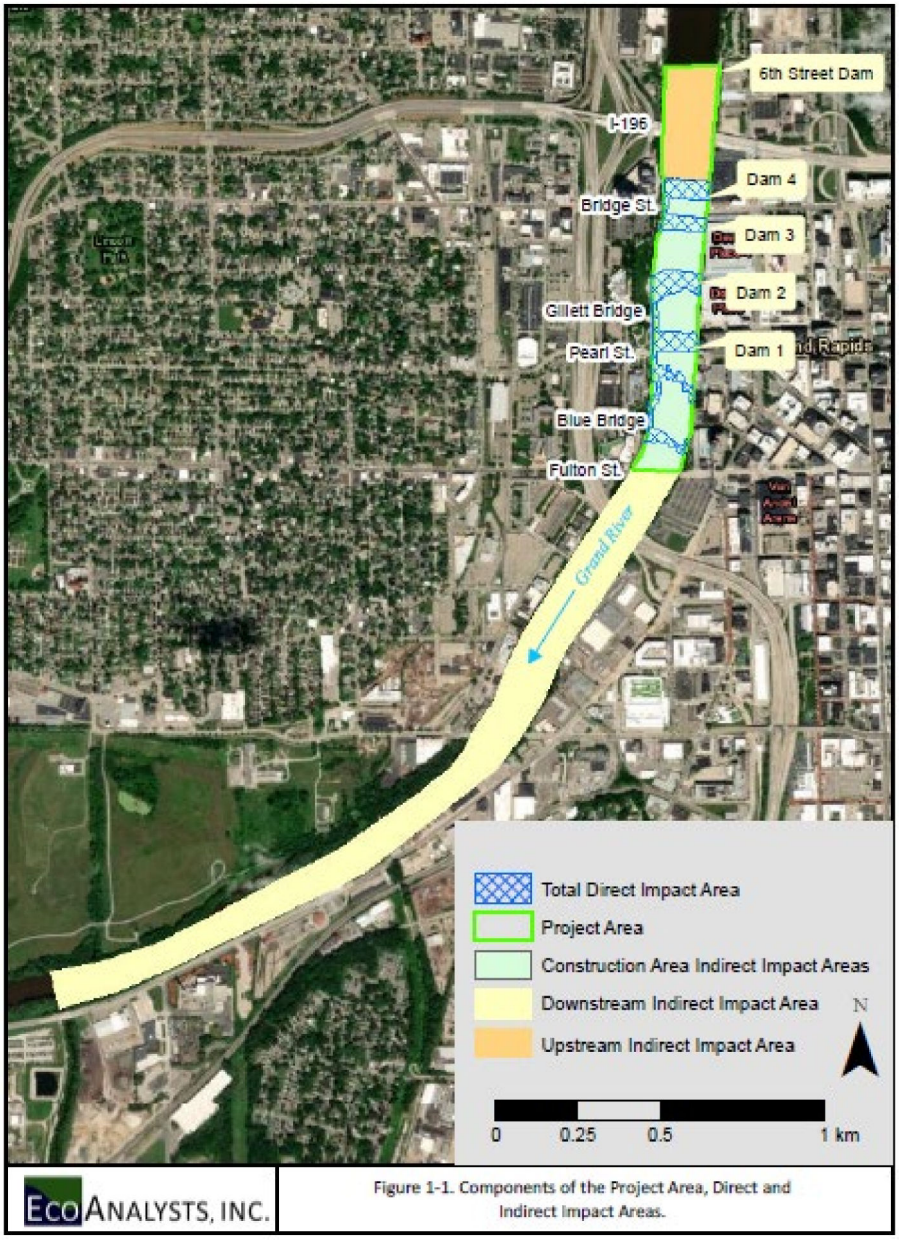


Figure 2: Direct and Indirect Impact Areas (Source: Ecoanalysts BA 2020, Figure 1-1)

Summary of Effects

Surveys conducted by Ecoanalysts Inc. to determine mussel distribution, mussel density, and species composition utilized a combination of semi-quantitative, quantitative, and qualitative survey methods (Dunn 2000). Semi-quantitative sampling consisted of searching a given area visually and tactually. Quantitative sampling consisted of excavating all substrate within a 0.25 m^2 quadrat to a depth of 15 cm (6 in). Semi-quantitative and quantitative sampling were supplemented with qualitative sampling in areas most likely to contain federal and state listed species to better estimate species richness and recover listed species. Qualitative sampling consisted of collecting as many individuals as practicable in higher density areas for 5 to 20 minutes and was geared towards finding rare species (Kovalak et al. 1986).

The area from the 6th street Dam upstream 1 mile, the NRCS WFPA Project Area, a portion of the indirect impact area below Fulton Street (500 m below), and Riverside Park were sampled in 2013 using quantitative, semi- quantitative, and qualitative methods (ESI 2014). The area from the 6th Street Dam upstream 1 mile was also quantitatively sampled in 2015, 2016, and 2017, and the NRCS WFPA Project Area was quantitatively sampled in 2016, 2017, and 2020 (ESI 2016; EcoAnalysts, 2018, 2021). Sites between Ada and Grand Rapids (Ionia, Saranac, Flat River, Chief Hazy Cloud, Ada, and Site 7) were qualitatively and quantitatively sampled in 2015 (ESI 2016). Peace Park and Roselle Park were quantitatively sampled in 2016 (ESI 2017), and Roselle Park was also quantitatively sampled in 2017 (EcoAnalysts 2018). Sites near Plaster Creek and the M-11 Bridge downstream of Plaster Creek were qualitatively sampled in 2017 (ESI 2018) and semi-quantitatively sampled in 2018 and 2020 (EcoAnalysts 2019, 2021).

Mussel density from the 6th Street Dam downstream to Fulton Street was calculated each year based on quantitative sampling:

1. 2013 – average density was 0.6 mussels/m^2 (95% CI=0.2 to 1.0 mussels/m^2, although samples were biased toward higher density areas);
2. 2016 - average density was 0.3 mussels/m^2 (95% CI=0.1 to 0.5 mussels/m^2);
3. 2017 – average density was 0.3 mussels/m^2 (95% CI=0.2 to 0.5 mussels/m^2); and
4. 2016 and 2017 – average density under the I-196 Bridge was 0.25 mussels/m^2 (Cardno, 2017).
5. 2020 - average density was 0.3 mussels/m^2 (95% CI=0.2 to 0.5 mussels/m^2)

The density for Snuffbox and all state listed mussels was based on the total average density of freshwater mussels between the 6th Street Dam and Fulton Street. Therefore, the density of Snuffbox within the upstream indirect impact area and the Construction Area is based on the total average density of all freshwater mussels, which is 0.3 mussels/m^2 (ESI 2016, 2017; EcoAnalysts 2018, 2021; Cardno 2017). The density of state listed mussels is also based on the total average density of all freshwater mussels, 0.3 mussels/ m^2, upstream of the 6th Street Dam and the NRCS WFPA Project area. Within the downstream indirect impact area, from Fulton Street to Plaster Creek density averaged only 0.1 mussels/m^2 (ESI 2018; EcoAnalysts 2019). Recent surveys in potential dredge areas found 0-2 mussels per 5-minute search and .0.9unionids/5-meter semi-quantitative sample near the mouth of Plaster Creek (ESI 2018; EcoAnalysts 2019). The density near the bank of the I-196 South Bridge was 0.9 unionids/m2 and Snuffbox were found in the relocation of the I-196 bridge (GEI 2023). The number of snuffbox and state listed mussels within the NRCS WFPA Project Action Area and the City/GRWW Project Action Area was calculated by taking the average density multiplied by the impact area multiplied by the relative abundance for each species rounded to the nearest 5 (Ecoanalysts 2020, 2024). The relative abundance of each species was calculated by taking the

percent of the total and is based off the total mussels collected by ESI in 2013, 2016, 2017, and Cardno in 2016 and 2017 (ESI 2014, 2017; Ecoanlysts 2018; Cardno, 2017).

Salvage and relocation would at a minimum be conducted within the isolated area for Dam 2. Outside the isolated area for Dam 2, mussels from within each direct impact area would salvaged and relocated in workable flows. The direct impact areas would be divided into 5 x 10 m blocks within workable flow areas. Workable flow would be defined as current velocity in which the diver/snorkeler can maintain position (not be swept downstream) within the block and collect mussels. Blocks would be further divided into smaller 2 m x 1 m grids using a 3/8 inch metal that would lay flat on the river bottom grid. Each 2x1 grid is split into 1m x 1m cells and would be searched individually. Each of the 1 m x 1 m cells would be visually searched for habitat and mussels (visual search). If no habitat (bedrock or entirely non-movable rock) is found, then that 1 m2 is clear. If habitat and/or mussels are found, that 1 m2 would be excavated down to 15 cm (6 inches), collecting any mussels that are found (first pass) with and average search effort of 2 min/m2. That 1 m2 would be excavated a second time (second pass) with an average search time of 2 min/m2, and if <5% of the mussels are collected on the second pass compared to the completed first pass and no state and federally listed species are found, then the 1 m2 would be declared clear. If not, it would need to be searched again until the <5% criteria and no state and federally listed species found threshold, is reached. Searching would require an average of 2 min/m2 Once the entire 2 m x 1 m grid is clear, the 2 m x 1 m grid would be moved to the next 2 m x 1 m grid.

Incidental Take has been calculated for the "worst case scenario," which is salvage and relocation limited to the isolated area for Dam 2. Collection efficiency in this area is expected to be 85%; however, up to 5% mortality could occur from handling, and it is estimated that 15% of the mussels would not be detected and therefore suffer mortality as well. The maximum mitigation fund contribution would be based on $34.10/mussel (2020 BA $28.50/mussel escalated for inflation) and would not exceed $456,743 (Table 2-13 updated in 2024 BA). This fund would be reduced by the amount of mussels that are expected to survive translocation (i.e., relocated minus the 5% of relocated animals anticipated to be lost due to handling stress). The mitigation fund contribution may not be reduced by a percent greater than the percent of area cleared (i.e., area of quadrats cleared from the total area of the direct impact areas). Prior to reducing the funding, the proportion of areas cleared as result of a determination of non-diggable rock must be compared to prior survey efforts to help ensure that estimates of mussels impacted are consistent with the 2024 BA.

The following tables summarize the total number of Snuffbox and state listed mussels that are likely to be harmed broken down by the specific activity within the overall proposed action. Death may occur due to direct interactions or indirect effects that result in impairment of essential behavior patterns. We did not break down the number of state listed mussels by species, but rather used the cumulative relative abundance of all state listed mussels to calculate harm. Given that the role of the overall health and abundance of the mussel community in the Action Area is critical to assessing impacts to the localized population of Snuffbox. As a result, the impact to state listed species as a whole seemed most appropriate.

Table 2: Predicted Number of Snuffbox and State Listed Mussels in Direct Impact Area excluding the Isolated Area for Dam 2 Harmed:

Total Direct impact Area Excluding Isolated Area = 44,130 m^2

Average Density of Freshwater Mussels within the Construction Area = .3 mussels/ m^2

Relative Abundance of Snuffbox = .90%

Relative Abundance of State Listed Species = 13.20 %

Number of Snuffbox within the Direct Impact Area Excluding Isolated Area = .90% *(44,130m2*.3 Snuffbox/m^2) = 119 Snuffbox

Number of state listed species within the WIW area = 13.20% *(44,130m2*.3 state listed mussels/m^2) = 1,748 state listed species

Total Number of Snuffbox Killed in Direct Impact Areas Excluding Isolated Area Areas = 119

Total Number of State Listed Species Harmed Due to Direct Mortality in WIW Areas = 1,748

Table 3: Predicted Number of Snuffbox and State Listed Mussels Present in Isolated Area for Dam 2:

Total Salvage Area within Isolated Area = 3,285 m^2

Average Density of Freshwater Mussels within the Construction Area = .3 mussels/ m^2

Relative Abundance of Snuffbox = .90%

Relative Abundance of State Listed Species = 13.20%

Number of Snuffbox within the Salvage area = .90%*(3,285m2*.3 Snuffbox/m^2) = 9 snuffbox

Number of State Listed within the Salvage area = 13.20%*(3,285*.3 state listed mussels/m^2) = 130 State Listed mussels

Total Number of Snuffbox in the Salvage Area = 9

Total Number of State Listed Mussels in the Salvage Area = 130

Table 4: Snuffbox and State Listed Mussels Detected During Salvage Operations Harmed Due to Increased Physiological Stress Impairing Essential Behavior Patterns:

The number of Snuffbox and state listed mussels detected during salvage operations that have the potential to be harmed due to increased physiological stress that impairs essential behavior patterns. Snuffbox and state listed mussels that are present within the isolated area that are salvaged have the potential to be killed due to direct interactions. Therefore, of the Snuffbox and state listed mussels detected (85% detection rate), a small number (<5%) of Snuffbox and state listed mussels may be killed due to direct interactions as a result of unknown or uncontrollable factors. The following calculations break down the number of Snuffbox and state listed mussels harmed as a result of salvage activities including the number of those salvaged that will suffer direct mortality (5%).

Snuffbox Mussels:

85% Detection Rate

9 Snuffbox * .85 detection rate = 8 Snuffbox Salvaged.

Of the 8 snuffbox salvaged, 5% will die due to unforeseen/ uncontrollable factors 8 snuffbox *.05 mortality rate = .4 Snuffbox if rounded = likely to be 0 mortality of Snuffbox.

To calculate the number of Snuffbox that will be killed due to being undetected 9 Snuffbox – 8 Snuffbox = 1

8 Snuffbox harmed due to impairment of essential behavior patterns of those likely 0 will be killed, and 1 Snuffbox will be killed as a result of being undetected during salvage.

State Listed Mussels

85% Detection Rate

130 state listed mussels * .85 detection rate = 111 state listed mussels salvaged.

Of the state listed salvaged, 5% will suffer direct mortality due to unforeseen/ uncontrollable factors

111 state listed mussels *.05 mortality rate = 6 state listed mussels (rounded).

To calculate the number of state listed mussels that will be harmed and suffer direct mortality due to being undetected 130 state listed – 111 state listed = 19

111 state listed mussels will be harmed due to impairment of essential behavior patterns of those 6 will be harmed due to direct mortality. 19 state listed will be harmed and suffer direct mortality as a result of being undetected during salvage.

Table 5: Predicted Number of Snuffbox and State Listed Mussels in Operations, Maintenance, Repair, Rehabilitation, or Replacement Harmed:

Total Repair, Rehabilitation, or Replacement Area = 10,000 m^2
Average Density of Freshwater Mussels within the Construction Area = .3 mussels/ m^2

Relative Abundance of Snuffbox = .90%

Relative Abundance of State Listed Species = 13.20 %

Number of Snuffbox within the Repair, Rehabilitation, or Replacement Area = .90% *(10,000*.3 Snuffbox/m^2) = 27 Snuffbox

Number of state listed species within the Repair, Rehabilitation, or Replacement Area = 13.20% *(10,000*.3 state listed mussels/m^2) = 396 state listed species

Total Number of Snuffbox Harmed Due to Direct Mortality in Repair, Rehabilitation, or Replacement Areas = 27

Total Number of State Listed Species Harmed Due to Direct Mortality in Repair, Rehabilitation, or Replacement Areas = 396

Table 6: Predicted Number of Snuffbox and State Listed Mussels in the Indirect Impact Area within the Construction Area Harmed:

Total Indirect Impact Area within the Construction Area = 80,185 m^2

Average Density of Freshwater Mussels within the Construction Area = .3 mussels/ m^2

Relative Abundance of Snuffbox = .90%

Relative Abundance of State Listed Species = 13.20 %

Number of Snuffbox within the Indirect Impact Area within the Construction Area = .90% *(80,185 m2*.3 Snuffbox/m^2) = 216 Snuffbox

Number of state listed species within the Indirect Impact Area within the Construction Area = 13.20% *(80,185 m^2*.3 state listed mussels/m^2) = 3,175 state listed species

Total Number of Snuffbox Harmed Due to Disruption of Normal Respiration, Feeding, Growth, and Reproduction, Impairing Essential Behavior Patterns in the Indirect Impact Area within the Construction Area = 216

Total Number of State Listed Species Harmed Due to Disruption of Normal Respiration, Feeding, Growth, and Reproduction, Impairing Essential Behavior Patterns in the Indirect Impact Area within the Construction Area = 3,175

Table 7: Predicted Number of State Listed Mussels in the Downstream Indirect Impact Area Harmed:

Total Downstream Indirect Impact Area = 282,600 m^2

Average Density of Freshwater Mussels within the Downstream Area = .1 mussels/ m^2

Relative Abundance of State Listed Species = 29.47 %

Number of State listed species within the Downstream Indirect Impact Area = 29.47% *(282,600*.1 state listed mussels/m^2) = 8,328 state listed species

Total Number of State Listed Species Harmed Due to Disruption of Normal Respiration, Feeding, Growth, and Reproduction, Impairing Essential Behavior Patterns in the Downstream Indirect Impact Area = 8,328

Cumulative Effects

Cumulative effects are those "effects of future State or private activities, not involving federal activities, that are reasonably certain to occur within the Action Area" considered in this Opinion (50 CFR 402.02).

The following are a summary of the non-federal actions that are reasonably certain to occur within the Action Area in the future and have a reasonable certainty of take of Snuffbox mussel.

- Coldbrook Water Pump Station- The project seeks to transform a property with mostly surface parking lots and storage buildings, which drain directly to the Grand River, into a prominent public recreation and outdoor education amenity. This existing site has a concrete floodwall limiting access to the river. The new site layout will be an opportunity to provide education on the importance of best management practices related to stormwater and the positive changes happening along the Grand River and its tributaries. This site will be a critical hub for river and trail access. Envisioned improvements include the following:
    - Removal of approximately 150 lineal feet of concrete floodwall allowing access into and out of the river as well as creating a naturalized edge and additional flood storage.
    - Interpretation of Coldbrook Creek to demonstrate the channel's historic alignment and educate the public on the other hidden streams in the area.
    - Flexible plaza spaces adjacent to the building provide areas for outdoor learning, events, and cultural activities, such as canoe building with the Anishinaabe and programmed outdoor recreation activities could be pursued here.
    - Mixed use redevelopment above the 100-year floodplain is anticipated at the corner of Leonard Street and North Monroe Avenue with plazas oriented towards the river.
    - A large multipurpose lawn provides flexible space with an option for future bus drop off ADA and small parking lot is located onsite.
    - An emergency access boat ramp. This project is in the master plan stage. Project is upstream of the 6th Street Dam, where mussel density is approximately 1.7/m2.
- Fish Ladder Park- Fish Ladder Park has been identified as an important community gathering spot and the fish ladder structure is an iconic piece of functional art. The park would continue to serve these purposes and the project seeks to enhance and improve the site to function with any future changes to the river. If or when the 6th Street Dam is removed, the Fish Ladder structure would be modified to continue to provide fish passage, and improvements would be implemented within the surrounding park, which would continue to be a primary hub for fishing access. Envisioned improvements include the following:
    - Viewing deck located north of the Fish Ladder.
    - Existing fish ladder structure will remain for rapids viewing and fish observation.
    - Increase the flood protection system to 100-year base flood elevation plus 3 feet.
    - Changing room, restroom, and fish cleaning station.
    - Flexible plaza and adjacent parking area to accommodate small events.
    - Sloped event lawn next to new trees, planted on the high point of the existing berm to provide shade.
    - Emergency access boat ramp.

- Upper viewing perches on the embankment link to Scribner with Fish Ladder Park, provide small lounging pockets and expand spectator areas.
- Approximately 800 lineal feet shared use trail.
- Angling and wading access steps link the river trail to the bank.
- Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.

This project is in the master plan stage. Project is upstream of the 6th Street Dam, where mussel density is approximately 1.7/m2.

- Wealthy St. Access- Wealthy St. Access is situated at the southern end of the downtown river corridor and a vital connector for residents within the Roosevelt Park and Black Hills Neighborhoods. The eastern edge is a City-owned parking lot with minimal use. The western edge is a small City-owned parking lot that is also minimally used, with dilapidated stairs that provide access about halfway down to the river. The stairs were originally installed for City workers to access an outfall that is now abandoned. The envisioned improvements will provide equitable river access in an area that currently consists of 15-foot-tall concrete flood walls and a neglected river edge with some trees. Please note only one of the river edges is anticipated to be improved in this project. At this time, it is unknown which side of the river the project would occur on. Envisioned improvements include the following:
    - Approximately 250 lineal feet of elevated boardwalk/ramps providing access from the existing parking lot to the river.
    - Reconfiguration of the existing parking lot with improved drop-off location.
    - Site amenities including pedestrian-scale lighting, benches, litter, and interpretive signage.
    - Vegetated rip rap.

      This project is a concept design. It is downstream of Fulton St.
- 201 Market Ave. (updated)- The existing river's edge on the east side of the Grand River between Fulton Street and Wealthy Street is approximately 2/3 of a mile. The current parcel contains buildings used to store the City's public works equipment. The river edge condition is a combination of cast in place concrete wall and steel sheet piling. Dependent upon the water level, portions of the river's edge include a sloped bank at the base of the walls. The entire length is populated with a combination of mature large trees and dense scrub-shrub underbrush providing screening of views for the current industrial and commercial uses. The conceptual designs for the river's edge propose removal of the existing floodwall to provide better access to a more natural shoreline while adding freeboard to the flood control system in order to reach the 3 feet above the 100-year base flood elevation. Flood control will be maintained by utilizing a variety of design features rising to the flood control level with gentler slopes, naturally terraced dolomitic limestone and native plantings combined with walking running and biking trails paralleling the river and joining the properties along the Grand River. The proposed trail will be connected to river access points and public right of ways using universal design guidelines, creating universal access for all to enjoy the Grand River. This In addition to the proposed improvements to the river wall, the conceptual plan is proposing the addition of two pedestrian bridges to connect the existing collegiate campus and residential developments west of the river to the proposed amphitheater and mixed-use

development east of the river. Both pedestrian bridges would be used to connect to the downtown urban trail network and are being planned structurally so the abutments land outside the river and flood control measures. Both bridges have not had feasibility studies, including hydraulics, performed on them and substantial changes could occur. The serpentine pedestrian bridge would stay within the footprint of the US-131 bridge and would be assumed to be 12 foot wide by 600 feet long (not shown on figure as it remains within footprint of US-131). The other pedestrian bridge is estimated to be 12 feet wide and approximately 500 feet long. A proposed zip line could also span the river with the structural support system outside the river flood boundaries anchoring and landing above the 100-year flood elevation. A structure (assumed 20x8 foot) to accommodate the zip line was estimated and is shown on the island but would have to be vetted with the design process.

The permit application for this project was submitted to EGLE in Spring 2024. The proposed project does not extend past the 890 CFS line, and no equipment is expected in the river. Therefore, no direct impacts to mussels are anticipated. Appropriate soil erosion and sedimentation control BMPs would be installed to minimize any potential indirect impacts to mussels.

- 6th St. Park- This park currently consists of a north/south linear trail, a restroom, fish cleaning station, small pavilion, public parking lot, and a concrete floodwall that spans the entire length of the park from I-196 to 6th Street with only one (1) point of access (which is not universally accessible) to the river located at the 6th Street Dam. Due to the concrete floodwall, there is minimal to no biodiversity along the river's edge. Additionally, there are several storm sewers that discharge into the river through the existing concrete floodwall. The southern half of the park consists of an electrical substation and remnant surface parking lots. The City acquired the parking lot parcels through a Michigan Natural Resources Trust Fund acquisition grant and has been temporarily activating the site. Permanent improvements will not proceed for several years as this is one of the anticipated staging and access sites for the Corps Project. This site will provide an opportunity to transform how the City and its citizens engage with its most valuable natural resource in one of its most prominent downtown locations. Envisioned improvements include the following:
    - 1,800 lineal feet of new shared use trail.
    - Increase the flood protection system to 100-year base flood elevation plus 3 feet.
    - Removal of approximately 740 lineal feet of concrete floodwall allowing access into and out of the river as well as creating a naturalized edge and additional flood storage.
    - River landing providing a safe and accessible public river access space.
    - A large universally accessible walk for river access.
    - Daylighted stormwater outfall and stormwater marsh provide resilient, natural stormwater treatment and re-establish a healthy river edge.
    - Stepped seating terraces at the river edge to provide an expanded, resilient rapids viewing area.
    - A shaded seating edge expands park access, even during high water events.
    - An event pavilion to accommodate concessions, restrooms, and services to support recreation.
    - An event lawn sized for markets, concerts, and a number of other uses.

- Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.
- A flexible mid-level terrace can host seasonal events and recreation.
- A skate park in the area near I-196.
- Non-motorized watercraft takeout point.

This project is a conceptual design and is upstream of the 6th Street Dam where mussel density is approximately 1.7/m2.

- Riverside Park- Riverside Park is Grand Rapid's largest and most prominent park for active and passive recreation users. The 182-acre park with approximately 2,000 lineal feet of river frontage lies almost entirely within the 100-year flood limit with a few exceptions along Monroe Avenue. The river edge is primarily naturalized except for some armored locations and 3 public boat launch facilities. The park also has an interior lagoon with two heavily vegetated islands. Numerous smaller improvements have been made within the park over the last 20 years, but the last major investments were implemented in the late 1990's. Due to the park's popularity, use, and location within a highly fluctuating floodplain, most of the built assets are nearing the end of their functional life cycle. Roads, bridges, trails, and other structures are in need of repair, replacement. or removal. Additionally, over 100 acres of the park consists of maintained turf. This practice, along with the surface runoff from interior roads and parking, and siltation from seasonal flooding have contributed to poor water quality within the park's lagoon. The park is also situated at the downstream end of several large storm outfall pipes. These pipes collect stormwater from an approximately 1,800-acre watershed to the east and discharge directly into the Grand River. The City's master plan contains a broad list of ambitious and exciting changes for the park that focus on the following community priorities:
  - Remove, replace, and expand non-motorized trails network within the park
  - Daylight existing stormwater low-flow and route through new bio-swales, rain gardens, constructed wetlands to collect, cleanse and infiltrate water prior to reaching the lagoon and/or Grand River.
  - Reduce road and parking impervious surfaces.
  - Increase native wetland, wet meadow, and upland plantings, especially along areas receiving surface runoff.
  - Renovate existing restrooms and maintenance facility.
  - Provide multi-purpose community waterfront center with restrooms, concessions, large event area, accessible watercraft launch, and river amphitheater.
  - Improve existing active recreation programs including sport fields, cross country course and disc golf.
  - Improve accessibility to the lagoon and river's edge as well as increase edge resiliency through use of bio-engineering techniques.
  - New dog park dedicated as off-leash area.
  - Improve all 3 existing boat launches.
  - Renovate existing play areas and incorporate nature-based play elements.

This project is only in the Master Plan phase. It would impact approximately 4,046 m2 of river, where mussel density is approximately 3/m2.

JEOPARDY ANALYSIS

Section 7(a)(2) of the ESA requires that federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat.

Jeopardy Analysis Framework

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). The following analysis relies on 4 components: (1) Status of the Species, (2) Environmental Baseline, (3) Effects of the Action, and (4) Cumulative Effects. The jeopardy analysis is competed wholistically considering both proposed actions and as such this Opinion emphasizes the rangewide survival and recovery needs of the listed species and the role of both Action Areas in providing for those needs. It is within this context that we evaluate the significance of both proposed federal actions (NRCS WFPA Project and the City/GRWW Project), taken together with cumulative effects, for purposes of making the jeopardy determination.

Analysis for Jeopardy

Mussel biodiversity and abundance plays a critical role in ecosystem function (Nobles and Zhang 2011). An adult freshwater mussel filters anywhere from 1 to 38 gallons of water per day (Baker and Levinton 2003, Barnhart pers. comm. 2019). A 2015 survey found that in some areas mussels can reduce the bacterial populations by more than 85% (Othman et al. 2015 in Vaughn 2017). Mussels are also considered to be ecosystem engineers, stabilizing substrate and providing habitat for other aquatic organisms (Vaughn 2017). In addition to ecosystem services, mussels play an important role in the food web, contributing critical nutrients to both terrestrial and aquatic habitats, including those that support sport fish (Vaughn 2017). Therefore, our Effects Analysis analyzed both the effects to Snuffbox as well as the broader community of state listed mussels within both Action Areas. While our Jeopardy Analysis does not characterize impacts to individual species of state listed mussels at the individual, population, and species level, we do consider the impact to the community of state listed mussels as a whole in the context of how these impacts influence the health and abundance of the Snuffbox at the population level and as a species as whole.

Impacts to Individuals – The NRCS WFPA Proposed Action includes removal of 4 low-head dams, the addition of substrate material, and installation of hydraulic features to create recreational opportunities. One of the stated goals of the project is to restore aquatic habitat diversity and suitability for native Great Lakes drainage fish and mussel species, especially threatened and endangered species in the Grand River by increasing the quantity, quality, and diversity of instream habitat features throughout the project area. As discussed in the Effects of the Action, potential effects of the action include effects to federally endangered snuffbox and state listed mussels present within both Action Areas. Effects generally include direct harm to adults, juveniles, and glochidia, due to crushing, injury, smothering, desiccation, as well as interference with normal respiration, feeding, growth, and reproduction. Any Snuffbox or state listed mussels harmed during spawning or that are gravid, may suffer reduced reproductive

output for the year as a result of lost reproductive potential or glochidia that are killed or released prematurely. In summary, we anticipate impacts to individual Snuffbox and state listed mussels species in either their annual survival or reproductive rates.

Impacts to Populations – As we have concluded that individual Snuffbox and state listed mussels are likely to experience impacts in their annual survival or reproductive rates resulting in harm. We need to assess the aggregated consequences of the anticipated impacts on the population to which these Snuffbox individuals belong.

The NRCS WFPA Project and the City/GRWW Project is expected to potentially affect the survival and reproductive output of Snuffbox and state listed mussels. A portion of Snuffbox and state listed species will be harmed by the City/GRWW Proposed Action through impairment of essential behavior patterns resulting from salvage and relocation, these impacts will be temporary and should not result in significant mortality. Snuffbox and state listed species removed from the project area through salvage and relocation, will not be permanently removed from the Grand River ecosystem. Instead, they will be relocated upstream of the NRCS WFPA Project Area. As such, while Snuffbox abundance will decrease within the NRCS WFPA Project Area, the overall population of Snuffbox within the Grand River Watershed should not be significantly impacted and change the current status of the population in the Grand River as a "stronghold" for the species. For example, localized populations of Snuffbox elsewhere in the Grand River such as in Lyons and Lowell, are much larger than the population within the NRCS WFPA Project Area. Furthermore, the critical role that the broader mussel community plays in sustaining Snuffbox health and fitness should not be severely impacted given that state listed species and Snuffbox will be relocated as a community. The critical role that the diversity and abundance of Snuffbox and state listed mussels make to the aquatic ecosystem will continue albeit in a different stretch of the Grand River.

Lastly, one of the stated goals of this project is to restore aquatic habitat diversity and suitability for native Great Lakes drainage fish and mussel species, especially threatened, endangered, and special concern native species in the Grand River NRCS WFPA Project Area. Therefore, one of the goals of project design has been to try to provide long-term benefits to fish (game and nongame species) and the mussel community by increasing the quantity, quality, and diversity of instream habitat features throughout the project area. While there is great uncertainty regarding the creation of suitable freshwater mussel habitat and it is largely experimental, the hope is that the proposed project will result in higher quality mussel habitat for freshwater mussels.

These effects are not expected to measurably decrease the fitness of Snuffbox within these Action Areas. Snuffbox occur at relatively low density in the NRCS WFPA Project Area in comparison to other areas in the Grand River Watershed. The population of Snuffbox in the NRCS WFPA Action Area is considered relatively low in terms of density and abundance in comparison to localized populations of Snuffbox elsewhere in the watershed. While cumulative effects will occur in the NRCS WFPA Action Area, the additional impacts to mussels are anticipated to be limited in spatial scale by project designs (e.g., limits to areas within project that are wadable) and some features or restored habitats will provide adequate cover to mussels from human activity. In summary, any reduction in abundance, reproduction, and growth, are likely to be small given the low abundance and density of snuffbox in the NRCS WFPA Action Area, and that some individuals will be safely relocated within the Grand River as a mussel community as a whole. Further the funding provided to help offset project impacts included in the proposed action will provide opportunities to implement additional measures that significantly benefit state and federally listed mussels in the Lower Grand River.

Impacts to Species – As we have concluded that Snuffbox mussel populations are unlikely to experience a significant reduction in fitness, there will be no harmful effects (i.e., there will be no long-term reduction in reproduction, numbers, and distribution) on snuffbox species as a whole.

CONCLUSION

We first considered the current overall rangewide status of Snuffbox mussels. We then assessed the effects of the proposed action and the potential for future cumulative effects in the NRCS WFPA Action Area on individuals, populations, and Snuffbox as a whole. As stated in the Jeopardy Analysis, we do not anticipate any long-term reductions in the overall reproduction, numbers, and distribution of Snuffbox present within the NRCS WFPA Action Area. It is the USFWS's Opinion that the NRCS WFPA Project and the City/GRWW Project as proposed, are not likely to jeopardize the continued existence of Snuffbox mussels.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined in section 3 of the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (50 CFR § 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary and must be undertaken by the City of Grand Rapids/ GRWW as the non-federal representative implementing the salvage and relocation project and NRCS for the WFPA Project so that they become binding conditions of any grant or permit issued to another entity, as appropriate, for the exemption in section 7(o)(2) to apply. The City of Grand Rapids/ GRWW and NRCS has a continuing duty to regulate the activity covered by this incidental take statement. If the City of Grand Rapids/ GRWW and the NRCS: (1) fails to assume and implement the terms and conditions or (2) fails to require a grantee/permittee to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of Section 7(o)(2) may lapse. To monitor the impact of incidental take, the City of Grand Rapids/ GRWW and NRCS must report the progress of the action and its impact on the species to the USFWS as specified in the incidental take statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

Incidental take is associated with salvage and relocation for the City/GRWW Project as well as with construction activities for the NRCS WFPA Project. The incidental take for the two projects is interdependent, such that we have one combined reasonable and prudent measure and term and condition that is generally applicable to both relocation and construction. The anticipated take is described below in Table 8.

Table 8. Anticipated Take of Snuffbox Mussel

Species	Amount of Take Anticipated (Number of Individuals)	Life Stage when Take is Anticipated	Type of Take	Take is Anticipated as a Result of	Surrogate Measure of Incidental Take
Snuffbox Mussel	119	Larvae, Juveniles, and Adults	Harm-Direct Mortality	Direct Impact Area Excluding Isolated Area for Dam 2 1. Adults and juveniles may be crushed, injured, smothered, or desiccated; and 2. Glochida in marsupial gills of gravid adult females may be crushed and injured leading to mortality and disruption of dispersal.	Direct Impact Area Excluding Isolated Area for Dam 2 = 44, 130 m^2
Snuffbox Mussel	27	Larvae, Juveniles, and Adults	Harm-Direct Mortality	Repair, Rehabilitation, or Replacement Operations 1. Adults and juveniles may be crushed, injured, smothered, or desiccated; and 2. Glochida in marsupial gills of gravid adult females may be crushed and injured leading to mortality and disruption of dispersal.	Repair, rehabilitation, or Replacement Operations = 10,000 m^2

Snuffbox Mussel	1	Larvae, Juveniles, and Adults	Harm-Direct Mortality	Salvage, Relocation, and Lack of Detection with 85% Collection Efficiency 1. Adults and juveniles may be crushed, injured, smothered, or desiccated; 2. Glochida in marsupial gills of gravid adult females may be crushed and injured leading to mortality and disruption of dispersal; and 3. Unknown factors that may result in mortality during salvage and relocation.	Salvage Area = 3,285m^2
Total Number of Snuffbox Harmed Due to Direct Mortality					**147**
State Listed Mussels	1,748	Larvae, Juveniles, and Adults	Harm-Direct Mortality	Direct Impact Area Excluding Isolated Area for Dam 2 1. Adults and juveniles may be crushed, injured, smothered, or desiccated; and 2. Glochida in marsupial gills of gravid adult females may be crushed and injured leading to mortality and disruption of dispersal.	Direct Impact Area Excluding Isolated Area for Dam 2 = 44,130 m^2
State Listed Mussels	396	Larvae, Juveniles, and Adults	Harm-Direct Mortality	Repair, Rehabilitation, or Replacement Operations 1. Adults and juveniles may be crushed, injured, smothered, or desiccated; and 2. Glochida in marsupial gills of gravid adult females may be crushed and injured leading to mortality and disruption of dispersal.	Repair, rehabilitation, or Replacement Operations = 10,000 m^2

State Listed Mussels	25	Larvae, Juveniles, and Adults	Harm-Direct Mortality	Salvage, Relocation, and Lack of Detection with 50% Collection Efficiency 1. Adults and juveniles may be crushed, injured, smothered, or desiccated; 2. glochida in marsupial gills of gravid adult females may be crushed and injured leading to mortality and disruption of dispersal; and 3. unknown factors that may result in mortality during salvage and relocation.	Salvage Area = 3,285 m^2
Total Number of State Listed Mussels Harmed Due to Direct Mortality					**2,169**
Snuffbox Mussel	8	Larvae, Juveniles, and Adults	Harm Due to Impairment of Essential Behavior Patterns	Salvage/Relocation - Capture, Handling, Temporary Holding, and Transport 1. increased physiological stress, resulting in disruption of spawning and fertilization, growth, or feeding.	Salvage Area = 3,285 m^2
Snuffbox Mussel	216	Glochida, Glochidia on Host Fish, Larvae, Juveniles, and Adults	Harm Due to Impairment of Essential Behavior Patterns	Increased Turbidity and Changes in Hydrology in the Construction Area 1. disruption of normal respiration, feeding, growth, or reproduction.	Construction Indirect Impact Area = 80,185 m^2
Total Number of Snuffbox Harmed Due to Impairment of Essential Behavior Patterns					**224**

State Listed Mussels	105 (111 individuals – of which 6 individuals accounted for under direct mortality)	Larvae, Juveniles, and Adults	Harm Due to Impairment of Essential Behavior Patterns	Salvage/Relocation - Capture, Handling, Temporary Holding, and Transport 1. Increased physiological stress, resulting in disruption of spawning and fertilization, growth, and feeding.	Salvage Area = 3,285 m^2
State Listed Mussels	3,175	Glochida, Glochidia on Host Fish, Larvae, Juveniles, and Adults	Harm Due to Impairmet of Essential Behavior Patterns	Increased Turbidity and Changes in Hydrology in the Construction and Downstream Area 1. disruption of normal respiration, feeding, growth, and reproduction.	Construction Indirect Impact Area and Downstream Indirect Impact Area = 80,185 m^2
Total Number of State Listed Mussels Harmed Due to Impairment of Essential Behavior Patterns					**3,280**

For the Snuffbox, detecting take that occurs incidental to the Action is not practical. Snuffbox are small, benthic, embedded in the substrate, and may be displaced to other areas where they would not necessarily be detected.

When it is not practical to monitor take in terms of individuals of the listed species, the regulations at 50 CFR §402.14(i)(1)(i) indicate that an ITS may express the amount or extent of take using a surrogate (*e.g.,* a similarly affected species, habitat, or ecological conditions), provided that the USFWS also:

- describes the causal link between the surrogate and take of the listed species; and
- sets a clear standard for determining when the level of anticipated take has been exceeded.

We have identified surrogate measures in our analyses of effects that satisfy these criteria for monitoring take of the species named above during Action implementation. Table 8 lists the surrogate measures for each portion of the proposed action that is likely to cause incidental take of the Snuffbox.

REASONABLE AND PRUDENT MEASURES

The USFWS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of snuffbox and state listed species:

1. NRCS/ The City/GRWW – NRCS, the City, and GRWW, will install the isolation area for Dam 2 in accordance with the Terms and Conditions.
2. The City/GRWW Project - The salvage methodology (i.e., search effort) for all Snuffbox and state listed mussels must be in accordance with the Michigan Freshwater Mussel Survey Protocols and Relocation Procedures (Hanshue et al. 2019) and the Relocation Plan for this Project (Appendix A). The critical components of these documents are incorporated as Terms and Conditions.
3. The City/GRWW Project - Relocation and all capture, handling, and temporary holding of Snuffbox and state listed mussels must be in accordance with the Michigan Freshwater Mussel Survey Protocols and Relocation Procedures (Hanshue et al. 2019) and the Relocation plan for this Project (Appendix A). The critical components of these documents are incorporated as Terms and Conditions.
4. The City/GRWW Project - Post relocation monitoring surveys will be conducted in accordance with the Michigan Freshwater Mussel Survey Protocols and Relocation Procedures (Hanshue et al. 2019) and the Monitoring Plan for this Project (Appendix A). The critical components of these documents are incorporated as Terms and Conditions.
5. The City/GRWW Project - A Mitigation Fund will be established for mussel conservation (Appendix B). The critical components of this Fund are incorporated as Terms and Conditions.
6. The City/GRWW Project - Fish will be salvaged from isolation areas and in accordance with the Terms and Conditions.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the NRCS and the City/GRWW must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary.

Terms and Conditions to fulfill RPM # 1, NRCS, the City/GRWW

1. Prior to installation of isolation area for Dam 2, NRCS, the City, and GRWW, will coordinate directly with USFWS Sea Lamprey Control Program: Peter J. Hrodey, Unit Supervisor, Sea Lamprey Control, Alternative Control and Evaluation, U.S. Fish and Wildlife Service, 1095 Cornerstone Drive, Marquette, MI 49855-9649.
2. Installation of the isolation area for Dam 2 should be implemented when the water temperature is > = 20°C, which should correspond to a date no earlier than July 1st.

Terms and Conditions to fulfill RPM # 2 the City/GRWW

1. Methodology for Salvage and Relocation within Isolation Area for Dam 2
    a. Mussels will be collected from the substrate using visual-tactile search methods. Surveyors will locate mussels by moving cobble, and woody debris; hand sweeping away silt, sand and/or small detritus; and disturbing/probing the upper five centimeters (two inches) of the substrate to increase the likelihood of mussel detection.
    b. The isolation area would be divided into 10 m wide corridors. Four or more individuals would thoroughly search (≤0.5 minute/m^2) each corridor (one

biologist/corridor) until two or fewer mussels are found per 100 m^2, <5% of the mussels found in the first pass are found in the last pass, or at least 1 min/m2 of search time has been expended, whichever comes first.

c. At least one pass would be conducted over the entire area to ensure that most freshwater mussels are collected in case of any emergency that could prevent the completion of a salvage effort (sudden rise in water level overtopping the isolation measures or other unforeseen circumstances). Additional passes would then be conducted until the aforementioned criteria are met.
d. Collection efficiency is estimated at 85% within the isolation area for Dam 2.
e. Any logperch that are not salvaged from within the isolation area and suffer mortality should be recorded and provided to the USFWS.

2. Methodology for Salvage and Relocation within Direct Impact Areas Excluding Isolated Area for Dam 2 if there are Workable Flows:
    a. Workable flow would be defined as current velocity in which the diver/snorkeler can maintain position (not be swept downstream) within the block and collect mussels.
    b. Each direct impact area would be divided into 5 x 10 m blocks. Workable flow would be defined as current velocity in which the diver/snorkeler can maintain position (not be swept downstream) within the block and collect mussels. Blocks would be further divided into smaller 2 m x 1 m grids using a 3/8 inch metal that would lay flat on the river bottom grid. Each 2x1 grid is split into 1m x 1m cells and would be searched individually. Each of the 1 m x 1 m cells would be visually searched for habitat and mussels (visual search). If no habitat (bedrock or entirely non-movable rock) is found, then that 1 m2 is clear.
    c. If habitat and/or mussels are found, the 1 m2 area would be excavated down to 15 cm (6 inches), collecting any mussels that are found (first pass) within an average search effort of 2 min/m2. Excavation includes moving cobble and woody debris and moving away silt, sand, and small detritus, then digging the substrate down at least 15 cm (6 inches). That 1 m2 would be excavated a second time (second pass) for an average of 2 min/m2, and if <5% of the mussels are collected on the second pass compared to the completed first pass and no state and federally listed species are found, then the 1 m2 would be declared clear. If not, it would need to be searched again until the <5% criteria and no state and federally listed species found threshold, is reached. Searching would require an average of 2 min/m2 . Once the entire 2 m x 1 m grid is clear, the 2 m x 1 m grid would be moved to the next 2 m x 1 m.
    d. "Clear" is defined as:
        a. Area is bedrock or non-diggable rock on the visual search;
        b. No mussels >0.5 inches are found on the completed first dug up pass (divers/snorkelers would strive to collect all mussels, but can only guarantee that mussels >0.5 inches would be collected);
        c. Mussels are found after digging up the area (first pass), but <5% of the total number of mussels>0.5 inches found on the first pass are found after the area is dug up again (second pass) AND no State and federally listed species are found;
        d. Passes continue until <5% criteria of the completed first pass is met and no state and federally listed species are found.

Terms and Conditions to fulfill RPM #3, the City/GRWW Project

1. On the day(s) of the relocation, minimum expected air temperatures should be greater than 50°F, and maximum expected air temperatures should be less than 90°F.
2. Collected freshwater mussels would be held in flowing water or in flow through tanks (under ambient water conditions) while awaiting processing and/or relocation. Freshwater mussels would be processed within a few hours of collection.
3. All collected Snuffbox and state listed species would be tagged, measured (length in mm), and aged (external annuli count).
4. Snuffbox would be tagged with Passive Integrated Transponder (PIT) tags and state listed species would be tagged with shellfish tags. Common species would be identified, counted, and marked with a Dremel tool (slash on the anterior ventral edge of the shell to assess growth).
5. Tagged Snuffbox and state listed species would be randomly assigned a recipient site grid cell within the relocation area. Once at the site, common species would be hand placed on the substrate (either marked with buoys or GPS points).
6. Snuffbox and state listed species would be hand placed on the substrate within their assigned area at a density of 1 unionid/m^2.
7. Freshwater mussels would be kept in water at ambient temperature (flowing water, flow through tanks, or buckets with frequent water changes) throughout this process and while awaiting transport to recipient sites.
8. Mussels will be transported in containers that minimize jostling or impact.
9. Freshwater mussels would be translocated to recipient sites at the end of each day or the beginning of the following day wrapped in moist towels within coolers. Mussels will be kept cool and moist during transport by covering with wet towels or burlap bags if transport time will exceed one hour or by immersion in water if less time is needed.
10. All live Snuffbox mussels will be identified to species and sexed if possible.
11. Photographic vouchers (live and shell) of all native species will be provided to MDNR and/or the USFWS's Michigan Ecological Services Field Office. Photographs of individuals will include a closeup view of the umbo and one of the valves. Any questionable species will include photographs of the left valve, right valve, and dorsal view to provide adequate reference for verification.

Terms and Conditions to fulfill RPM #4, the City/GRWW Project

1. Freshwater mussels within recipient sites would be monitored within one year of each year of salvage if that effort spans more than one year (2024/2025) between June and October 15 when water temperature is greater than 10○ C (50○ F), and air temperature is between 10 and 32○ C (50 and 90○ F).
2. Up to 100, 1 m2 cells in each recipient site will be randomly selected for monitoring. A PIT tag wand would be first used to find and collect Snuffbox. A diver/snorkeler would systematically search each selected 1 m2 area. A PVC grid with 1 m2 cells would be used to facilitate searching.
3. At least 10 1-m2 cells within each area would be excavated to calibrate surface to buried ratio. The remainder would be surface searched (visual, tactile, moving rocks, logs, probing the top inch) for at least 1 minute/m2. All collected unionids would be checked for tags, recorded as tagged or not tagged, measured (length in mm), and aged (external annuli count), and Lampsilini would be checked for gravidity.

4. Any dead marked animals would be collected and reported.
5. If any of the area where freshwater mussels were placed appears to no longer be suitable habitat (e.g., too shallow, covered with sand or silt), NRCS will consult with the MDNR and the USFWS on whether the freshwater mussels should be collected and moved to a more suitable location within the recipient site or another nearby site.
6. Species, tag numbers, initial location and final destination would be recorded.
7. A report would be prepared to summarize relocation and monitoring results. Tag numbers, lengths and ages, collection site and relocation grid of Snuffbox and state listed species would be reported. Area searched, search efficiency, and number of each species collected would be summarized.
8. Monitoring results would include recovery rate, survival rate, growth, and movement of Snuffbox and state listed species.
9. Recovery rate of each species would be calculated as number of each species collected in surface search multiplied by the ratio of total: surface estimated from excavated cells/number of each species placed in the area.
10. Survival would be estimated as estimated number of live recovered/estimated live + dead recovered.
11. Growth would be assessed by both visual observations of shell material past the slash mark on the shell and by comparison of lengths.
12. Movement would be estimated by comparing placement grid cell position with collection grid cell position.
13. Species, number, ages, and assemblage metrics (% Snuffbox and state listed species, % *A. plicata* + *L. cardium,* % ≤ 5 years old, % ≥ 15 years old, % mortality, density, % *Lampsilini*, species evenness, tribe evenness, rarefaction species richness) of resident freshwater mussels would also be summarized and compared among years.

Terms and Conditions to fulfill RPM #5, the City/GRWW Project

1. The Mitigation Fund Governance Framework will be developed in coordination with NRCS, MDNR, GRWW, the City of Grand Rapids, and the USFWS.
2. The maximum mitigation fund contribution pre-construction would be based on $34.10/mussel (2020 BA $28.50/mussel escalated for inflation) and would not exceed $456,743. This fund would be reduced by the amount of mussels that are expected to survive translocation (i.e., relocated minus the 5% of relocated animals anticipated to be lost due to handling stress). The mitigation fund contribution may not be reduced by a percent greater than the percent of area cleared (i.e., area of quadrats cleared from the total area of the direct impact areas).
3. Prior to reducing the funding, the proportion of areas cleared as result of a determination of non-diggable rock must be compared to prior survey efforts to help ensure that estimates of mussels impacted are consistent with the 2024 BA.
4. The Mitigation Fund will be established to off-set impacts to freshwater mussels as a result of the proposed project and to continue efforts to conserve mussels in the Grand River Watershed.
5. The Mitigation Fund will be established prior to in-river construction starting with the exception of construction associated with the Isolation Area for Dam 2.
6. The NRCS and the City of Grand Rapids/GRWW will establish separate funding for post relocation monitoring. As such, no mitigation funding can be used for post relocation monitoring.
7. The amount of the Mitigation Fund is based on the anticipated scenario of the collection and

relocation of 85% of freshwater mussels from the Isolation Area for Dam 2 (3,285 m^2).

8. Additional mitigation fund contribution will be made post installation for any mussel impacts that occur as result of repair, rehabilitation, or replacement operations based on the area impacted and the updated mussel density (i.e., .3 mussels per m2 or as documented in post construction monitoring) and updated mussel costs (i.e., either an estimate considered current at the time of impact or using the 2020 BA $28.50/mussel escalated for inflation if a more current updated cost estimates are not available).

Term and Condition to fulfill RPM #6 the City/GRWW and NRCS

1. The number and species of any fish that are unable to be salvaged and suffer mortality as a result of the construction and isolation process should be recorded.

MONITORING AND REPORTING REQUIREMENTS

1. The NRCS and City of Grand Rapids/GRWW shall notify the Michigan Ecological Services Field Office, via email, when salvage and relocation operations are going to begin.
2. The NRCS and City of Grand Rapids/GRWW must notify the Michigan Ecological Services Field Office within 24 hours if there is the potential for incidental take to be exceeded which would be indicated by exceedance of the surrogate measures in square meters.
3. The City/GRWW Project - A final report that includes the following information as well as the information specified in RPM #3 and associated Terms and Condition 3, should be submitted to the USFWS and MDNR within 90 days of completion of each of the salvage and relocation operations.
    a. The final area impacted broken down by each activity to inform tracking of incidental take in accordance with the surrogate measures outlined in the incidental take table.
    b. Description of conditions at the time of the survey, level of effort, Snuffbox, and state listed species collected.
    c. Number and species of fish that suffer mortality during the construction isolation and drawdown process.
    d. Description of the number of Snuffbox and state listed species, affixed with pit tags, and GPS coordinates of collection and relocation site.
    e. Photographs of representative vouchers.
    f. It should be noted if any mussel mortality is due to salvage and relocation.

The contact for daily and final reporting requirements is as follows: Jessica Pruden, U.S. Fish and Wildlife Service, Michigan Ecological Services Field Office, 2651 Coolidge Road, Suite 101, East Lansing, MI 48823, 517-351-8245, jessica_pruden@fws.gov.

The post relocation monitoring reports should be submitted to the USFWS and MDNR within 60 days of the completion of post relocation monitoring.

The contact for post relocation monitoring reporting requirements is as follows: Jessica Pruden, USFWS, at the contact information listed above.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and

threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The USFWS has identified the following additional actions that, if undertaken would further the conservation and assist in the recovery of snuffbox. We recognize that limited resources and other agency priorities may affect the ability of the NRCS and the City and GRWW to conduct these activities at any given time.

1. Increase number of qualified individuals able to assist with relocation under workable flows to increase the effectiveness and efficiency of relocation.
2. Conduct additional years of post-relocation monitoring to assess future survival and growth rates of relocated mussels.
3. Conduct long term monitoring to determine if freshwater mussels specifically Snuffbox and state listed species have reseeded habitat within the Direct Impact Area.
4. Conduct long term monitoring to determine how dam removal, substrate enhancement, and installation of other in river features influence/ impact freshwater mussel and native fish communities.

In order to be kept informed of actions minimizing or avoiding adverse effects, or benefitting listed species or their habitats, the USFWS requests notification if any of these additional conservation actions are carried out or if additional measures consistent with these conservation recommendations are implemented.

REINITIATION NOTICE

This concludes formal consultation on the actions outlined in your request dated April 23, 2024.June As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded as is tracked and documented in accordance with the surrogate parameters for incidental take; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such a take must cease pending reinitiation.

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APPENDIX E

Other Supporting Information

Biological Assessment
Revised
March 2024

Biological Assessment 2024: Impacts to federal and state threatened and endangered species from rehabilitation of the Grand River between Bridge and Fulton Streets in Grand Rapids, Kent County, Michigan Revision 1

Prepared for:
Natural Resources Conservation Service and U.S. Fish and Wildlife Service under contract to Grand Rapids Whitewater

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Biological Assessment
March 2024

EcoAnalysts, Inc.



EXECUTIVE SUMMARY

The City of Grand Rapids is pursuing PL83-566 funding with the Natural Resource Conservation Service (NRCS) to improve aquatic habitat in the Lower Grand River where it flows through downtown Grand Rapids, Kent County, Michigan. The purpose of the proposed PL83-566 action in Grand Rapids is to restore the rapids, improve public safety, restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species, and enhance river access and use. The Project Area extends from 6th Street Dam to Fulton Street in downtown Grand Rapids, Kent County, Michigan. Grand Rapids Whitewater, the City of Grand Rapids, and NRCS have coordinated with the Michigan Department of Environment, Great Lakes, and Energy, Michigan Department of Natural Resources, and U. S. Fish and Wildlife Service to reduce the construction footprint, ensure fish passage, enhance aquatic habitat, diversify recreational opportunities, and restore the rapids. Additionally, the *Petromyzon marinus* barrier would be maintained at the 6th Street Dam with the same efficacy as under existing conditions. Direct impacts to threatened and endangered species (TES) would be limited to construction areas. Construction impacts have been reduced from 89,195 m^2 (22 acres) to 45,445 m^2 (11 acres), a reduction of 50% through coordination.

The four low-head dams currently within the Project Area would be removed and replaced with riffles, diversified boulder arches, and emergent habitat boulders. In the Dam 3 and 4 area, low-head dams would be removed, the river bottom would be graded, and emergent habitat boulders would be placed in the Dam 3 area. In the Dam 2 area, the low-head dam would be removed and replaced with diversified boulder arches on the west side and a riffle on the east side. In the Dam 1 area, the low-head dam would be removed and replaced with a riffle. Emergent habitat boulders would be placed throughout both the Dam 1 and 2 riffle. Two emergent boulder habitat fields would be created downstream of Pearl Street. The downstream feature would include diversified boulder arches. Boulder vanes would be created up and downstream of the Grand Rapids Public Museum carousel and on the east side to provide slack water habitat for public access.

Impacts within Direct impact areas include Take of TES mussels and disturbance of *Acipenser fulvescens* and *Moxostoma carinatum*. Unionid mussel species that would be impacted include *Epioblasma triquetra*, *Pleurobema sintoxia*, *Cyclonaias tuberculata*, *Ligumia recta*, *Potamilus alatus*, *Toxolasma parvum*, *Truncilla truncata*, *Venustaconcha ellipsiformis*, *Alasmidonta marginata*, *Alasmidonta viridis*, *Lasmigona compressa*, *Lasmigona costata,* and *Utterbackia imbecillis*. All of these species occur in other areas of the Grand River, other rivers in Michigan, and other rivers in the United States. *Pleurobema sintoxia, E. triquetra*, *T. parvum*, *V. ellipsiformis*, *A. marginata*, *A. viridis*, *L. compressa*, and *Utterbackia imbecillis* seem to be limited to upstream of Fulton Street. *Potamilus alatus* is limited to downstream of the 6th Street Dam. These species would be directly affected by this Project. The project would not jeopardize the continued existence of *E. triquetra*.

Indirect impacts during construction include minor changes in depth and velocity and increased turbidity. Turbidity would be managed through Best Management Practices.

Post construction, depth would decrease and velocity increase between the 6th Street Dam on the upstream feature. Depth and velocity would be diversified within features, and flow refugia would be created from the emergent habitat boulders. More slow flowing areas would be available near the banks, and velocity would be slower in most of the area downstream of the Dam 3 emergent habitat boulders. Rock vanes downstream of Pearl Street would provide slow flowing areas for public access.

To minimize the impacts to freshwater mussels, Grand Rapids/GRWW with the assistance of U.S. Fish and Wildlife Service would translocate mussels from Direct impact areas under the Urban Water Federal Partnership Program. Pre-construction (2024), mussels would be translocated from as much of the Direct impact area as safely possible. Mussels would also be translocated from the Dam 2 area that requires isolation for construction in 2025. Fish would also be salvaged from the isolated area. Translocated mussels would be moved to Ada, Riverside Park, or Plaster Creek recipient sites. Mussels would be monitored for survival, growth, and movement within one year of translocation (2025 and 2026).

To mitigate for mussels not translocated and for anticipated mortality during translocation, a mitigation fund would be established based on the number of mussels not translocated. The objective of the mitigation fund would be to fund projects that provide a direct benefit to mussels to achieve the USFWS "no net loss" policy and offset any potential impacts from mussels that were unable to be translocated. The work performed through the mitigation fund would help inform future conservation and habitat restoration efforts.

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ACRONYMS AND DEFINITIONS

Acronyms

BA – Biological Assessment

BMPs – Best management practices

BO – Biological Opinion

CFS – Cubic feet per second

EA – Environmental Assessment; document generally required under NEPA for Biological Assessments

EGLE – Michigan Department of Environment, Great Lakes, and Energy (formerly DEQ)

ESA – Endangered Species Act of 1973 as amended

ESI – Ecological Specialists, Inc.

FD – Freshly dead mussel shell; periostracum condition similar to live animals, valves attached, hinge line flexible, and nacre shiny; animal likely died within a few months of the survey. Species collected as FD shells are likely living in the area at a low frequency.

FERC – Federal Energy Regulatory Commission

GLFC – Great Lakes Fishery Commission

GRWW – Grand Rapids Whitewater

GVMC – Grand Valley Metro Council

IPac – Information for Planning and consultation (USFWS)

LDB – Left descending bank

MDKey – Michigan Determination Key for project review and guidance for federally listed species

MDNR – Michigan Department of Natural Resources

MDOT – Michigan Department of Transportation

MLC – Mean Lethal Concentration (lampricide)

MNFI – Michigan Natural Features Inventory

NEPA – National Environmental Policy Act

NRCS – Natural Resources Conservation Service

NREPA – Natural Resources and Environmental Protection Act

OHWM – Ordinary high-water mark; 10,000 CFS or high-water level that is within the channel

OMRRR – Operations, maintenance, repair, rehabilitation, and replacement

MHH – Modeled Hydrophysical Habitat

PIT tags – Passive Integrated Transponder tags

RDB – Right descending bank

RRO – RiverRestoration Organization

TES – Threatened, endangered, and species of special concern; includes both federal and Michigan listed species
- **FE** – Federally endangered species
- **ME** – Michigan endangered species
- **MT** – Michigan threatened species
- **MSC** – Michigan special concern species

TFM – 3-trifluoromethyl-4-nitrophenol; lampricide

TSS – Total Suspended Solids

USACE – U.S. Army Corps of Engineers

USDA – U.S. Department of Agriculture

USFWS – U.S. Fish and Wildlife Service

UWFP – Urban Waters Federal Partnership

WD – Weathered dead mussel shell; periostracum eroded more than live animals, valves attached or separate, hinge line brittle, nacre chalky; animal likely died from a few months to decades before the survey. Species only present as weathered shells are less likely than species found as FD shells to be live in the Project Area.

WSE – Wetted surface elevation (ft)

Definitions

Action Area – Area potentially affected by all aspects of the Project. Includes the Construction Area, three recipient sites (Ada, Riverside Park, Plaster Creek), downstream indirect impact area (Fulton St. to Plaster Creek), and upstream indirect impact area (Grand River from the 6th Street Dam to 91 m [300 ft] upstream of Bridge Street)

Bradytictic – Long-term brooders; refers to the length of time unionids hold glochidia in their gills

City – City of Grand Rapids

Construction Area – Includes the area from approximately 91 m (300 ft) upstream of Bridge Street Bridge to the upstream edge of the Fulton Street Bridge in downtown Grand Rapids, MI. It includes areas that would be physically disturbed during project construction (direct impact areas) and areas that would not be physically disturbed but may experience temporary increases in turbidity during construction and altered local hydraulics during and after construction (indirect impact areas).

Construction indirect impact area – Areas within the Construction Area where the river bottom would not be physically disturbed during construction but may experience temporary increases in turbidity during construction and altered local hydraulics during and after construction.

Critical flow levels used in evaluations –

890 CFS = 7Q10 flow defined as the minimum flow rate sustained for a 7-day period within a 10-year window
1000 CFS = 90% exceeded 7-day minimum flow rate
2500 CFS = 75% exceeded average daily flow rate (low flow)
3900 CFS = 50% exceeded average daily flow rate
5300 CFS = 25% exceeded average daily flow rate
7700 CFS = 10% exceeded average daily flow rate
10,000 CFS = 1 yr flood - Ordinary High-Water Mark [OHWM]
13,000 CFS = bankfull (1.5 yr flood)
18,000 CFS = 2 yr flood
26,000 CFS = 5 yr flood
31,000 CFS = 10 yr flood
35,100 CFS = 2013 spring flood
38,000 CFS = 25 yr flood
44,000 CFS = 50 yr flood
50,000 CFS = 100 yr flood

Direct impact area – River bottom area physically disturbed by construction within the Construction Area

Downstream indirect impact area – Upstream edge of Fulton Street Bridge to the mouth of Plaster Creek; area potentially impacted by increased turbidity during construction

Harm – Activity actually kills or injures. Total displacement causes harm when it results in injury or death.

Isolated area – Area isolated with isolation measures. Water level would be reduced, and mussels and fish would be salvaged before construction

Isolation measures – Aggregate bags used to isolate the Dam 2 riffle and drop structure construction area for dewatering and construction

Low-head dam – Any of four existing low-head dams between the 6th Street Dam and Fulton Street

Maintenance – Includes routine, planned and scheduled upkeep of project features, equipment, or supplies necessary to maintain proper functionality of project elements

Minimize – Measures to reduce take (e.g., reducing the footprint of direct impact, revising construction plans to avoid areas with mussels)

Mitigate – Measures to compensate for take that cannot be avoided

Modeled Hydrophysical Habitat (MHH) – Areas with current velocity under1,200 CFS conditions between 0.12 and 0.50 ft/sec; this defines areas where some current velocity (suitable to keep substrates clean of fines) occurs under low flow, but substrate is not scoured at high flow. Shear stress at 3,900 CFS >0.01 lb/sf to prevent sand deposition

Operations – Includes regular monitoring, inspections, data collection, and reporting

Project – All work occurring in Project Area

Project Area – Downstream face of the 6th Street Dam to upstream face of Fulton St. Bridge

Recipient Sites – Sites where translocated unionids would be placed (Ada, Riverside Park, and Plaster Creek)

Rehabilitation – Correcting anticipated shifting, wear and tear, weathering, or materials degradation by resetting features, augmenting features with additional materials, replacing protective coatings, or refurbishing of features or components

Repair – Unanticipated corrections resulting from unforeseen circumstances that are outside the design assumptions of the Project

Replacement – Removal, demolition and disposal, and replacement of project features or components that cannot be repaired or rehabilitated

Tachytictic – Short term brooders; refers to the length of time unionids hold glochidia in their gills

Take – "To harass, harm, pursue, hunt, shoot, wound, kill, trip, capture, or collect, or to attempt to engage in any such conduct" ESA, 1973

Take – "To harass, harm, pursue, hunt, shoot, wound, kill, trip, capture, or collect, or to attempt to engage in any such conduct of individuals of a species" Michigan DNR Part 365 of NREPA

Upstream – Area between Ann St. and the 6th Street Dam

Upstream indirect impact area - Grand River from the upstream edge of the Construction Area to the 6th Street Dam

1.0 INTRODUCTION

The City of Grand Rapids (City) is pursuing PL83-566 funding with the Natural Resource Conservation Service (NRCS) to improve aquatic habitat in the Lower Grand River where it flows through downtown Grand Rapids, Kent County, Michigan (GVMC, 2011). The funding would be used for revitalizing the rapids in the Project Area (downstream face of the 6th Street Dam to upstream face of Fulton St. Bridge; Figure 1-1) under the U.S. Department of Agriculture (USDA) NRCS Watershed Protection and Flood Prevention Act, PL83-566 program (PL83-566). To reduce the impacts on freshwater mussels from this project, The City and Grand Rapids Whitewater (GRWW) plan to relocate as many freshwater mussels as practicable from impact areas (Grand Rapids/GRWW mussel relocation project). The U.S. Fish and Wildlife Service (USFWS) has engaged in the planning for this project since Grand Rapids was first selected by the U.S. Environmental Protection Agency (USEPA) to be part of the Urban Waters Federal Partnership (UWFP) in 2013. USFWS plans to assist the City and GRWW during the mussel relocation portion of the action in this Biological Assessment (BA) (Grand Rapids/GRWW mussel relocation) where feasible.

1.1 Purpose of the Document

Natural Resource Conservation Service (NRCS) would provide funds under PL83-566 for construction and operation of a Grand River revitalization project in downtown Grand Rapids (PL83-566), which would directly and indirectly affect federal and Michigan protected species (NRCS Action). As a result of the NRCS action, unionid mussels would be translocated from direct impact areas. The USFWS will assist with aspects of the mussel translocation (USFWS Assistance). This purpose of the BA is to determine the effects both the NRCS project and the Grand Rapids/GRWW Relocation are likely to have on the federally endangered species *Epioblasma triquetra* (Snuffbox) and Michigan listed threatened, endangered, and special concern species (threatened and endangered species; TES). Adversely affecting a species may result in “take” as defined by Section 3(18) of the Endangered Species Act (ESA) and Part 365 of Michigan Department of Natural Resources (MDNR) Natural Resources and Environmental Protection Act (NREPA) Public Act 451 of 1994 as (Part 365 of NREPA); to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect an animal, or to attempt to engage in such conduct. The term "harm" is further defined by the ESA's implementing regulations (50 CFS 17.2).

1.2 Proposed Action

1.2.1 NRCS Action

The purpose of the proposed PL83-566 action in Grand Rapids is to:

> Restore the rapids, improve public safety, restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species, and enhance river access and use.

This action includes removing the four low head dams, constructing riffles and boulder arches, bank vane structures, and creating emergent habitat boulder fields (Figure 1-2). The PL83-566 funding, along with additional private and public funding, would be used to revitalize habitat in the Project Area. The current design reduces construction and permanent impacts from the previous Project design.

A BA was previously submitted, and a Biological Opinion (BO) obtained on a previous design in 2020 (EcoAnalysts, 2020; USFWS, 2020). A 404 permit application for the previous design was submitted to Environment, Great Lakes, Energy (EGLE) in 2022. Following objections from U.S. Environmental Protection Agency (USEPA), the City of Grand Rapids (City) withdrew the permit application in March of

2023. NRCS, Grand Rapids WhiteWater (GRWW) and the City worked with EGLE and Michigan Department of Natural Resources (MDNR) to modify the previous design to avoid and minimize impacts to freshwater mussel and fish species. Figure 1-3 shows the previous proposed project. Appendix A shows the design that was coordinated with EGLE and MDNR in September 2023.

Changes that were incorporated into this design to reduce construction and permanent impacts included:

- Between Blue Bridge and Fulton Street
    - The boulder wave structure on the west side of the channel was replaced with an augmented boulder vane structure with a reduced footprint and surrounding scattered boulders.
    - The scour pool downstream of the wave structure would not occur.
    - Excavation beneath Blue Bridge in the previous design needed for construction access and increased flood conveyance is no longer needed.
    - Total estimate permanent direct impact area in this section of the reach have been reduced from 1.0 acres to 0.2 acres.
- Between Pearl and Blue Bridge
    - The hydraulic feature in this area, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with an emergent habitat boulder field and a series of bank vane structures to provide slack water near designated access points on the bank.
    - The recovery pool of the previous design has been removed.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from 1.2 acres to 0.1 acres
- Between Gillett and Pearl Street (Location of Dam 1)
    - The hydraulic feature at Dam 1, which included a boulder wave structure on the west side connected to a constructed riffle structure on the east side, has been replaced with a single constructed riffle with emergent habitat boulders and moved downstream to have more overlap with the Dam 1 removal footprint.
    - The recovery pool of the previous design has been removed.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from 1.9 acres to 1.4 acres.
- Between Bridge and Gillett Street (Location of Dam 2)
    - The hydraulic feature at Dam 2, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with a hydraulic feature that combines constructed riffles on either side of the river with a series of boulder arches in the center of the channel. The new hydraulic feature has a reduced footprint.
    - The recovery pool of the previous design has been removed. Small scour pools are included directly downstream of the boulder arches, similar to other Michigan projects that have implemented W-weir or Aadland rock arch designs.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from 3.0 acres to 1.5 acres
- Between Bridge Street and Gillet (Location of Dam 3)

  - The dam removal limits have been expanded, based on coordination with EGLE, to include a re-grading of the channel upstream of Dam 3.
  - Emergent habitat boulders are proposed to be placed within the dam removal footprint.
  - Total estimated permanent direct impact area in this section of the reach has been changed from 0.2 acres to 1.2 acres.
- Upstream of Bridge Street (Location of Dam 4)
  - The dam removal limits have been expanded based on coordination with EGLE, to include re-grading of the channel upstream of Dam 4.
  - Total estimate permanent direct impact area in this section of the reach has been changed from 0.3 acres to 1.6 acres

Total estimated permanent direct impact area for the project was reduced from 7.6 acres to 6.1 acres.

Additionally, construction of the new design would be performed primarily in the wet, negating the need for most of the isolation areas previously proposed for construction. The current preferred design meets the project purpose while avoiding and minimizing impacts to mussel and fish species.

Informal consultation with U.S. Fish and Wildlife Service (USFWS) was initiated in October 2023 (Table 1-1). A series of meeting between NRCS, GRWW, City, USFWS, MDNR, and EGLE have been held to discuss the design and to further avoid, minimize, and mitigate impacts to the river, fish, and unionid mussels. Of the 127,600 m^2 (31.5 acres) Construction Area, 45,445 m^2 (11 acres) would be directly impacted during construction (direct impact area) of this project. This is approximately a 50% reduction in impact area from the previous design, 89,195 m^2 (22 acres).

The Construction Area addressed in this BA encompasses the Grand River from approximately 91 m (300 ft) upstream of the Bridge Street Bridge to the upstream face of the Fulton Street Bridge; approximately 880 m (2,894 ft) upstream to downstream and 145 m (476 ft) wide for a total area of 127,600 m^2 (31.5 acres) (Figure 1-1). The Action Area addressed in this BA includes the construction direct and indirect impact areas, all construction staging and access areas, downstream indirect impact area, and upstream indirect impact area (Figure 1-1).

1.2.2 Grand Rapids/GRWW Relocation

The NRCS action would result in direct impacts in areas where project features would be constructed and from causeways constructed to access construction areas (Figure 1-1). The purpose of the Grand Rapids/GRWW Relocation is to translocate unionid mussels from direct impact areas of the NRCS action. The Action Area for this project includes the direct impact areas from which unionids would be collected and translocated, and the Recipient Sites where collected unionids would be placed (Figure 1-4).

1.3 Species Considered in this BA

Under Section 7 of the ESA, federal agencies (both NRCS and USFWS) are required to consider two main issues with respect to a TES: 1) whether the proposed action is likely to jeopardize the continued existence of the species; and 2) whether the proposed action would destroy or adversely modify designated critical habitat for that species. If an endangered or threatened species is present and may be adversely affected, formal consultation with the USFWS must be initiated.

Ecological Specialists, Inc. (ESI) and EcoAnalysts, Inc. (formerly ESI) performed unionid mussel surveys within the NRCS and USFWS Project Areas in 2013, 2015, 2016, 2017 and 2020 to determine if TES were present and assess species richness, abundance, and distribution (ESI, 2014, 2016, 2017a; EcoAnalysts, 2018, 2021). Additionally, Cardno (2017) conducted a survey and translocation of unionid mussels from the Michigan Department of Transportation (MDOT) I-196 Bridge construction area in 2016 and 2017.

Freshwater unionid mussels (average density 0.3 unionids/m^2) occur in the Project Area. Species richness is high (20 live unionid species), and the federally endangered *E. triquetra* and state TES have recently been collected (Table 1-2). Fish surveys have also been conducted in the project reach as part of an NRCS monitoring program (EnCompass, 2020). Two Michigan threatened fish species (*Moxostoma carinatum,* River Redhorse; *Acipenser fulvescens,* Lake Sturgeon) and host fish for unionid mussel TES also occur in the Project Area (Table 1-3).

USFWS Information for Planning and Consultation (IPac) system was queried to determine what other federal species might occur in the Project Area (Appendix B). The list included three bat species, *Myotis sodalis* (Indiana Bat), *Myotis septentrionalis* (Northern Long-ear Bat), and *Perimyotis subflavus* (Tricolor Bat), one bird species, *Grus americana* (Whooping Crane), one reptile, *Sistrurus catenatus* (Eastern Massasauga Rattlesnake), and one insect, *Lycaeides melissa samuelis* (Karner Blue Butterfly) that are endangered or threatened or proposed as endangered or threatened. A DKey was completed to determine if these species would be affected by the project. A "no effect" determination was received for *M. sodalis*, *L. m. samuelis*, *D. plexippus*, *M. septentrionalis*, *P. subflavus*, and *G. americana*. A "may effect" determination was returned for *S. catenatus* and *E. triquetra*. After further consultation, USFWS determined that no habitat was available for *S. catenatus* in the project area, but E. triquetra could be adversely affected. Critical Habitat for *E. triquetra* is not currently designated, but *E. triquetra* would be adversely affected. Both Construction (NRCS project) and translocation (Grand Rapids/GRWW Relocation) effects on *E. triquetra* are discussed in this BA.

Michigan Natural Features Inventory (MNFI) was consulted for a list of state endangered, threatened or special concern species for Canal Park and Ah-Nab-Awen Park improvements (rare species review #3507) in 2023 with the same project area as this project to comply with NREPA part 365 (Appendix B). Several TES freshwater mussel species and one fish species were listed as occurring within 1 mile of the Project Site; *E. triquetra*, *Cyclonaias tuberculata* (Purple Wartyback), *Potamilus* (*Leptodea) leptodon* (Scaleshell), *Ligumia recta* (Black Sandshell), and *Alasmidonta viridis* (Slippershell), and *M. carinatum* (River Redhorse).

All of these species have recently been collected in the Project Area, except *P. leptodon* (Table 1-2 and 1-3) and are included in this assessment. Special concern mussel species on the MNFI list known to occur in the Project Areas and included in this assessment include *Truncilla truncata* (Deertoe), *Venustaconcha ellipsiformis* (Ellipse), *Alasmidonta marginata* (Elktoe), *Pleurobema sintoxia* (Round Pigtoe), *Lasmigona costata* (Flutedshell), and *Potamilus alatus* (Pink Heel-splitter).

Species not included on the MNFI list that have been included in this assessment include *A. fulvescens* (Michigan threatened) and *Utterbackia imbecillis* (Paper Pond Shell, Michigan special concern), as these species have recently been collected alive or as fresh shells in or near the Project Areas (Table 1-2 and 1-

3). *Toxolasma parvum* (Lilliput, Michigan endangered) is also included, as it was recently collected live upstream of the Project Areas near Riverside Park and may be present in the Project Areas (ESI, 2014).

Potamilus leptodon is not included, as the record was pre-1930 and was thought to be a misidentification by S. Hanshue (personal communication). Species on the MNFI list that have not recently been collected alive or as fresh shells in the Project Areas include *Cambarunio (Villosa) iris* (Rainbow), and *Lasmigona compressa* (Creek Heel-splitter) (Table 1-2). Other Michigan endangered or threatened species that are not included in this assessment include plant species, reptiles, and insects that typically do not occur in an urban setting such as the Project Area.

This BA is prepared in accordance with legal requirements set forth under Section 7 of the ESA (16 U.S.C. 1536[c]). Michigan TES are also included in this BA to facilitate MDNR review under Part 365 of NREPA. This BA describes NRCS and Grand Rapids/GRWW projects, unionid mussel and fish distribution within the lower Grand River, and the potential direct and indirect effects projects may have on unionids, threatened fish, and host fish species. Conservation measures that would be implemented to avoid and minimize impacts and mitigation measures to compensate for unavoidable impacts are also described.

As *E. triquetra* and Michigan TES were collected within the Action Areas, formal consultation, a Biological Opinion (BO) and Incidental Take Authorization are requested for both projects under Section 7 of the ESA. Michigan Threatened/Endangered Species Permits for both Proposed Actions is also being requested pursuant to part 365 of NREPA.

2.0 PROJECT DESCRIPTION

The NRCS Project in the Grand River would revitalize an 880 m (2,887 ft) stretch of the river flowing through the City of Grand Rapids (City). The Project is designed to restore aquatic connectivity and enhance habitat for fish and aquatic life, including Michigan TES and federally endangered *E. triquetra*. Collaboration with agencies has resulted in a project that improves aquatic habitat and recreational opportunities, while minimizing direct impacts to the river bottom, ensuring fish passage, and maintaining the existing *P. marinus* barrier at the 6th Street dam.

The Grand Rapids/GRWW relocation project would translocate unionid mussels from direct impact areas of the NRCS project to three recipient sites; Ada, Riverside Park, and Plaster Creek.

2.1 NRCS Project

Only 1% of the river habitat in the lower peninsula of Michigan is composed of rapid-type habitat, which is important to the life cycle of many aquatic species (Daugherty et al., 2009). Rapid-type habitat is defined as a river area with a relatively steep energy gradient, coarse bed substrates, and non-uniform distribution of flow velocities. High gradient areas have been eliminated and fragmented in many Michigan watersheds and their rehabilitation is highly desirable (Dodge, 1998; Wesley, 2005). The historic rapids of the Grand River that ran through the City were important for subsistence, socially and culturally for Native Americans. These rapids also established the namesake for the City. The ecosystem processes and recreational functions of the rapids-type habitat have been degraded by dams, channelization, dredging, and urban development over more than 170 years.

Five dams have been constructed within the historic rapids, including the 6th Street Dam and four low-head dams. The 6th Street Dam was constructed over 170 years ago. It was initially constructed in 1849 to increase water-power in the canal that went around the rapids on the left descending side of the river (http://www.mfhn.com/glsdb/rivers/grandriver.html#canalrapids). It also facilitated the floating of logs over the bedrock outcrop rapid upstream of Leonard Street on the left descending side of the river. The last known maintenance on this structure was in 1929. Concrete erosion due to water flow and abrasion, joint deterioration, cracks, holes, and other localized deterioration have increased the likelihood that the dam could fail and the need to be maintained or replaced soon (Vos, 2015). Four low-head dams were subsequently constructed downstream of the 6th Street Dam to add grade control and maintain channel-width during low flow to prevent the concentration of raw sewage that was discharged into the river. Part 315 or 307 of the NREPA does not regulate dams in the Project Reach, as they do not meet the criteria for regulation. However, dams are regulated by part 301 of NREPA.

Dredging and mining of large substrate downstream of the 6th Street Dam has occurred in the channel. In addition, the river is laterally constrained at high flow by over a mile of floodwalls or berms on both sides of the channel. These modifications have created a straight and uniform channel with little diversity in flow depth, substrate, or flow velocity that limits natural aquatic ecosystem processes, and constrains the physical, chemical, and biological processes of the river (Figure 2-1).

The City, in collaboration with GRWW, proposes revitalizing the Grand River within the City between 91 m (300 ft) upstream of Bridge Street to Fulton Street, Grand Rapids, Kent County, Michigan (Figure 1-2). The proposed Project is within an urbanized reach of the Grand River where rapids historically existed

within the City. Between Lake Michigan and Ada, Michigan, a distance of approximately 97 river km (60 river miles), river gradient sufficient enough to restore rapid habitat only exists between Ann Street and Fulton Street. The area between Bridge and Fulton Street is currently a relatively homogeneous river channel. Through removing low-head dams, creating riffles and diversified boulder arches, and creating emergent habitat boulder fields, the NRCS Project seeks to improve public safety, restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species, and enhance river access and use.

Locations upstream and downstream of the Project Area that would result in less take to TES were considered. However, between Lake Michigan and Ada, Michigan, a distance of approximately 97 river km (60 river miles), river gradient sufficient enough to create rapid-type habitat only exists between Ann Street and Fulton Street. The Project purpose could not be met in any other area.

This urbanized stretch of river places constraints on the complete restoration of the rapids to pre-development conditions due to existing infrastructure and public uses: the channel complex was historically over 427 m (1,400 ft) wide but is now restricted in floodwalls to approximately 160 m (600 ft) wide (Carey et al., 2016). The pre-developed channel was not only significantly wider but had multiple side channels and islands and likely covered a much broader area during periods of flooding. The existing encroachments of infrastructure on the river (floodwalls, bridges, properties, and other facilities) renders restoration to pre-development conditions infeasible.

2.1.1. Project Location

The Action Area (Figure 1-1) for the NRCS Project includes:

- Project area (Downstream face of the 6th Street Dam to upstream face of Fulton St. Bridge);
- Construction Area (between 91 m [300 ft] upstream of Bridge Street and the upstream edge of Fulton Street within the Grand River),
    - Direct impact areas include the area where the river bottom would be physically disturbed by construction within the Construction Area (Figure 1-1),
    - Indirect impact areas within the construction area include the area where the river bottom will not be physically disturbed during construction within the Construction Area (Figure 1-1);
- Upstream indirect impact (upstream edge of the Construction Area to the 6th Street Dam);
- Downstream indirect impact area (upstream edge of Fulton Street Bridge to the mouth of Plaster Creek);
- Staging and access areas adjacent to the Project Area (Ah-Nab-Awen Park); and
- 3 Recipient sites for relocation of mussels (Figure 1-4).

The Construction Area is within the wetted channel of the Grand River between Bridge and Fulton Street bridges in Grand Rapids, Kent County, Michigan. Of the 127,600 m^2 (31.5 acres) Construction Area, 45,445 m^2 (11 acres) would be directly impacted during construction (direct impact area) (Table 2-1). This is approximately a 50% reduction in construction impact area from the previous design, 89,195 m^2 (22 acres). The river bottom would not be physically modified in approximately 82,155 m^2 (20 acres) of the Construction Area (construction indirect impact area), but could be affected by turbidity and changes in local hydraulic conditions. Staging and access areas would primarily be from Ah-Nab-Awen Park (park). Some equipment may be staged north of I-196 on the east side of the river, but access to the river will

only be from the park. The downstream indirect impact area that could be affected by turbidity increases during construction is conservatively estimated as 2.5 km (1.5 miles) from Fulton Street to Plaster Creek. The upstream indirect impact area between the 6th Street Dam and the Construction Area that would be affected by slight changes in hydraulics includes approximately 38,420 m^2 (9.5 acres).

The three recipient sites include a mussel bed at Ada, MI, where the majority of mussels will be relocated, Riverside Park, where any *T. parvum* or *U. imbecillis* would be relocated, and Plaster Creek, where any *T. truncata* and *P. alatus* would be relocated (Figure 1-4).

2.1.2 Evaluation Metrics

Metrics that could affect freshwater mussel and fish species that were evaluated in this analysis included;

- Direct impact areas during construction,
- Permanent impact areas after construction is complete,
- Transient sand (areas of deposition and scour)
- Lamprey barrier hydraulics (prevent lamprey escapement),
- Fish passage,
- Host fish habitat,
- Unionid habitat, and
- "Take" of TES species.

Area affected by construction (direct impact areas) considered all areas that would be impacted by causeways constructed to access and work in construction areas in the dam removal and riffle construction areas, and tracking in the river needed for placement of emergent habitat boulder fields, diversified boulder arches, and rock pile vanes downstream of Pearl Street. See Appendix C for construction plans.

Permanent impact area includes a sum of all structures that would not be available to freshwater mussels post-construction. This includes boulders and rock used for riffles, diversified boulder arches, emergent habitat boulder fields, rock vanes, and transient sand.

Transient sand was based on sediment transport analysis. Sand initiates motion from upstream of the 6th Street Dam at approximately 3,900 CFS (approximately 50% exceedance flow). At lower flow rates, sand supply into the Project Area is limited, and active deposition is unlikely. Depositional sand areas were estimated from shear stress analysis at 3,900 CFS. If an area did not produce suitable hydraulics (shear stress >0.01 lbs/ft^2) for mobilizing sand at 3,900 CFS, it was assumed depositional. The flow rate of 3,900 CFS was chosen as it approximately corresponds to the initiation of sand load transport from the upstream river reaches. Identified areas are anticipated to have some amount of local deposition; however, sand in these areas would also be remobilized at flow rates at or below approximately 10,000 CFS. Due to the transient nature of these areas, they were excluded from mussel habitat area.

Lamprey barrier hydraulics were evaluated based on literature values for blockage criteria and modeling of hydraulic conditions at the 6th Street Dam (Appendix D). Literature indicates that *Petromyzon marinus* (Sea Lamprey) is blocked by endurance swimming limits of 2.5 m/second (sec) (8.2 ft/sec) for 3 m (10 ft), burst speed limit of 4 m/sec (13.1 ft/sec), or a jumping barrier of at least 46 centimeters (cm) (18 in)

(Hansen, 1980; Hunn and Youngs, 1980; McAuley, 1996) and impeded at velocities >1 m/sec (3.28 ft/sec) (Almeida et al., 2007; Quintella et al., 2009). Water temperature also affects passage; burst speed and endurance is substantially reduced at water temperatures <10° C (50° F) (Applegate, 1950; McAuley, 1996).

The tailwater velocity and jumping barrier at the 6th Street Dam are primarily a function of tailwater elevation. Decreases or negligible changes in tailwater elevation with low probability of occurrence were determined to have no adverse impacts to *P. marinus* barrier effectiveness (P. Hrodey, GLFC, personal communication, October 10, 2019). Tailwater elevations were modeled over a range of typical flow rates through a given year and compared under existing, temporary, and 2025/2026 Project conditions (Appendix D).

Spawning and larval habitat for *P. marinus* was qualitatively evaluated using literature values for preferred conditions. Physical factors essential for successful *P. marinus* reproduction include steady, unidirectional water flow, and suitable gravel substrates (0.9 to 5.1 cm diameter; 0.4 to 2 inches) with very little sand, water velocity (0.5 to1.5 m/sec; 1.6 to 4.9 ft/sec), depth (13 to 170 cm; 5 to 67 inches), and temperature (10.0 to 26.1° C; 50 to 79° F) (Manion and Hanson 1980). Nest building begins when water temperature warms to 15° C (59° F) (Applegate 1950, SLCB, 2017). Preferred larval habitat (Type I substrate) consists of silt with minor sand and detritus in depositional area (SLCB, 2017).

Fish passage was evaluated by identifying 15 swim paths that might pose a challenging route for upstream fish passage based on flows of 2,500 CFS, 3,900 CFS, and 7,500 CFS in consultation with MDNR and EGLE, peer review literature, and a panel of fish experts (Appendix E). Depth and velocity under these flows are shown in Appendix F. Targeted depths for passage were ≥0.25 m (0.75 ft) to allow fish headroom. Deeper areas under higher flows (0.76 m; 3 ft) were evaluated for use as flow refugia. Ichthyomechanics (Katopodis and Gervais, 2016) were used to evaluate if a fish group would be capable of upstream passage and the proportion of fish expected to pass. *Stizostedion vitreum* (Walleye) group was used for fish of spawning sizes 0.38 m (15 in.), 0.43 m (17 in.) and 0.51 m (20 in.) in total length. *Acipenser fulvescens* group was used for larger fish, 1.5 m (60 in.) in total length. See Appendix E for fish passage report.

Host fish habitat availability was evaluated by identifying habitat for host fish groups at various flows (2,500 CFS [75% exceedance, typical low flow], 3,900 CFS [approximately 50% exceedance], 7,500 CFS approximately 10% exceedance]) (Appendix F). Habitats were identified from depth, velocity, and substrate maps created from hydraulic models. Host fish that occur within the Project Area include Cyprinidae (Minnows; hosts for *P. sintoxia* and *L. costata*), Catostomidae (Suckers; host for *A. marginata*, *L. costata*), Ictaluridae (Catfish; host for *C. tuberculata*, *L. costata*, *U. imbecillis*), Centrarchidae (Sunfish and Bass; hosts for *P. sintoxia*, *L. recta*, *T. parvum*, *A. marginata*, *L. costata*, *U. imbecillis*), Percidae (Perches; hosts for *E. triquetra*, *L. recta*, *T. parvum*, *V. ellipsiformis*, *A. viridis*, *L. costata*, *U. imbecillis*), and *Aplodinotus grunniens* (Freshwater drum; host for *L. recta*, *P. alatus*, *T. truncata*, and *L. costata*) (Table 1-3).

Fish hosts were grouped based on habitat preferences. Cyprinidae are typically found along slow flowing sloping river margins. *Lepomis* sp. (Sunfish within the Centrarchidae), *Catostomus commersoni* (White Sucker), and many juvenile fish are typically found in areas with moderate depth and slow velocity with

cover in the form of large rock, vegetation, and/or woody debris. Adult Ictaluridae and *Micropterus* sp. (Bass species) are typically found in deeper, slow flowing pools. *Etheostoma* sp. and *Percina* sp. (Darters), juvenile Ictaluridae, and juvenile Catostomidae prefer riffles (fast moving shallow river area, less turbulent than rapids). Other Catostomidae species (*Moxostoma* sp. [Redhorse], *Ictiobus* sp. [Buffalo], *Hypentilium nigricans* [Hogsucker]) prefer raceways (areas with moderate depth and flow velocity and low turbulence). *Aplodinotus grunniens* prefers open water habitats (deeper pools and raceways).

Changes in unionid mussel habitat were evaluated by comparing available aquatic area (wetted areas under 890 CFS without sand deposition or permanent structures that unionids could occupy) and Modeled Hydrophysical Habitat (MHH; hydrophysical areas that unionids seem to prefer and should occur at higher densities).

Changes in unionid mussel habitat were evaluated by comparing available aquatic area (wetted areas under 890 CFS without sand deposition or permanent structures that unionids could occupy) and Modeled Hydrophysical Habitat (MHH; hydrophysical areas that unionids seem to prefer and should occur at higher densities). Unionid habitat is difficult to quantify. Factors that affect unionid presence and distribution include substrate stability (measured as shear stress divided by critical shear stress; shear ratio), some current velocity or turbulence under low flow conditions (allowing waste removal and delivery of oxygen, food, and calcium), adequate food (bacteria, phytoplankton), temperature conditions for reproduction (spawning, glochidia release from the female, and juvenile release from the host fish), good water quality (unionids are particularly sensitive to ammonia, heavy metals, and chlorine), and host fish availability (Wang et al., 2007; Strayer, 2008; Wang et al., 2010). Unionid mussels could be limited by any of the above factors, and not all of these factors were evaluated in the Project Area. Substrate in the Project Area is currently very coarse and compact, as the supply of smaller substrate (gravel, sand) entering this reach is limited, and existing scour potential is insufficient to move the armored larger substrate. Unionids were generally found in flow refugia near banks and downstream of structure in unionid surveys conducted in 2013, 2016, 2017, and 2020 (Figure 2-2). The Project would only affect physical habitat, which seems to be limiting, and only physical habitat is included in this analysis. However, other factors could also affect unionid colonization post-construction.

Area available for unionid mussels post-project was calculated as wetted area at 7Q10 flow (minimum flow rate sustained for a 7-day period within a 10-year window) of approximately 890 cubic feet per second (CFS), minus permanent impact areas that would have substrate not conducive to mussels; substrate either too hard and fast for burrowing or transient sand (mussels could be washed in and out at various flows). Unionids could colonize available areas at a similar density to existing (0.3 unionids/m^2).

To evaluate where mussels would be most likely to reside or recolonize, a hydrophysical habitat model (modeled hydrophysical habitat [MHH]) was developed by EcoAnalysts and RiverRestoration Organization (RRO) based on physical habitat conditions where some current velocity (suitable to keep substrates clean of fines) occurs under low flow, but substrate is not scoured at high flow. The MHH parameters included areas with current velocity during 1,200 CFS conditions between 0.12 and 0.50 ft/sec. Shear stress at 3,900 CFS >0.01 lb/sf defined conditions preventing sand deposition and scour.

Take in direct and Indirect Impact areas was calculated as the impact area multiplied by the average density of mussels in the Project Area (0.3 unionids/m^2). Take within direct impact areas would be reduced by the Grand Rapids/GRWW relocation Project (see Section 2.2).

2.1.3 Existing Conditions

Existing conditions provide a baseline for comparing existing hydraulics and channel dynamics to the Project. Physical characteristics of the channel within the Project Area are shown in Figure 2-1 and Appendix F. Under existing conditions approximately 167,353 m^2 (41 acres) is wetted under 890 CFS. Approximately 643 m^2 (0.16 acres) is occupied by the four low head dams (Table 2-1). Unionids are scattered among the remaining 166,710 m^2 at a low density of 0.3 unionids/m^2, but seem to be slightly more abundant along the banks (Figure 2-2). MHH area is approximately 6,080 m^2 (1.5 acres), primarily along the banks (Figure 2-3). A total of 20 live unionid species have been collected within the Project Area, including *E. triquetra*, *P. sintoxia*, *C. tuberculata*, *L. recta*, *P. alatus*, *T. truncata*, *V. ellipsiformis*, *A. marginata, A. viridis*, and *L. costata* (Table 1-2). Seventy-three (73) fish species have been collected in the Project Area including *M. carinatum* and *A. fulvescens* (Table 1-3).

The 6th Street Dam is considered an effective barrier to *P. marinus* migration (GLFC, 2018). Hydraulic conditions at the 6th Street Dam and fish ladder are thought to be an effective barrier to *P. marinus* (Table 2-3 and Table 2-4). A jump of <0.5 m (18 in) is needed for *P. marinus* to escape over a barrier. Less than 0.5 m (18 in) barrier occurs under existing conditions at 26,000 CFS (Table 2-3). However, current velocity is prohibitive at this flow (Appendix D). A few *P. marinus* have been collected upstream of the dam in the Lowell Creek (1965) and the Rogue River (2008 and 2022; Barber and Steeves, 2023). The spawning status of *P. marinus* within the Project Area is unknown due to lack of sampling; however, larval habitat does not appear to be present (P. Hodrey, SLCP, personal communication).

Fish passage under existing conditions is impeded by the four low-head dams. Fish passage is impeded at the two upstream low-head dams during low flow, and is restricted by high flow velocity on the RDB between Bridge Street and Pearl St. Bridge (Figure 2-1; see Holtgren, 2024; Appendix E). Existing conditions allow jumping fish to pass upstream of the 6th Street Dam using the fish ladder on the right descending bank (RDB). The largest jump distance from the wetted surface elevation (WSE) to the invert on the fish ladder under existing conditions is approximately 0.26 m (0.86 ft) (Table 2-4).

Seventy-three (73) species of fish have been recorded in the Project Area, 55 of which were collected in recent surveys (Table 1-2). Gradual sloping margins for Cyprinidae and juvenile fish are limited to the RDB in the upstream portion of the Project Area (Table 2-6). Cover is primarily in the form of riprap on the low-head dams and a few willow trees that are inundated near the banks in wetland areas. Few areas with cover, moderate depth, and slow current suitable for *Lepomis* sp. and juvenile fish are currently available. Deeper pools for Ictaluridae and *Micropterus* sp. occur along the LDB between I-196 and Bridge Street, near some of the bridge piers, and between Pearl and Fulton Street. Riffles with large boulders for *Percina caprodes* (Logperch) are not present under existing conditions, but *P. caprodes* was collected downstream of low-head dams in a recent survey (M. Holtgren, Encompass, pers. comm.) and during mussel sampling near wetland along the LDB. Most of the existing habitat is raceway and open water, suitable for *Moxostoma* sp. and *A. grunniens* (Table 2-5; Appendix F).

2.1.4 NRCS Project

The NRCS project includes removing the four low head dams and creating riffles, diversified boulder arches, emergent habitat boulder fields, and rock vanes (Appendix C). Through coordination with USFWS, MDNR, and EGLE, improving public safety, achieving fish passage and aquatic enhancement targets, maintaining the *P. marinus* barrier at the 6th Street dam, diversifying recreational opportunities, and restoration of rapids were identified as important elements. Through a collaborative process these elements were identified, and the Project configuration modified from the 2020 project where possible to maximize each element and reduce impacts to the river.

Through continued coordination with EGLE and MDNR, the September 2023 design has been revised to achieve shared project goals and also avoid and minimize impacts to the existing streambed. EGLE and MDNR also provided feedback on ways to further avoid and minimize the temporary impact areas during construction. The project team has worked closely with the construction management advisor for the project to further reduce temporary construction impacts, while also maintaining a feasible construction plan. The primary reduction in temporary impacts during construction was made by moving away from larger isolation areas and greater volumes of temporary cofferdams and causeways to only one small isolation area and much less temporary fill for causeways. Additionally, through ongoing efforts to further minimize temporary impacts, the causeways within the isolation area were removed so that the entire area could be unimpacted during mussel relocation. Additionally, the footprint areas of the causeways have been overlapped with proposed grading limits wherever possible to minimize the cumulative direct impact footprint for the project. Lastly, the number of habitat boulders with footer boulders has been reduced, which may result in settling of boulder into the existing bed over time, but also a reduced impact footprint during construction. Wetlands have been avoided to the greatest extent possible. Those that fall within direct impact areas would be covered with timber mats before any causeway construction or tracking on the river occurs.

Collaboration with agencies has resulted in a project that improves aquatic habitat and recreational opportunities, while minimizing direct impacts to the river bottom, ensuring fish passage, and maintaining the existing *P. marinus* barrier at the 6th Street dam. Continued collaboration with EGLE, MDNR, and USFWS is planned throughout the formal consultation, 404 permit, and Environmental Assessment (EA) process. However, impacts would not be greater than described in this BA.

The construction methods presented below include avoidance and minimization measures to the greatest extent practicable and have benefited from collaboration with agency representatives, stakeholders, and the interested public. 60% construction plans are provided in Appendix C. The future contractor may propose other means and methods but impacts and effects to TES would be no greater than those described herein. Any changes to construction and/or final project design would be discussed with USFWS, MDNR, NRCS, and EGLE to ensure take no greater than estimated in this BA or subsequent BO. This clause would be stipulated in all bidding documents. The contractor would be responsible for developing a care-of-water plan with best management practices (BMPs).

To minimize impacts to freshwater mussels within direct impact areas, mussels would be relocated from as much area as possible during the 2024 field season (June 1 to October 15) under the Grand Rapids/GRWW relocation Project (see Section 2.2)

Equipment staging would be primarily within Ah-Nab-Awen Park. Some equipment may be staged on the east bank between I-196 and the 6th Street Dam, but the river would only be accessed from Ah-Nab-Awen Park. Erosion and sediment control measures would be used in accordance with the Michigan Unified Keying System and approved by the City's Stormwater (NREPA Part 91) reviewers. Standard erosion and sediment control measures are described in Appendix C.

Prior to in-stream construction, the contractor would conduct overall project mobilization, delineate the project limits, and implement erosion control and BMPs. This would include placing barriers/signs, installing safety fencing, and isolating the Project site from the general public. The contractor would also field locate all existing utilities.

The contractor would remove designated vegetation and protect-in-place bridges, utilities, and landscape features (boulders, trees) as required. Vegetation removal would only occur within the staging areas and would be minimized as much as practicable to provide access and limit any safety concerns. Vegetation removal in staging areas would be limited to smaller shrubs and urban trees. Construction staging and stockpile areas would be established, as well as areas for storage of spare oil booms and designated oiling and petroleum handling areas outside of the riparian zone. These areas would be isolated from the river using BMPs such as silt-fences, straw wattles, and berms. The contractor would also establish and post protocols for potential oil spill cleanup and emergency response.

Equipment used in construction would include construction equipment such as excavators, loaders, cranes, and haul trucks. General considerations for all equipment maintenance and storage areas would prescribe to EGLE guidelines. Runoff from equipment maintenance and storage areas would be directed to stabilized outlets designed to adequately convey the volume discharged. Heavy equipment would be well maintained to prevent leaks. Vehicles or other equipment would not be washed at locations where the runoff would flow directly into a watercourse or separate storm sewer. Construction materials, including topsoil and chemicals, would be stored, covered, or isolated to prevent runoff of pollutants and contamination of groundwater. Empty canisters, cans, or other chemical containers (e.g., hydraulic fluids, etc.), scrap wood, scrap metal, and all other waste materials would be disposed of daily or kept in sealed waste containers until they can be properly disposed of off-site, such as in a landfill. Waste materials would not be buried on-site.

Prior to entering the watercourse, all equipment would be washed under high-pressure water with a non-harmful and biodegradable degreaser. Once in the watercourse, equipment would be inspected frequently and maintained properly to ensure no grease, oils, or chemicals are entering the watercourse. If equipment is leaking such fluids, it would be removed from the water course and repaired prior to re-entering. Equipment regularly traversing in and out of the watercourse would be cleaned under high-pressure water (i.e., wheel washing station) at a minimum once per week. Biodiesel fuel would be used in any equipment entering the water. If needed, oil booms may be placed downstream of any equipment working in the wet.

All in-river construction work is expected to be conducted with river conditions approximately ≤3,900 CFS. However, the construction crew on site would ultimately decide on conditions they can safely work under.

Limiting construction to lower flows allows construction to occur in the wet, negating the need for most of the isolation measures previously proposed. Causeways of imported clean coarse aggregate would be installed along the west bank to access the Dam 1, 3, and 4 construction areas, as well as the bank vane structures and the emergent habitat boulder fields downstream of Pearl Street. The Dam 2 construction area would be accessed directly from the staging area. Construction equipment would be equipped with Global Positioning Systems (GPS) to ensure all construction and in river tracking is within the direct impact areas outlined in this BA.

To maintain flow conditions for in-river work and ~~a~~void and minimize potential temporary increases in tailwater elevations at 6th Street Dam, the following construction sequencing has been developed. This sequencing has been established through coordination with the construction management advisor and regulatory agencies as the most feasible means for construction and to minimize direct impacts to the channel.

Causeways would be installed before removal of dams or construction of proposed improvements. The construction causeways for Dams 1 and 2 should be installed first. Construction of proposed improvements could then occur at any location downstream of Dam 3 as the first construction activities, with the Dam 2 feature being prioritized first (if construction begins in spring/early summer). Installation of the access causeway and construction of proposed improvements to Dam 3, including the removal of the dam, would not occur until the cofferdam within the Dam 2 construction area is removed and the contractor is confident the Dam 2 feature will be completed within the same construction season. The installation of the access causeway and the removal of Dam 4 would not occur until the Dam 2 feature has been fully constructed.

Isolation measures at Dam 2 would be installed as soon as flows are low enough after Spring melt or after *P. marinus* migration season ends (approximately July 1), whichever occurs first. If flows are low enough before the *P. marinus* migration season ends, isolation measures would be installed if approved after coordination with the USFWS Sea Lamprey Control Program. Isolation measures would be removed immediately following the completion of the work on the west side of Dam 2. Construction within the isolation measures would require approximately three weeks. The isolation measures would not be left in the river overwinter. The modeled impacts to tailwater at 6th Street Dam were evaluated and considered at length during the development of the construction sequencing and modeled increases in tailwater have been avoided and minimized to the greatest extent practicable. Refer to Table 2-3 and Appendix D for the modeled tailwater elevations at 6th Street Dam during the anticipated temporary construction conditions.

The Dam 2 construction area would be accessed from the Ah-Nab-Awen Park staging area via an access ramp (Appendix C). Temporary causeways of clean imported aggregate would be constructed around the outside of the area to be isolated for construction of the diversified boulder arches, and around the construction area for the east side riffle feature (Figure 2-4). A cofferdam constructed of aggregate bags filled with clean imported material would be installed inside the causeways. The causeways cannot be used to isolate the area, as the rock used for the causeway is too permeable. Aggregate bags cannot be used for the causeway, as they not designed to hold construction equipment.

Fish would likely move out of this area during construction of the causeway. However, once the area is isolated, the area would be electofished and/or seined to remove as many fish that remain as practicable. Unionid mussels would be collected and translocated (see Section 2.2, Grand Rapids/GRWW relocation Project). Water would then be pumped out. A screen would be placed around the pump and a net around the pump area to limit entrainment of fish. During pumping, if fish remain in the area, a crew would be on site to collect and remove fish from the isolated area. Because the lack of flow and potentially increased water temperature may stress unionid mussels inhabiting the isolated area, sufficient personnel would be on site to limit the unionid collection time to less than 10 days (see Section 2.2 for details).

Once mussels are removed from the isolated area, Dam 2 would be removed, and a diversified hydraulic structure would be constructed at its location. The proposed structure would include constructed riffles with emergent habitat boulders on either side of a series of boulder arches and scour holes. (Figure 1-2). Once the west side is complete, the cofferdams would be removed and the proposed improvements on the east side would be constructed, using previously installed causeways to access.

On the east side of the river, Dam 2 would be demolished and removed, and the proposed riffle structure would be constructed. The riffle would be constructed of stable imported alluvium and stabilized with imported riprap with a D_{50} of 30 cm (12 in), with large emergent habitat boulders placed throughout. Riffle slope would be 50:1. The isolation measure and causeways would be removed following the completion of Dam 2 feature construction. Temporary causeways would be removed following construction. The resulting features would provide a diversity of depths and flows for aquatic habitat, as well as recreation. Boulders provide structure for fish and flow refugia for mussels.

Causeways to, and along, Dams 3 and 4 would be installed and the dams demolished and removed. The channel upstream of the dams would be regraded after dam removal. Emergent habitat boulders would also be placed within the Dam 3 removal and regraded area. Dam 3 would be accessed from the north end of Ah-Nab-Awen Park, and Dam 4 would be accessed from a temporary causeway extending from the park to Dam 4. Temporary causeways would be removed following construction. Habitat boulders would provide structure for fish and flow refugia for mussels.

Dam 1 would be demolished and removed, and replaced with a riffle. The Dam 1 construction area would be accessed via a causeway that would run from Ah-Nab-Awen Park along the west bank to the Dam 1 construction area. Temporary causeways would be constructed on the upstream and downstream sides of the proposed riffle feature. The low-head dam would be demolished and removed. The riffle would be constructed with stable imported alluvium, and stabilized with imported riprap (D_{50}, 30 cm [12 in]), and have a slope of 50:1. Emergent habitat boulders would be placed throughout the riffle. Temporary causeways would be removed following construction. The resulting feature would provide a diversity of depths and flows for aquatic habitat and for recreation. Boulders provide structure for fish and flow refugia for mussels.

Two emergent habitat boulder fields would be constructed between Pearl and Fulton Streets. Both areas would be accessed from a causeway extending from Ah-Nab-Awen Park to the construction areas. Emergent habitat boulders on the west side would be placed from the causeway, while boulders on the east half of the river would be placed while tracking in the river. Boulder vanes would be constructed

upstream and downstream of Grand Rapids Public Museum Carousel and on the east bank to create slack water for public access to the river. The emergent habitat boulder fields provide structure for fish and flow refugia for mussels.

Between Blue and Fulton Street, diversified boulder arches would be created on the west side of the river and emergent habitat boulder field on the east side. Access would be provided by extending the causeway along the west bank downstream of Blue Bridge. The emergent habitat boulder field would be constructed by tracking in the river. Proposed improvements would provide a diversity of flows and cover for aquatic species, including structure for fish and flow refugia for mussels.

Once features are in place, some changes in depth and flow would result. Depths upstream of Bridge Street would be faster and shallower. Tailwater elevations are expected to be lower than existing, maintaining the existing *P. marinus* barrier (Table 2-3 and 2-4). The regraded area and emergent habitat boulder field in the area of Dams 3 and 4 would be deeper and slower. Flow velocity would also be slower between the Dam 3 and Dam 2 features. Downstream of the Dam 2 features, the area near the bank would be slower, with some deeper holes developing downstream of the diversified boulder arches. However, these scour holes are all within the direct impact area. The area between Dam 2 and Dam 1 features would be deeper and slower, but no changes in contours is expected. Depth would be greater in the Dam 1 features and flow more variable than under existing conditions. Flow velocities would be more variable downstream of Pearl Street, but depth should be similar to existing conditions (see Appendix F).

The Project was designed to minimize long-term Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRRR). Operation includes regular monitoring, inspections, data collection and reporting. These activities would not require any tracking of equipment into the river bed and would therefore not affect unionid mussels. Maintenance includes routine, planned and scheduled upkeep of project features, equipment, or supplies necessary to maintain proper functionality of project elements. The proposed grading is anticipated to adjust to post-construction hydraulics and some localized scour and deposition may result, along with slight shifts in boulder and riprap. This is expected, and features would be left alone to adapt to river conditions. No routine maintenance is anticipated. Therefore, maintenance would not affect unionid mussels.

Repair is for currently unanticipated corrections resulting from unforeseen circumstances that are outside the design assumptions of the project. Rehabilitation is to correct anticipated shifting, wear and tear, weathering, or materials degradation by resetting features, augmenting features with additional materials, or refurbishing of features or components. Replacement includes removal, demolition and disposal, and replacement of project features or components that cannot be repaired or rehabilitated. Repair, rehabilitation, and/or replacement that could require instream activity would be scour or deposition that threaten public safety (flood threats, bank access, or adverse hydraulics for recreation) or infrastructure (flood wall, bank, or bridge scour). Whenever possible, repair, rehabilitation or replacement of structures would be conducted from the river bank or, if flows and depths allow, from floating work platforms floated upstream from the Butterworth ramp with minimal impacts to the river bottom. Any debris that might hang up on riffles, bridge piers, diversified boulder arches, or rock vanes would be removed by chain sawing in place and allowing debris to float downstream, or floating debris to the riverbank for removal.

Tracking equipment in the river would only be used when these activities could not be completed from the bank or floating work platform. The greatest impact would occur if equipment needed to track from the existing emergency access at Ah-Nab-Awen Park to the diversified boulder arches downstream of Blue Bridge. The most direct route to each feature (considering bottom contours) would be followed. If possible (flow velocity permitting), the tracking path and area needing repair, rehabilitation, or replacement would be searched for mussels, and mussels would be translocated to recipient sites.

2.1.5 NRCS Project Impacts

No actions associated with site preparation would affect habitat for mussels or fish, as it occurs in the upland, and runoff and sedimentation would be prevented by BMPs. None of the trees that would be removed appear to be suitable roost trees for *M. sodalis* or *M. septentrionalis*, and trees would be replaced post-construction.

Project elements that could directly affect TES mussels include any actions that would affect freshwater unionid mussels and/or their habitat. TES would be harmed (killed or injured) by construction of temporary causeways and a cofferdam structure, substrate placement, grading, and equipment tracking within the river channel. Once the Project is constructed, the proposed grading is anticipated to adjust to post-construction hydraulics and some localized scour and deposition may result, along with slight shifts in boulder and riprap, all within direct impact areas. No routine maintenance is anticipated. Some repair, rehabilitation, and/or replacement may be needed in the case of unforeseen circumstances that would threaten public safety or infrastructure. TES could be harmed (killed or injured) if this involves tracking in the wet and flowing river. Translocating unionid mussels to minimize adverse effects is proposed.

Habitat for unionid mussels would be modified by changes in local hydraulic conditions, substrate constituents, flow velocity and depth, and host fish habitat. Predicted habitat changes are anticipated to benefit TES, fish hosts, and other fish species without increasing *P. marinus* spawning, larval habitat, or escapement probability or impeding fish passage.

The area that would be affected by project construction includes the area from 91 m (300 ft) upstream of Bridge Street to the upstream face of Fulton Street, an area of 127,600 m^2 (31.5 acres) (Table 2-1). Of this, 45,445 m^2 (11 acres) would be directly impacted during dam removal, and causeway and feature creation. If unionid mussels are evenly scattered throughout the direct impact areas, approximately 123 *E. triquetra*, 1,922 Michigan TES, and 11,588 other unionid species could be impacted during construction (Table 2-1). Unionids not relocated from direct impact areas could be crushed by construction activities. As many unionids as practicable would be translocated from direct impact areas before construction to minimize these impacts. However, unsafe diving/collection conditions may prevent some unionids from being removed (see Grand Rapids/GRWW relocation project, Section 2.2). Those not relocated would be considered Take and mitigated through a mitigation fund (see Section 2.3).

Indirect project impacts within the Construction Area (areas where the river bottom will not be physically disturbed during construction) include temporary increases in turbidity during construction and slight changes in local hydraulics (changes in flow velocity) during and after construction. No changes in depth or scour are expected during construction outside of direct impact areas. The area of indirect impact

within the construction area is approximately 82,155 m^2 (20 acres). Approximately 222 *E. triquetra*, 3,475 Michigan TES, and 20,950 other unionids could be affected by increases in turbidity and slight changes in local hydraulics (Table 2-1).

Indirect project impacts downstream of Fulton Street also include potential increased turbidity during construction (downstream indirect impact area). The river between Fulton Street and 500 m (1,640 ft) downstream was sampled for mussels in 2013 (ESI, 2014). Substrate was primarily sand, with the LDB being deeper with more flow and the RDB very shallow. Only 12 mussels were collected, and density averaged 0.1 unionids/m^2 (Table 2-7). The Grand River near the mouth of Plaster Creek was sampled in 2017 and 2018 (ESI, 2018; EcoAnalysts, 2019, 2021), and the I-196 South Bridge was sampled by JFNew (2013d), and mussels were relocated from the I-196 south bridge by GEI (2023). Few mussels were collected in any of these surveys, and substrate was primarily sand or silt, except near the I-196 bridge (downstream of Plaster Creek), where flow was greater and substrate was sand, gravel, and cobble (GEI, 2023). Less than three mussels per five-minute search were collected by ESI (2018), and only five mussels were collected by JFNew (2013d). However, almost 4000 mussels were relocated from the I-196 bridge in 2021/2022, including *E. triquetra* (GEI, 2023). A few Michigan TES have also been collected live (*C. tuberculata*, *L. recta*, *P. alatus*, *T. truncate, L. compressa*) (Table 2-7). Based on a conservative 0.1 mussels/m^2, approximately 28,250 mussels could occur in the downstream indirect impact area (Table 2-1). The mussels that occur within this reach could be temporarily affected by turbidity plumes. BMPs would be in place to reduce turbidity and a monitoring program in place to detect turbidity and initiate corrective actions.

Although sedimentation would be contained within direct impact areas and BMPs would be installed, turbidity increases within the construction area indirect impact areas and downstream indirect impact area may affect unionids. Prolonged periods of turbidity can affect feeding and reproduction (Aldridge et al., 1987; Gascho Landis et al., 2013; Gascho Landis and Stoeckel, 2016; Tuttle-Raycraft et al., 2017). Intermittent exposure to inorganic Total Suspended Solids (TSS) at high levels (>600 mg/L) can cause nutritive stress, resulting in shift to catabolism, decreasing glycogen reserves resulting in decreased growth and reproduction (Aldridge et al., 1987). Feeding of some species declined as organic TSS increased, with a threshold at 8 mg/L over a seven-month period (Gascho Landis et al., 2013; Gascho Landis and Stoeckel, 2016; Tuttle-Raycraft et al., 2017), and reproduction was affected at TSS >20 mg/L (Gascho Landis and Stoeckel, 2016).

Temporary increases in turbidity could affect mussel feeding, respiration, and spawning success, but are not expected to result in mortality. Mussels tend to close up and burrow into the substrate when disturbed by increased turbidity and changes in flow. This could result in reduced feeding and use of glycogen reserves, resulting in reduced fitness for reproduction and/or overwintering. Host fish behavior might also be modified within indirect impact areas. This could also result in decreased recruitment during construction.

Most large mobile fish would likely vacate the Construction Area due to activity. Small benthic fish in the direct impact areas could be harmed by equipment or buried beneath the causeways. *Moxostoma carinatum* may spawn in the Project Area. Spawning would likely occur before construction under higher water levels. If spawning conditions overlap with construction, recruitment of *M. carinatum* and other

species that use the Project Area may decline in the 2-year period in which construction activities are planned, but these species likely spawn in other sections of the Grand River outside of the Project Area. BMPs would be used to reduce turbidity to the greatest extent practicable. Some small benthic fish may be more affected than larger more mobile fish. However, turbidity would be monitored and a plan to reduce any unanticipated turbidity in place. Effects to small benthic fish would be temporary.

Fish, including host fish and *A. fulvescens* and *M. carinatum*, could also be affected by temporary increases in turbidity downstream of Fulton Street. Generally, fish are more mobile than mussels and would seek areas of less turbidity. However, increased suspended sediment can result in short-term physiological and behavioral effects such as displacement of fish, intraspecific aggression, disruption in migratory patterns, disruption in reproductive pairing and spawning success, changes in predator-prey interactions, changes in food web dynamics, and changes in larval disbursement and settlement (Kjelland et al., 2015 and references therein). These effects could be positive, negative, or neutral depending on the species, duration and frequency of exposure, and level of exposure.

Both *A. fulvescens* and *M. carinatum* are thought to spawn at the mouth of Plaster Creek (S. Hanshue, MDNR, personal communication). Both of these species spawn in the Spring when turbidity levels are higher than during other times of the year, and the increase in turbidity 2.5 km (1.6 miles) downstream of the Construction Area should be minimal. Spawning of these species should not be impacted by turbidity increases in the Construction Area. Additionally, water levels are typically higher during Spring spawning than are needed for construction. Construction is unlikely to be occurring during spawning season.

Indirect impacts upstream of the Construction Area include hydraulic changes between 6th Street Dam and 91 m (300 ft) upstream of Bridge Street (upstream indirect impact area); primarily some areas of slightly increased velocity and slightly decreased depth between I-196 and the construction area due to the demolition of the two low-head dams near Bridge Street (Appendix F). The project would not have negative permanent impacts to the effectiveness of 6th Street Dam as a barrier to *P. marinus*; tailwater elevations at the dam will not be increased due to the project and the dam will maintain its current effectiveness as a *P. marinus* barrier (Table 2-3; Appendix D). Tailwater elevations may increase less than 0.1 m (0.4 ft) during construction and will be lower post-construction.

After construction, most of the area would be available for recreational use and aquatic habitat. Deeper pools would provide habitat for Ictaluridae and other larger fish species. Shallow sloping banks with relatively low flow velocity would provide fish passage and habitat for Cyprinidae. Boulders would provide cover for Centrarchidae and juvenile fish. Boulders within riffle areas would provide habitat for darters such as *P. caprodes*, juvenile Ictaluridae, and juvenile Catostomidae. Riffles would also provide spawning areas for Catostomidae and Ictaluridae (Table 2-5).

Fish passage has also been thoroughly examined and the project modified to allow fish passage (Appendix E). At least 50% of the fish can pass along at least one swim path in each river reach (Table 2-6).

Mussel habitat is also expected to improve post-construction, although it may take several years for mussels to colonize. Mussels would still be more abundant along banks in slower flowing areas, but are

also expected to colonize flow refugia created by boulders within riffles and emergent habitat boulder fields (Figure 2-3). Modeled hydrophysical habitat suggests physical habitat would be available for mussels in approximately 7,565 m^2(1.9 acres), a slight increase over existing conditions (Table 2-1).

2.1.6 Conservation Measures

Conservation Measures for the NRCS project included further reduction in construction impacts with design modifications, mussel relocation from Direct Impact areas, and fish salvage from the isolated area. A mitigation fund would also be created to compensate for any unionid mussels not translocated from direct impact areas under the Grand Rive/GRWW relocation project.

NRCS, GRWW, and the City have coordinated with USFWS, EGLE, and MDNR over the past year to reduce project impacts to the river, fish, and mussels.

- The project has changed from most of the Project Area being isolated and impacted directly (89,195 m^2 direct impact Area; EcoAnalysts, 2020) to direct impact area of only 45,445 m^2, a 50% reduction in area affected by the project. Rather than the river being constrained by isolation measures during construction, construction would occur in the flowing river. Only a small area (3,285 m^2) at Dam 2 would be isolated during construction (Table 2-9), and the area would not be isolated during *P. marinus* migration season.
- Causeways have been removed from the isolated area construction design for less impact on unionid mussels; allowing more mussels to be translocated from within the isolated area.
- The footprint of causeways have been moved to overlap with proposed grading limits where possible to further reduce impacts to the river bottom.
- The number of habitat boulders has been reduced, reducing the construction impact area.
- Construction sequencing has been postponed to 2025 to allow the most time possible for unionid translocation under the Grand River/GRWW relocation project in 2024. In 2025, if needed, the translocation team would work with construction managers to allow mussels to be translocated before an area is under construction.
- Wetlands have been avoided to the greatest extent possible. Those that fall within direct impact areas would be covered with timber mats before any causeway construction or tracking on the river occurs.
- Construction sequencing has been changed to maintain the river grade and prevent scouring, but still maintain existing tailwater elevations during *P. marinus* migration season.
- To reduce impacts to fish, fish would be salvaged from the isolation area before it is dewatered.
- To prevent fish entrainment while dewatering the isolated area, a screen would be placed around the pump and a net around the pump area.
- Mussels would be removed from the isolated area after water levels are reduced. Sufficient personnel would be on site to ensure mussels are removed within a 10 day period to prevent stress due to lack of flow and increased water temperatures.
- Mussels in direct impact areas would be translocated under the Grand River/GRWW relocation Project (see Section 2-2).
- Mussels not relocated would be compensated through a mitigation fund.
- Constructed features would be allowed to adjust to post-construction hydraulics, and no operation or maintenance would be required, reducing impacts to the river bottom post-construction.

BMPs approved during the EGLE permitting process would be used to minimize impacts in indirect impact areas.

- Erosion and sediment control measures would be used in accordance with the Michigan Unified Keying System and approved by the City's Stormwater (NREPA Part 91) reviewers.
- Vegetation removal would only occur within the staging areas and would be minimized as much as practicable to provide access and limit any safety concerns.
- Construction staging and stockpile areas would be established, as well as areas for storage of spare oil booms and designated oiling and petroleum handling areas outside of the riparian zone. These areas would be isolated from the river using BMPs such as silt-fences, straw wattles, and berms. The contractor would also establish and post protocols for potential oil spill cleanup and emergency response.
- Runoff from equipment maintenance and storage areas would be directed to stabilized outlets designed to adequately convey the volume discharged. Heavy equipment would be well maintained to prevent leaks. Vehicles or other equipment would not be washed at locations where the runoff would flow directly into a watercourse or separate storm sewer.
- Construction materials, including topsoil and chemicals, would be stored, covered, or isolated to prevent runoff of pollutants and contamination of groundwater. Empty canisters, cans, or other chemical containers (e.g., hydraulic fluids, etc.), scrap wood, scrap metal, and all other waste materials would be disposed of daily or kept in sealed waste containers until they can be properly disposed of off-site, such as in a landfill. Waste materials would not be buried on-site.
- Prior to entering the watercourse, all equipment would be washed under high-pressure water with a non-harmful and biodegradable degreaser. Once in the watercourse, equipment would be inspected frequently and maintained properly to ensure no grease, oils, or chemicals are entering the watercourse. If equipment is leaking such fluids, it would be removed from the water course and repaired prior to re-entering. Equipment regularly traversing in and out of the watercourse would be cleaned under high-pressure water (i.e., wheel washing station) at a minimum once per week. Biodiesel fuel would be used in any equipment entering the water. If needed, oil booms may be placed downstream of any equipment working in the wet.
- Construction equipment would be equipped with Global Positioning Systems (GPS) to ensure all construction and in river tracking is within the direct impact areas outlined in this BA.
- Silt curtains would be used downstream of construction areas within the Project Area to reduce downstream turbidity,
- Turbidity would be monitored downstream of construction areas and in the downstream indirect impact area.

The current design meets the project purpose with significantly reduced impacts, achieves fish passage and aquatic enhancement throughout the project area, diversifies recreational opportunities, and restores the rapids. Additionally, the *P. marinus* barrier at the 6th Street Dam would be maintained with the same efficacy as under existing conditions.

A small area (3,285 m^2) at the Dam 2 diversified boulder arches needs to be isolated for construction. Without fish salvage, fish would be trapped in the isolated area and would die during construction. Some fish would leave the area due to construction activity disturbance during construction of causeways. Once

the area is isolated, a team of biologists would electrofish and/or seine the area to remove as many remaining fish as practicable. To protect any remaining fish from impingement or entrainment by pumps, a screen would be placed over the pump and a net would be placed around the pump area. A biologist team would remain on site to collect and remove any fish that remain trapped during the water drawdown. All live fish would be identified, counted, and released into the flowing channel. Any deceased large edible size fish would be offered to the public. A lined dumpster would be on site for disposal of non-edible dead fish.

2.2 Grand Rapids/GRWW Relocation Project

The Grand Rapids/GRWW Relocation Project would consist of collecting as many mussels as possible from the NRCS Project direct impact areas with USFWS assistance (Figure 1-1) and translocating them to three recipient sites (Figure 1-4). The area that would be affected by project construction includes the area from 91 m (300 ft) upstream of Bridge Street to the upstream face of Fulton Street, an area of 127,600 m^2 (31.5 acres) (Table 2-1). Of this, 45,445 m^2 (11 acres) would be directly impacted during dam removal, and causeway and feature creation. If unionid mussels are evenly scattered throughout the direct impact areas, approximately 123 *E. triquetra*, 1,922 Michigan TES, and 11,588 other unionid species could be impacted during construction (Table 2-1). Unionids not relocated from direct impact areas could be crushed by construction activities. As many unionids as practicable would be translocated from direct impact areas before construction in 2024 to minimize these impacts. However, unsafe diving/collection conditions may prevent some unionids from being removed.

2.2.1 Recipient Sites

A survey was conducted in 2015 to identify suitable recipient sites for mussels that would be translocated from NRCS Project impact areas (ESI, 2016). Five potential sites were identified; Ionia, Saranac, Chief Hazy Cloud, Ada, and Site 7. Of these, Ada is the largest (23,480 m^2 [5.8 acres]) site, and most of the TES were found at this site (Tables 2-7 and 2-8). The best habitat within the Ada bed is 3,400 m^2 (0.8 acres) mid channel (Figure 2-5). As many 10 m x 10 m areas as needed to accommodate TES would be established using corner markers driven into the substrate and either PVC pipe or ropes between the corner markers within this section of the site for the placement of TES. TES would be hand placed 1 unionid/m^2 into the 10 x 10 areas. A PVC grid with 1 m^2 cells would be used to delineate positions within the 10 x 10 area. The remainder of the site would be used to place common species. Density within this site averaged 2.8 unionids/m^2. If density is increased no more than 50%, the site can accommodate 4,760 TES individuals and 21,000 common individuals (Table 2-8). If mussels could be collected from all of the direct impact areas, approximately 98 *E. triquetra*, 1,440 Michigan TES, and 9,369 common individuals are expected based on collecting 80% of the unionids (Table 2-9). Landowners near the site would be contacted before any work is conducted.

Species that were not found at Ada include *P. alatus*, *T. parvum*, *T. truncata*, and *U. imbecillis*. *Potamilus alatus* was not found at any of the investigated sites, and *T. truncata* was only found at Saranac. *Aplodinotus grunniens* is the host for both *P. alatus* and *T. truncata* and is sparse upstream of the 6th Street Dam (Hanshue and Harrington, 2017). The river reach between Plaster Creek and the M-11 Bridge was investigated for a suitable recipient site in 2020 (EcoAnalysts, 2021). A suitable site with both species and suitable substrate was found just downstream of Plaster Creek (Figure 2-6). This is a small area, but very

few *P. alatus* and *T. truncata* would be expected in direct impact areas. A 10 m x 10 m area would be established in the most stable substrate of this area for these species.

Toxolasma parvum and *U. imbecillis* are both species that occur near the bank in siltier habitat. Neither of these species were found in the Project Area, but they could occur at a low frequency. A site along the edge of Riverside Park was investigated in 2013 as a staging area (ESI, 2014); however, since mussels were present, the area would not be used during NRCS Project construction. Several *T. parvum* were collected at Riverside Park, and habitat suitable for *U. imbecillis* was available. If these species are found in the Project Area they would be moved to Riverside Park (Figure 2-7). A 10 x 10 area would be established for these species.

Collection and translocation of mussels would occur when water temperature is above 10° C (50° F) and air temperature is between 10 and 32° C (50 and 90° F) unless permission is obtained from USFWS and MDNR to translocate outside of these temperature windows.

2.2.2 Collection and Translocation Safety Limitations and Timing

The collection and translocation effort would be limited by flow velocity. Michigan Department of Transportation (MDOT) indicated that divers were unable to safely work and translocate mussels from the I-196 bridge project, which is upstream of the Project Area, above 3,000 CFS due to high velocities. Dam 4 slows flow velocities between the 6th Street Dam and Dam 4 (Figure 2-1). Therefore, the flow velocity upstream of Dam 4 (at the MDOT project) during 3,000 CFS is equivalent to flow velocities downstream of Dam 4 (within the project area) during 1,200 to 1,500 CFS. Conditions suitable for relocating mussels at the I-196 bridge downstream of the project area were limited to <2,000 CFS (GEI, 2023).

ESI/EcoAnalysts experience in the Project Area (sampling in 2013- flows 1,860 CFS to 2,410 CFS), 2016 (flows 2,100 CFS to 3,000 CFS), 2017 (flows 1,300 CFS to 1,600 CFS), and 2020 (flows in September 3,400 CFS, October 2,000 CFS to 2,400 CFS) indicated that most (but not all) of the NRCS Project Area was sampleable at flows ≤2,500 CFS. At flows >2,500 CFS sampling became difficult and only the area along the west bank upstream of Dam 2 was accessible at 3,400 CFS. At 3,400 CFS, they moved from upstream to downstream, as moving upstream was not possible. Sampling was aborted mid-day as flows rose above 3,400 CFS. Equipment had to be floated down and across the river, then up a steep bank into the parking lot downstream of Fulton Street. Even at flows <2,500 CFS, moving equipment upstream to Ah-Nab-Awen Park at the end of the day was very difficult. Even at flows <1,500 CFS the west bank from the Grand Rapids Public Museum to just up of Fulton Street was not sampleable.

Sampling at all flows required holding a diver/snorkeler in place for a few minutes to dig a 0.25 m^2 quadrat. Translocation requires a diver to not just hold position, but move freely around an area to search for and collect mussels. Flows required for translocating mussels would be lower than required for sampling.

Relocating mussels at flows lower than 1,500 CFS would be ideal. However, 1,500 CFS flow has a very low probability of not being exceeded (frequency of <5%) and may not occur within the next few years (Table 2-10). A higher probability maximum flow was therefore considered that would allow at least some unionid mussels to be collected and translocated within the 2024 season.

Ecological Specialists, Inc. (ESI) dive teams have conducted over 45 translocations since 1990 in small, medium, and large rivers. Dunn and Sietman (1997), Dunn et al. (2000), and Cope et al. (2003) are often cited in methods for translocations and were the basis for the translocation protocols developed for Wisconsin and West Viriginia. The West Virginia protocol was the basis for the Ohio and Michigan freshwater mussel protocols. Ms. Dunn also teaches the sampling and translocation portions of the "Conservation Biology of Freshwater Mussels" and teaches "Scientific River Diving Safety" at the Department of Interior National Conservation Training Center. In her experience, safe diving/snorkeling conditions are limited to ≤0.3 m/sec (1 ft/sec); however, since depths are 1.2 m (≤4 ft) in most of the direct impact areas (Appendix F), divers/snorkelers should be able to relocate mussels in 0.6 m/sec (≤2 ft/sec) current.

Based on 2D modeling results, approximately 20% of the direct impact areas would have flow velocity ≤0.6 m/sec (2 ft/sec) at 2,500 CFS. At higher flows, very little of the direct impact area is expected to have safe diving/snorkeling conditions; 13% of direct impact areas would have flow velocities ≤0.6 m/sec (2 ft/sec) at 3,000 CFS, and only 6% at 3,500 CFS. Some of the area along the west bank where causeways are proposed, and some of the Dam 4 area may be accessed up to 3,000 CFS. Areas further riverward and along the east bank would likely only be workable at less than 2,500 CFS. However, the velocity and flow that is workable is ultimately decided by the diver/snorkelers on site.

Areas unable to have mussel translocation due to safety include areas within 10 meters of dams and areas determined to be too swift for a diver/snorkeler to hold position. Flow velocity near the dams is higher and more turbulent and could result in a diver/snorkeler being swept over or downstream of the dam, or being caught in a hydraulic downstream of the dam. The Grand Rapids Fire Department also discourages activity within 10 m of the dams.

2,500 CFS has a 37-72% probability of being exceeded during mid-July to October 1 (Table 2-10). 3,000 CFS has a 4-67% probability of being exceeded during mid-July to October 1. 3,500 CFS has a 0-60% probability of being exceeded during mid-July to October 1.

Safe diving/snorkeling areas would be determined based on the evaluation of the dive crew on site. If a diver/snorkeler cannot hold position, conditions would be considered unsafe. Attempts to maximize translocation efforts and efficiencies would occur if divers/snorkelers and the dive supervisor deem the hydraulic conditions safe. Figure 2-8 shows portions of the direct impact area that are predicted to be ≤0.6 m/sec (2 ft/sec) at 2,500 CFS. Divers/snorkelers would use these polygons, generated from modeling results at 2,500 CFS as a guide, but use judgement to determine if they could work safely further riverward. The area worked would be as large as possible while maintaining diver/snorkeler safety.

Hopefully, safe diving conditions would occur throughout the 2024 season and all mussels within direct impact areas could be collected and translocated. However, that probability is very low. Therefore, divers/snorkelers would prioritize areas based on mussel abundance (highest abundance areas first), and secondly areas that that would be constructed first (Dam 1 and 2 construction area and access causeways) (Figure 2-8). Additional areas would be worked as flow conditions and time permit.

The National Oceanic and Atmospheric Administration (NOAA) would be contacted to obtain flow predictions for the Grand River during non-flood periods if possible. One translocation crew would mobilize once flow rates are predicted to remain below 3,000 CFS for 7 days or more; a flow rate with a higher probability of occurring and at least some area being safe for collecting mussels. The mussel translocation crew would evaluate safe diving conditions at 3,000 CFS and determine the amount of area that could safely be worked. If more than 7 days of area is available, additional crews would be mobilized and mussels would be removed from as much of the direct impact areas as possible (see Table 2-11 for areas and estimated times). As flows decline and additional area is workable, up to four crews would be mobilized to maximize the area that mussels could be translocated from before construction. Once translocation begins, if flows are predicted to remain above safe diving conditions as determined by the translocation crew (approximately 3,000 CFS) for 7 days or more, translocation crews would demobilize and plan to return to the site once flows are predicted to be at or below safe levels for 7 days or more.

In 2025, construction would be prioritized. If mussels in parts of the direct impact areas were not collected and translocated in 2024 and river conditions are determined to be safe for collecting in 2025, the translocation crew would coordinate closely with the construction manager to determine areas where mussel collection could occur safely without interfering with construction.

Mussel translocation would occur within the isolated area around Dam 2 unless flows and time allow mussel translocation to occur prior to construction of the isolation structure. Mussels would be collected after isolation and before water is drawn down. Sufficient personnel would be on site to remove as many mussels as practicable within 10 days.

2.2.3 Collection and Translocation Methods

Collection and translocation of mussels would occur when water temperature is above 10° C (50° F) and air temperature is between 10 and 32° C (50 and 90° F) unless permission is obtained from USFWS and MDNR to translocate outside of these temperature windows. Water temperature and water clarity would be recorded within each collection area and at the recipient sites.

Each direct impact area would be divided into 5 x 10 m blocks within workable flow areas as determined by divers/snorkelers on site. Workable flow would be defined as current velocity in which the diver/snorkeler can maintain position (not be swept downstream) within the block and collect mussels. Tethering and additional weight would be used as needed. However, added weight can impair movement. Blocks would be further divided into smaller 1 m x 5 m rows using a PVC grid. The grid would consist of 5, 1 x 1 m^2 cells. Use of smaller blocks rather than a moving transect would allow collectors/snorkels to still systematically search an area, but also stay within irregular search areas.

Each of the 1 m x 1 m cells would be visually searched for habitat and mussels (visual search). If no habitat (bedrock or entirely non-movable rock) is found, then that 1 m^2 is clear. If habitat and/or mussels are found, that 1 m^2 would be excavated down to 15 cm (6 inches), collecting any mussels that are found (first pass) within a minimum search effort of 2 min/m^2. Excavation would include moving cobble and woody debris and moving away silt, sand, and small detritus, then digging the substrate down at least 15 cm (6 inches). That 1 m^2 would be excavated a second time (second pass) for a minimum of 1 min/m^2, and if <5% of the mussels are collected on the second pass compared to the completed first pass and no TES are

found, then the 1 m^2 would be declared clear. If not, it would need to be searched again until the <5% criteria and no TES is reached. Searching would require an average of 2 min/m^2 for the first pass and 1 m/m^2 for the second pass.

Once the entire 1 m x 5 m row is clear, the 1 m x 5 m grid would be moved to the next 1 m x 5 m.

"Clear" would be defined as

1. Area is bedrock or non-diggable rock on the visual search,
2. No mussels >0.5 inches are found on the completed first dug up pass (divers/snorkelers would strive to collect all mussels, but can only guarantee that mussels >0.5 inches would be collected),
3. Mussels are found after digging up the area (first pass), but <5% of the total number of mussels >0.5 inches found on the first pass are found after the area is dug up again (second pass) AND no TES are found.
4. Passes continue until <5% criteria of the completed first pass is met and no TES are found.

All areas within the direct impact areas that are deemed safe by the snorkeler/diver will be searched as above. Once an area is deemed unsafe it would not be worked unless river conditions improve.

Collected unionids would be held in flowing water or in flow through tanks (under ambient water conditions) while awaiting processing and/or translocation. Unionids would be processed within a few hours of collection. All collected TES would be tagged, measured (length in mm), and aged (external annuli count). Michigan TES would be tagged with shellfish tags, and *E. triquetra* would also be tagged with Passive Integrated Transponder (PIT) tags. Common species would be identified, counted, and marked with a Dremel tool (slash on the anterior ventral edge of the shell to assess growth). Unionids would be kept in water at ambient temperature (flowing water, flow through tanks, or buckets with frequent water changes) throughout this process and while awaiting transport to recipient sites. Unionids would be translocated to recipient sites at the end of each day or beginning of the following day wrapped in moist towels within coolers. Once at the site, common species would be spread on the bottom by a diver/snorkeler within a defined area at a density not to exceed 1 unionid/m^2 (either marked with buoys or GPS points). TES would be hand placed on the substrate within their assigned area at a density of 1 unionid/m^2. Hand placing unionids on the substrate rather than in holes dug by the diver/snorkeler allows the animal to select where it wants to be burrowed and previous studies indicate no difference in mortality or recovery with this method (Dunn et al., 2000).

Unionids could be stressed by handling and translocation; however, the above methods would minimize stress as much as possible. Results differ among studies that looked at mortality and/or reduced growth due to handling and translocation. Cope and Waller (1995) found that recovery and survival after translocation averaged 51% and 43%, respectively. Low survival and recovery were attributed to water and air temperature extremes, improper collection methods, improper handling and transport, and substrate instability at the recipient site. Subsequent translocations that reduced handling, kept animals in oxygenated water before and during transport or kept animals moist during transport and translocated mussels to stable recipient sites had very little mortality (Dunn et al., 2000; Cope et al., 2003; Tsakiris et

al., 2017). Survival, growth, and movement were similar between translocated mussels and those from the recipient site (all collected, measured, aged, marked) in four translocations (Dunn et al., 2000). Tsakiris et al. (2017) also compared survival, growth, and body condition in translocated vs. resident *Amblema plicata* (Three-ridge) and *Quadrula houstonensis* (since placed in synonymy with *Cyclonaias pustulosa* [Pimpleback]; FMCS, 2023) and found no difference in *A. plicata* and only minor differences in *Q. houstonensis*. Survival in two translocations was 85 to 100% after two years (Cope et al., 2003). Dunn et al. (2000), Cope et al. (2003), and Tsakiris et al. (2017) all used similar handling and transport methods. Roznere et al. (2017) did find difference in metabolites between mussels moved to their captive facility and to Big Darby Creek from the Muskingum River, and suggested that the differences in these metabolites were consistent with physiological processes that would result in reduced growth and mortality. The aforementioned translocations moved mussels within the same river, whereas Roznere et al. (2017) moved mussels to a captive facility and a different river system.

Results from studies looking at growth due to handling also differed. Both Dunn et al. (2000) and Tsakiris et al. (2017) handled mussels that remained in the recipient site and those relocated to the recipient site similarly. Since both groups of animals were handled similarly, any change in growth due to handling would not have been observed. Reduction in *Q. pustulosa* (changed to *Cyclonaias pustulosa*; Williams et al., 2017) growth with handling was reported by Haag (2009) when mussels were only handled once a year for two years. However, Ohlman and Pegg (2020) compared changes in *Lampsilis cardium* (Pocketbook) length with no handling, handling every other week, once a week, and twice a week for 85 days and saw no mortality and no difference in growth. Species differed between these studies; *C. pustulosa* is a thicker shelled, slower growing species than *L. cardium*. Handling and translocating mussels could result in stress, which could manifest in reduced growth and mortality in some species. However, stress can be significantly reduced through proper handling.

Based on previous translocations (H. Dunn, personal communication), 80% of the unionids within each collected area should be collected and survive translocation (estimated 15% not collected and 5% mortality of those collected) (Table 2-12).

A report would be prepared within 45 days of completion of each year's translocation.

2.2.4 Monitoring

Translocated unionids would be monitored within one year following each year's translocation (2024 and if needed 2025) between June and October 15 when water temperature is greater than 10° C (50° F), and air temperature is between 10 and 32° C (50 and 90° F) or whatever monitoring schedule is provided in the BO. Up to 100, 1 m^2 cells in each recipient site would be randomly selected for monitoring. A PIT tag wand would be first used to find and collect *E. triquetra*. A diver/snorkeler would systematically search each selected 1 m^2 area. A PVC grid with 1 m^2 cells would be used to facilitate searching. Since excavating all cells may destabilize substrate and render habitat unsuitable for mussels, at least 10 1-m^2 cells within each area would be excavated to calibrate surface to buried ratio. The remainder would be surface searched (visual, tactile, moving rocks, logs, probing the top inch) for at least 1 minute/m^2. All collected unionids would be checked for tags, recorded as tagged or not tagged, measured (length in mm), and aged (external annuli count), and Lampsilini would be checked for gravidity.

The area within 5 m around the grid would also be searched with a PIT tag wand and visually searched for relocated mussels to detect mussels that may have moved out of the grid area.

A report would be prepared at the end of each year to summarize translocation and monitoring results. Tag numbers, lengths and ages, collection site and translocation grid of TES would be reported in an Appendix. Area searched, search efficiency, and number of each species collected would be summarized. Monitoring results would include recovery rate, survival rate, growth, and movement of TES. Recovery rate of each species would be calculated as number of each species collected in surface search multiplied by the ratio of total:surface estimated from excavated cells/number of each species placed in the area. Survival would be estimated as estimated number of live recovered/estimated live + dead recovered. Growth would be assessed by both visual observations of shell material past the slash mark on the shell and by comparison of lengths. Movement would be estimated by comparing placement grid cell position with collection grid cell position.

2.3 Mitigation Fund

As many mussels as possible would be collected from direct impact areas and translocated to one of the three recipient sites under the Grand Rapids/GRWW project (see Section 2.2). The estimated area of direct impacts is 45,445 m^2. Using an average unionid density of 0.3 unionids/m^2, approximately 13,633 unionids occur within direct impact areas (Table 2-9). Mussels would at least be collected and translocated from within the isolated area. Up to 15% of those mussels may be missed during collection, and up to 5% might die due to handling. Minimum number of mussels that would be translocated would be 830 mussels, with mortality of 12,803 mussels (Table 2-12). If mussel collection in all of the direct impact area can be safely done, then with 15% of the mussels missed and 5% mortality due to handling, the maximum number of mussels that would be relocated would be 11,486.

A mitigation fund would be established to offset the take for the mussels that were unable to be translocated under the Grand Rapids/GRWW Project. The maximum mitigation fund contribution would be based on $34.10/mussel (2020 BA $28.50/mussel escalated for inflation) and would not exceed $436,589 (Table 2-13). This fund would be reduced by the amount of mussels that are translocated multiplied by the cost per mussel as stated above. The objective of the mitigation fund would be to fund projects that provide a direct benefit to mussels to achieve the USFWS “no net loss” policy and offset any potential impacts from mussels that were unable to be translocated. The work performed through the mitigation fund would help inform future conservation and habitat restoration efforts.

USFWS, NRCS, and MDNR would act as decision makers for the mitigation fund to determine what mitigation projects are selected for implementation. Priority would be given to projects that provide a direct benefit to mussels within the Project Area or the Lower Grand River Watershed. Specific mitigation activities, and mitigation fund management protocols would be developed in coordination with appropriate regulatory agencies.

The City and GRWW are interested in the long-term success of these habitat restoration efforts and would like to continue to partner with USFWS, NRCS, and MDNR on potential future projects that benefit mussels in the Project Area. The City and GRWW would advance the goals of the mitigation fund by encouraging local scientific partners including, but not limited to, the Grand Valley Metropolitan Council, Grand Rapids

Public Museum, John Ball Zoo, Grand Valley State University, and Trout Unlimited, to apply to the mitigation fund for projects that directly benefit mussels and the advancement of habitat restoration efforts in the Lower Grand River Watershed.

An initial deposit would be made to the mitigation fund following the completion of the 2024 mussel translocation efforts based on the collection efficiency. A second and final deposit to the fund covering the balance of the required mitigation fund would be made following any mussel translocation activities that occur during the 2025 construction season. Any excess funds of the initial deposit would be returned if the mussel translocation exceeds the estimated collection efficiency. The financial assurance shall take the form of proof of funding deposited into an escrow account, City of Grand Rapids Commission Resolution, proof of deposit and an executed agreement with a Non-Government Organization, or another agreed upon form of financial assurance documentation.

2.4 NRCS and Grand Rapids/GRWW Project Schedule

A proposed project schedule is provided in Table 2-14. This BA is expected to be submitted to USFWS in March 2024. A Biological Opinion from USFWS is expected before July 2024, allowing the USFWS project of mussel translocation to proceed in August, once river levels are safe. Information in the BA would be used to complete the Draft Environmental Assessment (EA). Once the EGLE permit is granted and PL83-556 funds are received, the mobilization and construction can begin. Construction would begin in 2025 to allow as much time as possible for mussel translocation. Mussels in areas that were not collected and translocated in 2024 and not under construction may also be translocated in 2025 if river conditions permit. Mussels would also be translocated from the isolated area in the Dam 2 construction area in 2025, once the area is isolated and water drawn down. Construction is expected to take up to two construction seasons; however, construction is highly dependent on safe river levels.

3.0 ENVIRONMENTAL SETTING AND BIOLOGICAL RESOURCES

Information in this section is largely based on information in Hanshue and Harrington (2017), supplemented with data collected by Ecological Specialists, Inc/EcoAnalysts (mussels) and EnCompass (fish).

The Grand River is Michigan's longest river, with a drainage area of 14,256 km^2 (5,504 mi^2). It begins in northern Hillsdale County as a series of lakes and ends at Grand Haven, MI in Lake Michigan. Hanshue and Harrington (2017) divided the river into five mainstem valley segments based on common channel and landscape features: headwaters, upper, middle, lower, and mouth segments (Figure 3-1). The headwaters flow 87 km (54 miles) to the confluence with Sandstone Creek, the upper river flows 68 km (42 miles) from Sandstone Creek to Eaton Rapids upstream of Red Cedar River, the middle river extends 97 km (60 miles) down to the mouth of the Maple River, the lower river flows 113 km (70 miles) from the Maple River to the Village of Lamont, and the mouth of the river continues for 40 km (25 miles) from Lamont to Lake Michigan.

The Action Area is within the Lower Grand River, which extends from the confluence with the Maple River downstream to the Village of Lamont (Figure 3-1). The Lower Grand River is within a glacial-fluvial valley formed approximately 14,000 years ago. Several major tributaries enter the lower Grand River, including the Maple, Flat, Thornapple, and Rogue Rivers (Hanshue and Harrington, 2017). Annual flow patterns are typical of most Michigan streams and include high flows in Spring and Fall, and low flows in late Summer and Winter. Seasonal flow stability was rated as moderately unstable approximately 64 km (40 miles) upstream at Ionia, MI, but is somewhat more stable in Grand Rapids due to inputs from the Flat, Thornapple, and Rogue Rivers, as well as groundwater inputs (Mandle and Westjohn, 1989 *in* Hanshue and Harrington, 2017).

Mean annual flow in Grand Rapids from 1901-2005 was 3,775 CFS (Hanshue and Harrington, 2017). Low flow (7Q10) is approximately 890 CFS. Under existing conditions, the bedrock shelf upstream of Leonard Street in Grand Rapids is submerged at all flows. Bankfull flow (1.5 yr flood) is 13,000 CFS. At 23,000 CFS, the 6th Street Dam becomes submerged. Ten (10), 25, and 100-year flood levels are 31,000 CFS, 38,000 CFS, and 50,000 CFS, respectively. The 2013 flood peaked at 35,100 CFS in Grand Rapids.

Anthropogenic alterations in the Project Area include narrowing of the river, placement of floodwalls, quarrying of bedrock, removal of glacial boulders, channel dredging, and installation of a series of low-head dams over the last two centuries. Recently the I-196 bridge (within the upstream indirect impact area) was widened. Cofferdams to facilitate construction extended into the river channel, increasing the tailwater levels at the 6th Street Dam and altering hydraulics. Construction duration was approximately 2 years.

The Grand River within Grand Rapids was estimated to be 430 m (1,400 ft) wide before modification. The width is currently approximately 140 to 200 m (450 to 600 ft) (Hanshue and Harrington, 2017). Floodwalls are present on both banks throughout most of the Project Area. Approximately 229,366 m^3 (300,000 yds^3) of gravel, cobble and boulder were dredged to fill the city riverfront. The 6th Street Dam was constructed at its present location in 1849 for water power in the canal around the rapids and to facilitate log flotation over the upstream bedrock shelf. It is presently classified as a grade control structure and maintains

approximately 2.4 m (8 ft) of head. Four low-head dams were constructed downstream of the 6th Street Dam in 1931 as part of a project to provide and maintain dilution water for raw sewage that was being discharged into the river. These dams maintain an average of 0.6 m (2 ft) of head each.

3.1 Habitat

The Grand River offers a wide gradient of aquatic habitat types. Topography within the watershed ranges from flat glacial till in the headwaters, to rolling ground moraine in the upper, middle, and lower segments, to sandy lake plains in the mouth segment. Mainstem river gradient is variable: the highest average gradient is in the headwaters segment (0.8 m/km [4.2 ft/mi]), although much of this gradient is accounted for by a relatively small section of river that steps down over glacial moraine. Upper and middle segment gradients are intermediate at 0.3 m/km (1.7 ft/mi) and 0.6 m/km (3.0 ft/mi), respectively. The lower segment is relatively flat, averaging 0.15 m/km (0.8 ft/mi); however, gradient is significantly higher in the City (1.7 m/km [9 ft/mile]). In particular, the segment of the Grand River between Ann and Fulton Street was formerly rapids dropping approximately 5.5 m (18 ft) over a 3.2 km (2 mile) reach. This high gradient is a result of an elevated bedrock sill composed of Bayport Limestone and Michigan Formation dolostone in the channel bottom through the City of Grand Rapids (Churches and Wampler, 2013). The mouth segment has a very low average gradient at 0.05 m/km (0.3 ft/mi).

Except for the mouth, every mainstem segment of the Grand River is impounded. The headwaters contain five dams, all of which represent barriers to the movement of fish and other aquatic life. Thirteen (13) dams exist on the upper segment, the three largest of which are Federal Energy Regulatory Commission (FERC) licensed hydropower dams. None of the three hydropower dams on the upper segment have fish passage provisions in their FERC licenses. The middle segment is impounded by four registered dams and one remnant dam; all four registered dams on the middle segment provide some form of fish passage. One of these dams, Lyons, was recently removed by USFWS and MDNR to increase connectivity within the river, and Webber Dam in Portland, MI is now the closest upstream dam to the Project (90 km [56 miles] upstream of Grand Rapids). The lower segment of the Grand River is impounded by the dam complex at Grand Rapids (6th Street Dam and smaller low-head dams); while the 6th Street Dam is equipped with a fish ladder, it still represents a barrier to non-potadromous species such as *S. vitreus*, Catostomidae, *A. fulvescens*, and host fish species.

The river channel in the headwaters is characterized as low gradient with moderate sedimentation. Throughout much of the upper segment, the river is low gradient with a wide forested floodplain; large woody material, overhanging vegetation and deep runs are common, with submerged vegetation and pools less common. In the middle segment, the channel widens and becomes less shaded resulting in prominent aquatic vegetation beds; streambed substrates range from coarse sands and gravel to localized bedrock in this section. The lower segment is categorized as a large warm river; however, several smaller cold, cold-transitional, and warm-transitional tributaries discharge to the mainstem, providing a variety of thermal microhabitats. Channel form is diverse in the lower segment, ranging from relatively shallow riffles and runs to deep pools. However, the reach within Grand Rapids is uniform due to channelization, floodwalls, and dams. The mouth offers large river habitat with mostly fine sediments. Sections of the mouth exhibit a braided channel that provides nursery habitat for juvenile *A. fulvescens* and other fish species. Throughout these segments, habitat diversity is likely reduced, as the highest gradient and most hydraulically diverse habitats are inundated by impoundments.

Topography in the lower segment of the Grand River ranges from flat lake plains in the northeast to gently sloping moraines in central portions to moderately steep sloping ridges in the west. The western portion of the lower segment represents the greatest relief in all of the Grand River catchment. Land use is described as 59% agriculture, 20% forest land, 10% rangeland, 7% urban and residential, and approximately 4% wetlands, lakes, and streams. Major tributaries in this section include the Maple, Flat, Thornapple, and Rogue Rivers. With the exception of the Maple River, major tributaries exhibit relatively stable flow patterns; inputs from these tributaries also help to stabilize the mainstem as gauged at Grand Rapids. The Grand River had significant water quality problems prior to the Clean Water Act due to raw sewage input, industrial discharge, and non-point source pollution. However, current water quality is generally good, although an exceedance of the mercury standard was documented in Ionia County and exceedance of pathogen standard was reported from combined sewer effluent in Kent County, although combined sewage overflows have been eliminated within Kent County.

3.2 Aquatic Resources

3.2.1 Unionid Mussels

The Grand River historically supported a diverse unionid assemblage, and at least 32 species have been reported from the Grand River; 14 from the headwaters, 16 from the upper river, 23 from the middle river, and 32 from the lower river (Table 3-1). Many of the anthropogenic changes have affected unionid assemblages in the Grand River: logging, urbanization, and impoundment in the floodplain have changed local hydrological conditions, a reduction of floodplain vegetation has contributed to increased water temperature (lack of shading) and decreased water quality (lack of nutrient filtration), and discharge of sewage into the river undoubtedly had an effect on unionid assemblages, as juvenile unionids are particularly sensitive to unionized ammonia (Augspurger et al., 2003; Wang et al., 2011a; Strayer and Malcom, 2012; Gillis et al., 2017).

The Grand River continues to support a diverse unionid assemblage; although no recent data for the headwaters and upper segments is available, recent surveys from the lower and middle segments account for 27 species (Table 3-2). Twenty-two (22) species have been found between City of Portland and the mouth of the Maple River, including *E. triquetra*, *L. recta*, *T. parvum*, *C. tuberculata*, *P. sintoxia*, *T. truncata*, *V. ellipsiformis*, *Cambarunio* (formerly *Villosa*) *iris* (Rainbow), *A. marginata*, *Lasmigona compressa* (Creek Heelsplitter), *L. costata*, and *U. imbecillis* (Table 3-2). Twenty-seven (27) species have been recently (1999 to present) collected between the Maple River and the M-11 Bridge in Grand Rapids, including *E. triquetra*, *L. recta*, *T. parvum*, *C. tuberculata*, *P. sintoxia*, *P. alatus*, *T. truncata*, *V. ellipsiformis*, *A. marginata*, *A. viridis*, *L. compressa*, *L. costata*, and *U. imbecillis* (Table 3-2). Unionid species that have not been collected from the Grand River since 1950 include *Obliquaria reflexa* (Three-horned Wartyback) and *Obovaria olivaria* (Hickorynut) (Hanshue and Harrington, 2017).

The lower Grand River still supports 26 of the 32 species that historically occurred in the lower river, including the federally endangered *E. triquetra,* as well as an additional 12 species listed as endangered, threatened, species of special concern, or species of greatest conservation need in Michigan (Table 3-1). Although still species rich, many species have declined in abundance (Hanshue and Harrington, 2017). Most of the species that were commercially harvested seem to be less abundant, but non-commercial species also seemed to have declined, perhaps due to temperature, water quality, and habitat changes

(Hanshue and Harrington, 2017). Coker et al. (1919) reported density of approximately 32 unionids/m^2 in the lower Grand River, whereas the highest recent density was reported by Woolnough and Barnett (2013) below Lyons Dam (6.5 unionids/m^2). Downstream of the Maple River, the highest reported density was at Peace Park (4.5 unionids/m^2; Table 2-7). Other sites surveyed between the Maple River and Project Area were investigated as monitoring sites and recipient sites for Project-related monitoring and translocation plans; these sites include Ionia (density of 2.4 unionids/m^2, 16 live species), Saranac (density of 3.4 unionids/m^2, 17 live species), Peace Park (density of 4.5 unionids/m^2, 14 live species), Chief Hazy Cloud (density of 4.0 unionids/m^2, 9 live species), Ada (density of 2.8 unionids/m^2, 12 live species), Site 7 (density of 0.7 unionids/m^2, 3 live species), Riverside Park (density of 1.6 unionids/m^2, 10 live species), Roselle Park (density of 3.4 to 3.6 unionids/m^2, 14 live species), and Upstream (2.2 unionids/m^2, 15 species; Table 2-7). The area between 6th Street Dam and Fulton Street had the second lowest density of sites surveyed in the lower Grand River, 0.3 unionids/m^2, although 20 species were found in recent survey and translocation efforts (Table 2-7). Species that have not been collected from the lower Grand River since 1950 include *Elliptio crassidens* (Elephantear), *O. reflexa*, *O. olivaria*, and *C. iris* (Table 3-1). *Elliptio crassidens* was likely an artifact of the former button industry (S. Hanshue, MDNR, personal communication). Species that have declined in abundance include *Actinonaias ligamentina* (Mucket), *A. marginata*, *Eurynia dilatata* (Spike), and *P. sintoxia* (Goforth et al., 2000). Species that are stable or increasing include *A. plicata*, *E. triquetra*, *L. cardium, C. pustulosa*, *Quadrula quadrula* (Mapleleaf), *T. truncata*, and *Fusconaia flava* (Wabash Pigtoe), as multiple year classes were found for these species in 1999 (Goforth et al., 2000), and recruitment was observed in recent surveys (Table 3-3).

In general, the lower Grand River between Ionia and the Project Area consists of deeper silt/sand pools and shallower sandy runs in wider areas of the river. Velocity increases where the river constricts, resulting in shallower, swifter areas with coarse rocky (cobble, boulder, gravel) substrate. The area between Ann Street and the 6th Street Dam (Upstream) is impounded by the 6th Street dam. Substrate consists of bedrock or sand in many areas, but areas of heterogeneous sand, gravel, and cobble are present (ESI, 2014). The Project Area is currently rather homogeneous with respect to depth, substrate, and flow (Figure 2-1). Downstream of Fulton Street, gradient is less, and substrate becomes sandier, although a few areas with coarser substrate were found (ESI, 2014; ESI, 2018; EcoAnalysts, 2019, 2021). Habitat and unionids observed at recently surveyed sites are summarized below. These sites were sampled with a combination of quantitative, semi-quantitative, and qualitative sampling techniques.

The surveys utilized a combination of semi-quantitative, quantitative, and qualitative survey methods to determine mussel distribution, mussel density, and species composition (Dunn, 2000). Semi-quantitative sampling consisted of searching a given area (either a transect [Upstream] or a delineated cell [Project Area]) visually and tactually. Although a specified area was searched, not all mussels were recovered, as 30 to 60% of mussels can be buried and not visible on the substrate surface (Smith et al., 2001). However, a larger area can be searched in a short time period. Semi-quantitative sampling is preferred for determining mussel distribution, as results yield a relative estimate of unionids if applied consistently (Dunn, 2000). However, quantitative sampling is needed to obtain an accurate estimate of density, species relative abundance, and age distribution (Miller and Payne, 1988). Quantitative sampling consisted of excavating all substrate within a 0.25 m^2 quadrat to a depth of 15 cm (6 in) into a 6-mm (0.25-in) mesh bag. Bag contents were rinsed through a 6-mm (0.25-in) sieve, and mussels were sorted from substrate and debris. Although more accurate, quantitative sampling is labor intensive, and fewer individuals and

species are recovered. Semi-quantitative and quantitative sampling were supplemented with qualitative sampling in areas most likely to contain TES to better estimate species richness and recover TES. Qualitative sampling consisted of collecting as many individuals as practicable in higher density areas for five to 20 minutes. Since the number of species increases logarithmically with the number of individuals collected, qualitative sampling is the best means of finding rare species (Kovalak et al., 1986).

Upstream, Project Area, from 0 to 500 m downstream of Fulton Street, and Riverside Park were sampled in 2013 using quantitative, semi-quantitative, and qualitative techniques (ESI, 2014). Upstream was also quantitatively sampled in 2015, 2016, and 2017, and the Project Area was quantitatively sampled in 2016, 2017, and 2020 (ESI, 2016, 2017; EcoAnalysts, 2018, 2021). Sites between Ada and Grand Rapids (Ionia, Saranac, Flat River, Chief Hazy Cloud, Ada, and Site 7) were qualitatively and quantitatively sampled in 2015 (ESI, 2016). Peace Park and Roselle Park were quantitatively sampled in 2016 (ESI, 2017), and Roselle Park was also quantitatively sampled in 2017 (EcoAnalysts, 2018). Sites near Plaster Creek and the M-11 Bridge downstream of Plaster Creek were qualitatively sampled in 2017 (ESI, 2018) and semi-quantitatively sampled in 2018 and 2020 (EcoAnalysts, 2019, 2021).

Ionia

The Ionia site was along the RDB of the Grand River near Ionia, MI (Figure 3-1), and was approximately 9,400 m^2 (2.3 acres). Substrate was primarily cobble, gravel, and sand, with bedrock and boulder also present. Water depth ranged from 0.3 to 1.5 m (1 to 5 ft); relative current velocity was fast toward the upstream and downstream ends of the site, and moderate elsewhere (Table 3-4).

The Ionia site harbored a moderately dense, species-rich unionid assemblage. A total of 110 unionids of 16 species were collected in qualitative and quantitative samples combined, including *E. triquetra* and several state-listed species (Table 2-7). Catch per unit effort in qualitative samples was 39.8 unionids/hour, and density was 2.4 ± 1.0 unionids/m^2.

Saranac

The Saranac site was along the LDB of the Grand River near Saranac, MI, and encompassed approximately 5,650 m^2 (1.4 acres) upstream of the Saranac Bridge (Figure 3-1). Substrate in most samples was cobble, gravel, and sand, with some boulder present in a few samples in the downstream half of the area. Water depth ranged from 0.2 to 1.5 m (0.5 ft to 5 ft); relative current velocity was fast at the upstream end of the site and moderate to slow elsewhere (Table 3-4).

The Saranac site harbored a moderately dense, species-rich unionid assemblage. A total of 106 unionids of 17 species were collected in qualitative and quantitative samples combined, including *E. triquetra* and several state-listed species (Table 2-7). One additional species was collected as a freshly dead shell. Catch per unit effort in qualitative samples was 31.5 unionids/hour, and density was 3.4 ± 1.1 unionids/m^2.

Flat River

The Flat River site extended approximately 600 m upstream from its confluence with the Grand River, in the east channel and encompassed approximately 12,100 m^2 (3 acres) (Figure 3-1). Gravel was the primary substrate with smaller amounts of cobble and sand. Depth ranged from 0.2 to 0.9 m (0.5 ft to 3 ft), and current velocity was moderate (Table 3-4).

The site supported a dense (6.6 unionids/m^2) species rich (16 species) unionid assemblage. A total of 287 unionids were collected in qualitative and quantitative samples combined (Table 2-7). *Epioblasma triquetra* and several Michigan TES were collected. Catch per hour was 169.7 unionids/hour.

Peace Park

The Peace Park site was along the RDB of the Grand River approximately 4 km (2.5 miles) upstream of the Thornapple River (Figure 3-1) and encompassed approximately 6,750 m^2 (1.7 acres). Substrate in most samples was cobble, gravel, and sand, with silt and clay more prevalent near the bank (Table 3-4). Water depth ranged from 0.6 to 2.8 m (2 to 9 ft); relative current velocity was fast in the upstream portion of the site and declined with distance downstream.

The Peace Park site harbored a higher density, species-rich unionid assemblage. Only quantitative samples were collected, but 77 unionids of 14 live unionid species were recovered. *Epioblasma triquetra* and several state-listed species (*P. sintoxia*, *C. tuberculata*, and *V. ellipsiformis*) were collected. Density averaged 4.5 ± 1.3 unionids/m^2 (Table 2-7).

Chief Hazy Cloud

The Chief Hazy Cloud site was a small area (approximately 1,990 m^2 [0.5 acres]) along the RDB of the Grand River, approximately 2 km (1.2 miles) downstream of the Thornapple River (Figure 3-1). Substrate was primarily cobble with smaller amounts of gravel and sand. Water depth ranged from 0.3 to 0.8 m (1 to 2.5 ft), and relative current velocity was moderate to slow (Table 3-4).

The Chief Hazy Cloud site supported a moderately dense, moderately species rich unionid assemblage. Twenty (20) unionids of nine species were collected in quantitative samples, including *E. triquetra* and Michigan species of special concern *P. sintoxia* and *A. marginata*. One additional species was collected as a freshly dead shell. Density at this site was 4.0 ± 1.7 unionids/m^2 (Table 2-7).

Ada

The Ada site was approximately 3 km (1.9 miles) downstream of the Thornapple River, just upstream of a riffle (Figure 3-1). The bed spanned the left descending two-thirds of the channel, encompassing an area of approximately 23,480 m^2 (5.8 acres) (Figure 2-5). Substrate in the upstream half of the area was primarily gravel, sand, and shell, with more cobble present in the downstream half. Water depth ranged from 0.3 to 1.2 m (1 to 4 ft), and relative current velocity was moderate (Table 3-4).

The Ada site supported a moderately dense and species rich unionid assemblage. Thirty-seven (37) live unionids of 12 species were collected in quantitative samples, including *E. triquetra* and several Michigan listed species (*L. recta, P. sintoxia, A. marginata,* and *V. ellipsiformis*). An additional two species were collected as fresh dead shells, suggesting these species may occur in low abundance. Density in the unionid concentration was 2.8 ± 0.9 unionids/m^2 (Table 2-7).

Roselle Park

The Roselle Park mussel bed was approximately 6 km (3.7 miles) downstream of the Thornapple River (Figure 3-1). The bed spanned most of the river channel and encompassed approximately 44,300 m^2 (10.9

acres). Depths at Roselle Park ranged from 0.3 to 3.4 m (1 to 11 ft), with the greatest depths occurring mid-channel towards the upstream end of the site (Table 3-4). Substrate was a mix of gravel and sand, with boulder and cobble more prevalent along the RDB, and sand more common along the LDB. Relative current velocity was fast to moderate.

The Roselle Park site supported a moderately dense and species rich unionid assemblage. A total 14 species were collected in quantitative samples in 2016 and 2017, including *E. triquetra* and several Michigan listed species (*P. sintoxia*, *C. tuberculata*, *L. recta, V. ellipsiformis*). Three additional species, including Michigan special concern species *A. marginata* and *U. imbecillis*, were collected as fresh shells, indicating they likely reside in the area at a low density. Density in the unionid concentration averaged 3.6 ± 1.0 unionids/m^2 in 2016 and 3.4 ± 0.8 unionids/m^2 in 2017 (Table 2-7).

Site 7

Site 7 was a shallow run, approximately 750 m (0.5 miles) downstream of the Rogue River, covering 6,675 m^2 (1.6 acres) of river along the RDB (Figure 3-1). Substrate was primarily a mix of boulder, cobble, gravel, and sand; water depths ranged from 0.2 to 0.6 m (0.5 to 2 ft), and relative current velocity was moderate to slow (Table 3-4).

Unionid abundance and species richness were low at Site 7. Only four live unionids of three common species were collected in quantitative samples. Five additional species, including *E. triquetra,* were collected as weathered dead shells. Although the individual was outside of the quadrat, one live *E. triquetra* individual was observed during quantitative sampling. This site had the lowest density of all sampled sites at 0.7 ± 0.7 unionids/m^2 (Table 2-7).

Riverside Park

The area surveyed adjacent to Riverside Park was approximately 2.6 km (1.6 miles) upstream of the Project Area with an area of 8,650 m^2 (2.1 acres) (Figure 3-1). Substrate was primarily sand with silt and clay near the bank (Table 3-4). Depth ranged from 0.2 to 0.6 m (0.5 to 2 ft), and current velocity was slow.

Unionid abundance was fairly low, although several species were collected at Riverside Park. A total of 297 unionids of 10 species were collected in qualitative and quantitative samples combined (Table 2-7). Most of these unionids were collected in qualitative samples. Density averaged 1.6 ± 1.2 unionids/m^2 in quantitative samples. No live *E. triquetra* were found; however, a fresh shell was found in a muskrat midden on the bank, suggesting this species occurs at a low density at this site. Michigan TES collected at Riverside Park include *P. sintoxia* and *T. parvum*. A fresh shell of *U. imbecillis* was also found.

Upstream

The Upstream site was between the 6th Street Dam and 1.6 km (1 mile) upstream of the dam. The site was a slow flowing pool due to the backwater effect of the 6th Street Dam. Near the upstream end of the site, substrate was sand over mixed boulder, cobble, and gravel, transitioning to a thin layer of sand over bedrock along the LDB, with a deeper sand, gravel, boulder thalweg along the RDB. Substrate became sandier near the 6th Street Dam. Depths were generally <1.0 m (<3.3 ft) along the LDB upstream of Leonard Street due to the bedrock shelf but exceeded 2.0 m (6.6 ft) in the thalweg upstream of the dam.

Mussels appeared to be more abundant in the upstream most portion of this reach, primarily near the banks, immediately downstream of Leonard Street, and mid-channel between Leonard and 6th Street. Abundance declined approaching 6th Street. Mussel density in the Upstream site averaged 2.1 unionids/m^2 (average of 2013, 2016 and 2017 samples) and 15 species were collected live (Table 2-7). *Amblema plicata* was the most commonly collected species, accounting for 54.3% of individuals collected (Table 2-7). TES were found throughout the Upstream site and comprised an average of 5.3% of live unionids. TES in this reach include *P. sintoxia* (live), *C. tuberculata* (live), *E. triquetra* (live), *L. recta* (live), *A. marginata* (FD), and *U. imbecillis* (FD).

6th Street Dam to Fulton Street

Habitat between the 6th Street Dam and Fulton Street is currently a very rocky, swift armored area with pockets of softer substrate along banks and flow refugia behind boulders (Figure 2-1). Substrate is primarily composed of boulder, cobble, gravel, and sand, with most of the river bottom armored due to high current velocities between the dams and historical removal of boulders to facilitate the passage of flood flows. Depths at most sampling locations were less than 1 m (3 ft), although depths greater than 1 m (3 ft) were commonly encountered along the LDB between the 6th Street Dam and Bridge Street low-head dam (Figure 2-1; Appendix F).

Although too few mussels were present in quantitative samples to determine distribution (Figure 2-2), qualitative searches conducted in 2013 revealed a few areas with mussels within 10 m (30 ft) of the banks and associated with in-stream vegetation (wetlands), as well as within other flow refugia with more permeable substrate (ESI, 2014). Mussel density in quantitative samples averaged 0.6 unionids/m^2 in 2013 (95% CI=0.2 to 1.0 unionids/m^2, although samples were biased toward higher density areas), 0.3 unionids/m^2 (95% CI=0.1 to 0.5 unionids/m^2) in 2016, 0.3 unionids/m^2 (95% CI=0.2 to 0.5 unionids/m^2) in 2017, and 0.3 unionids/m^2 (95% CI=0.2 to 0.5 unionids/m^2) in 2020 (Table 1-2). Density under the I-196 bridge averaged 0.25 unionids/m^2 in 2016 and 2017 (Cardno, 2017). Project Area density was based on average density between the dam and Fulton Street, 0.3 unionids/m^2 (ESI 2016, 2017; EcoAnalysts 2018, 2021; Cardno, 2017; Table 1-2).

A total of 20 live species have recently been collected between the 6th Street dam and Fulton Street (Table 1-2). *Lampsilis cardium* (34.0%) and *A. plicata* (28.4%) were the most commonly collected species (Table 1-2). TES collected in this reach include *P. sintoxia* (live), *C. tuberculata* (live), *E. triquetra* (live), *L. recta* (live), *P. alatus* (live), *T. truncata* (live), *V. ellipsiformis* (live), *A. marginata* (live), *A. viridis* (live), *L. costata* (live), and *U. imbecillis* (FD). Total relative abundance of TES was 14.1%. Approximately 35,778 unionid mussels may occur between the 6th Street Dam and Fulton Street Bridge based on the average density of 0.3 unionids/m^2 (Table 1-2). Approximately 13,634 unionid mussels may occur within this Project's direct impact areas, and 24,647may occur within the Construction Area indirect impact areas (Table 2-1).

Fulton Street to M-11 Bridge

A few areas have been surveyed for mussels between Fulton Street and the M-11 Bridge downstream of Grand Rapids. Gradient is lower than in the Project Area and substrate is primarily loose sand. Unionid mussels seem to be scattered within the sand. Semi-quantitative, quantitative, and qualitative samples were collected 0 to 500 m (1,500 ft) downstream of Fulton Street, but only 12 mussels of six species were found, and density averaged only 0.1 unionids/m^2 (Table 2-7). Recent surveys in potential dredge areas

found 0 to 2 mussels per 5-minute search and 0.9 unionids/5-meter semi-quantitative sample near the mouth of Plaster Creek (ESI, 2018; EcoAnalysts, 2019). Some areas of higher density are present, as density near the bank of the I-196 South Bridge was 0.9 unionids/m^2 (JFNew, 2013d), and *E. triquetra* were found in the relocation for the I-196 bridge (GEI, 2023).

3.2.2 Fish

Little is known about the historical fish assemblages of the Grand River, but fish, particularly *A. fulvescens*, were an important food source for people during both pre-settlement and European settlement times (Hanshue and Harrington, 2017). Like unionids, anthropogenic influence has impacted composition and distribution of the fish assemblage of the Grand River. Effects of point and nonpoint source pollutants, dams, logging, agriculture, and urban development have altered and fragmented habitat necessary for spawning, feeding, and refuge. One hundred eight (108) fish species representing 23 families are currently known in the Grand River watershed, including introduced species and species that seasonally utilize the mainstem and/or tributaries (Hanshue and Harrington, 2017). Contributing to the diversity of the fish assemblage are the various cold, cold-transitional, and warm-transitional tributaries that feed the mainstem; these tributaries create a wide variety of thermal microhabitats that are utilized by various species with different thermal preferences, and the potadromous fish that seasonally migrate upstream are an important recreational fishery.

Species in the headwaters include several Centrarchidae species, and intolerant species such as *Moxostoma* sp., *Etheostoma* sp., and *Percina* sp. (Hanshue and Harrington, 2017). Fish families characteristic of the upper river include Centrarchidae, Cyprinidae, and Catostomidae. Common game fish include *Esox lucius* (Northern Pike), *S. vitreus*, and *Ictalurus punctatus* (Channel Catfish). These species are also common in the middle river, and larger river species such as *Moxostoma anisurum* (Silver Redhorse), *Carpiodes cyprinus* (Quillback) and *Pylodictis olivaris* (Flathead Catfish) also inhabit the middle river segment. The middle river is the upstream boundary for *Oncorynchus tshawytscha* (Chinook), *Oncorynchus kisutch* (Coho), and *O. mykiss*, recreationally important species in the Grand River. These species pass the 6th Street Dam via the fish ladder on the RDB. The lower river supports a diverse assemblage of Catostomidae, Cyprinidae, and Centrarchidae and good populations of game fish (*I. punctatus*, *P. olivaris*, *M. salmoides*, *M. dolomieu*, and *S. vitreus*). Most of these fish species also serve as hosts for freshwater mussels (Table 1-3). Seasonal migration of potadromous fish from Lake Michigan adds *Coregonus clupeaformis* (Lake Whitefish), *Prosopium cylindraceum* (Round Whitefish), *Salvelinus namaycush* (Lake Trout), *Catostomus catostomus* (Longnose Sucker), *A. fulvescens*, *Salmo trutta* (Brown Trout), *O. mykiss*, *O. tshawytscha*, and *O. kisutch* (Hanshue and Harrington, 2017). Michigan TES fish that occur within the watershed and are incorporated into this BA include the Michigan threatened *A. fulvescens* that occurs downstream of the 6th Street Dam and *M. carinatum* that occurs throughout the lower river and is known to spawn in the Project Area and near Plaster Creek (S. Hanshue, MDNR, pers. comm.).

Seventy-three (73) fish species occur in the lower Grand River, including two Michigan threatened species, *A. fulvescens* and *M. carinatum* (Table 1-3). The range of *M. carinatum* extends throughout the lower Grand River and into the Maple River; however, *A. fulvescens* is only known to occur downstream of 6th Street Dam. Five species that are primarily found in smaller streams are restricted to upstream of the dam; 11 species that are primarily big river/Great Lakes/invasive species are restricted to downstream of

the dam (Table 1-3). Forty-five (45) of the 73 species in the lower Grand River serve as fish hosts for at least one of the unionid species that occurs in the Project Area (Table 1-3). The lower Grand River is also very important as a recreational fishery. Game fish such as *S. vitreus* and *M. dolomieu* are abundant, and the *O. tshawytscha* and *O. kisutch* run in the Fall and *O. mykiss* run in the Spring and Fall are important to regional recreation.

The historic rapids that occurred within the Project Area provided important spawning habitat for *A. fulvescens*, *C. clupeaformis*, and *S. namaycush* (Hanshue and Harrington, 2017). Alterations to the Project Area's physical habitat and water quality dramatically altered the historic fish community. Currently, fish passage and movement within the Project Area is limited by the low-head dams and fish migration is limited by the 6th Street Dam. Riffle habitat is lacking, and deeper pools are limited (Table 2-5; Appendix F). *Acipenser fulvescens* are restricted to downstream of the 6th Street Dam. However, the Project Area does provide an important recreational fishery for *S. vitreus*, Catostomidae, *P. olivaris*, *I. punctatus*, and *M. dolomieu* and *M. carinatum* use the area for spawning. The area is also heavily fished during the Winter and Spring *S. vitreus,* and *O. mykiss* run and Fall *O. tshawytscha*, *O. kisutch*, and *O. mykiss* run. A recent fish survey (M. Holtgren, Encompass, pers. comm.) conducted between Dam 4 and Plaster Creek found 55 fish species. Species included several Cyprinidae, Catostomidae, Ictaluridae, *Lepomis* sp., *Micropterus* sp., *Etheostoma* sp., and *Percina* sp. (Table 1-3). Most of the species requiring cover and/or flow were found downstream of low-head dams in the recent survey.

3.3 Invasive Species

Invasive species can negatively impact aquatic ecosystems through dramatic modifications to food webs, alterations of biogeochemical cycles, and declines in native biodiversity. Invasive species are of particular concern in the context of the Project, as the existing 6th Street Dam represents a barrier to the upstream passage of certain invasive species. Invasive species of concern to the Project Area include *Neogobius melanostomus* (Round Goby), *P. marinus*, and *Dreissena polymorpha* (Zebra Mussel). Although *Dreissena rostriformis bugensis* (Quagga Mussel) occurs in Lake Michigan near the mouth of the Grand River, they have not been reported in the Grand River (USGS nonindigenous aquatic species website, accessed February 20, 2024; https://nas.er.usgs.gov/viewer/omap.aspx).

Neogobius melanostomus is a small, bottom-dwelling goby native to central Eurasia. In Michigan, *N. melanostomus* was reported from the Shiawassee, Flint, Saginaw, and Thunder Bay Rivers (Lake Huron drainage) and the River Raisin (Lake Erie drainage). It was also reported from lower Lake Michigan and the Chicago Sanitary and Shipping Canal (Fuller et al., 2016a). Grand River records include from its mouth to the 6th Street Dam to upstream of the I-96 bridge (USGS nonindigenous aquatic species database). It was recently 7% of the fish collected between 2018 and 2022 downstream of Dam 4, and was more abundant then *P. caprodes* (4.4%) (M. Holtgren, Encompass, pers. comm.). They were also reported in Indian Mill Creek (Grand Valley State University, 2017; W. Ogilvie, GVMC, personal communication).

Neogobius melanostomus may impact native fishes by eating the eggs and fry of other bottom-dwelling fish such as Cottoidea (Sculpins), *Percina* sp., and *Etheostoma* sp. (Fuller et al., 2016a); this in turn impacts native unionid assemblages, as many native bottom-dwelling species serve as host fish for unionids. They also prey on *A. fulvescens* eggs (Hay-Chmielewski and Whelan, 1997). *Neogobius melanostomus* may also pose a threat to nest-guarding fish such as *M. dolomieu* (Steinhart et al., 2004). *Neogobius melanostomus*

may compete with native fish for food, though studies have yielded variable results. French and Jude (2001) suggested *N. melanostomus* may compete with benthic fish for invertebrate prey; however, Burkett and Jude (2015) found that there was little diet overlap between *N. melanostomus* and most small benthic fish (*in* Fuller et al., 2016a).

Petromyzon marinus is an endemic parasite to the Atlantic Ocean and its tributaries. This species is primarily marine, but spawns in freshwater rivers (Fuller et al., 2016b). Adult *P. marinus* affix to prey fish and feed on their body fluids and tissues; this parasitism often results in death of the host fish (Phillips et al., 1982 *in* Fuller et al., 2016b). *Petromyzon marinus* are implicated in the decline of fisheries in the Great Lakes (Coble et al., 1990; Fuller et al., 2016b), and may also cause mortality in freshwater fish found in tributaries. The 6th Street Dam represents a barrier to *P. marinus* at low flows, and *P. marinus* occurrence in the mainstem is restricted to the stretch of river downstream of the dam. No *P. marinus* were collected in recent fish surveys (M. Holtgren, Encompass, pers. comm.). However, larval *P. marinus* were reported from Grand River tributaries upstream of Grand Rapids: Lowell Creek in 1965 and Rogue River in 2008 and 2022, and in Prairie Creek in 2022 (Barber and Steeves, 2023; Hrodey et al, 2022). Rogue River was treated with lampricide in 2009 (Sullivan and Adair, 2009). Larval lamprey were found in the Rogue River in 2022, and the area is expected to be treated with lampricide (Barber and Steeves, 2023). The source of these escapement events is unknown (Barber and Steeves, 2023). However in 2006, the stop logs in the fish ladder stop log with lip were reconfigured to increase the drop for a more effective barrier (Barber and Steeves, 2023). Several years after 2006, the steel lip at the top of the *P. marinus* barrier came loose and was replaced (Barber and Steeves, 2023). However, the loss of vertical drop needed for a *P. marinus* barrier in the fish ladder still occurs at a lower river stage height than the main spillway (Barber and Steeves, 2023). The 2022 larvae in Rogue River and Prairie Creek could have occurred in 2020 during a high discharge event (30,000 CFS in May 2020; Hrodey et al., 2022).

A two-year evaluation of larval and juvenile sea lamprey production potential was conducted in 2014 and 2015 to evaluate the production potential upstream of the 6th Street Dam (GLFC, 2015). The survey focused on finding native lamprey, which occupy the same habitat as *P. marinus*. Native lamprey were found in 463 km (287 mi) of the Grand River watershed upstream of the 6th Street Dam. Within that area there is approximately 2,957,701 m^2 (730 acres) of Type I habitat (preferred mix of sand and fine organic matter) and 6,396,646 m^2 (1,580 acres) of Type II habitat (acceptable shifting sand with no fine organic matter). Areas with Type I and II habitat include Bear Creek, Bellamy Creek, Crooked Creek, Fish Creek, Grand River, Honey Creek, Libhart Creek, Lowell Creek, and Maple River (Table 3-5). If *P. marinus* managed to successfully pass the 6th Street Dam, 3,058 km (1,900 miles) of the Grand River and tributaries could potentially be affected, and the Grand River could become one of the most productive *P. marinus* tributaries to Lake Michigan (GLFC, 2018).

Adult *P. marinus* do not feed during migration. They spawn in gravel substrates, which could harbor unionid mussels. Larval lamprey prefer sandy areas with organic matter, which are not preferred habitat for most mussel species. Once larvae metamorphose, they swim (although weakly) to Lake Michigan, where they feed. They typically do not feed in the Grand River. Although both *P. marinus* and unionids are filter feeders, since they do not occupy the same habitat, competition is unlikely.

Treating for *P. marinus* with lampricides could affect host fish and therefore be detrimental to unionid mussels. Although 3-trifluoromethyl-4-nitrophenol (TFM) and TFM/1% nicloamide (lampricides) do not appear to be lethal to most unionid mussel species, TFM/1% nicloamide can lead to narcosis in unionid mussels, which could increase vulnerability to predation and displacement by high water events (Boogaard et al., 2004). Bayluscide (nicloamide) exposure at current application levels can have lethal and sublethal effects to some unionid mussel species (Newton et al., 2017), and TFM can cause mortality to *P. caprodes*, a host fish for *E. triquetra*, and may affect other host fish species (Ictaluridae) at high concentrations (Boogaard et al., 2003 and 2015). In streams with unionid mussels, Bayluscide is not recommended (Boogaard and Riveria, 2011), and limiting TFM to 1.3x mean lethal concentration (MLC) is recommended to prevent mortality to *P. caprodes* in streams with *E. triquetra* (USFWS, 2013). However, a few other freshwater mussels have been tested (*Pyganodon grandis* [Floater], *Potamilus (formerly Leptodea) fragilis* [Fragile Papershell], and *V. ellipsiformis*) that are more sensitive to TFM than *E. triquetra* (Boogaard et al., 2004; Boogaard et al., 2015).

Although neither adult nor larval *P. marinus* appear to compete with unionid mussels, stream reaches where larvae are found would need to be treated with lampricides every three to four years. Treatment in tributaries generally involves applying lampricides from upstream of known *P. marinus* larvae to the confluence of the Grand River with 1.5x the mean lethal concentration (MLC) for 12 hours. If larvae were found in the Grand River proper, treatment would extend from upstream of the larval habitat to the nearest barrier, the 6th Street Dam. However, most of the Grand River downstream of Fulton Street has a sand substrate that could be used by *P. marinus*, but *P. marinus* larvae have not been reported in the Grand River proper (Sullivan and Mullett, 2018).

Dreissena polymorpha is native to the Baltic Sea and was introduced to the Great Lakes through the discharge of ballast water from ocean-going cargo ships. *Dreissena polymorpha* has rapidly colonized the Great Lakes, inland lakes, and rivers, and has caused significant ecological and economic harm to the region (Pimentel et al., 2000). *Dreissena polymorpha* is found in the lower Grand River near the mouth and in the bayous. Dispersal through human activities, such as the discharge of bilge or live-well waters containing veligers, has likely hastened the spread of *D. polymorpha* throughout the basin; the Flat River and lower Thornapple River, as well as many inland lakes within the basin, have also been invaded. *Dreissena polymorpha* impact ecosystems by reducing the biomass of phytoplankton significantly following invasion (Benson and Raikow, 2010). Survival rates of native unionid mussels have been shown to decline significantly with the increase in *D. polymorpha* colonization (Hart et al., 2001a, 2001b).

Dreissena polymorpha are known to occur throughout the lower Grand River at a low abundance (Badra, 2010). Woolnough (2015) reported *D. polymorpha* only as weathered shells below Lyons Dam. Live *D. polymorpha* were found at all sites sampled from Ionia though the Project Area; however, at the time these sites were surveyed, infestation of native unionids was low (only a few unionids had attached *D. polymorpha*) and only a few large *D. polymorpha* (<10 per individual) were attached to native individuals (ESI, 2014, 2016, 2017a, 2018; EcoAnalysts, 2018, 2021). Flow regimes of the mainstem may prevent *D. polymorpha* from becoming more established, as all dams on the mainstem are operated as run of the river dams and the variable flow that exists in this system is not conducive to *D. polymorpha* colonization. However, recreational boating may represent a constant input of more *D. polymorpha* into the river.

3.4 Climate Change

Climate change could affect habitat and aquatic resources in the Grand River. By altering the hydrological cycle, climate change alters water temperatures, precipitation, streamflow patterns, water quality, and sediment loads (Jimenez Cisneros et al., 2014), thereby changing in-stream habitat over time. Future predictions of climate change vary according to the multitude of prediction models used; however, commonalities between models include: a shift in Winter precipitation from snow to rain (Jyrkama and Sykes, 2007; Stewart, 2009; Christensen et al., 2004), earlier snowmelt (Stewart, 2009; Kunkel and Pierce, 2010), an increase in overall precipitation (Angel and Kunkel, 2010; NOAA Technical Report NESDIS 142-3, 2013; Stewart, 2009; 3rd US national climate assessment, 2014), and warmer water temperatures (Jyrkama and Sykes, 2007; Angel and Kunkel, 2010; Kunkel and Pierce, 2010; NOAA Technical Report NESDIS 142-3, 2013). Changes in streamflow, water quality, and temperature could alter mussel distribution and composition over time. These changes could lead to reductions in overall abundance, and/or may cause assemblages to shift toward species that are more tolerant of fluctuating streamflow, reduced water quality, and/or increased temperature.

Average annual precipitation is expected to increase over time, and in some regions, precipitation may trend toward less frequent but more intense rainfall (USFWS, 2014), with a resulting increase in frequency of high and low discharge levels. Increases in precipitation may increase river flows, changing patterns of sediment scour and deposition. Substrate composition may trend toward coarser constituents as more fines are removed by higher flows. Lower flows during droughts may result in more sediment deposition and/or drying out of channel margins. High and low discharge magnitude and frequency, and resulting local hydraulic changes, seem to be closely associated with the presence/absence of freshwater mussels (Morales et al., 2006a and 2006b; Young, 2006; Steuer et al., 2008; Zigler et al., 2008 and 2010). Since unionid habitat appears to be closely tied to hydraulic variables such as shear stress, alterations in streamflow that alter hydraulic variables could change mussel habitat conditions and therefore mussel distribution and species composition (Goodding et al., 2019).

Precipitation increases may also affect water quality and/or sediment loading in rivers. Greater runoff may carry more pollutants from urban areas and nutrients from the soil into the water, reducing water quality. Increased runoff may also increase soil erosion, leading to higher sediment loads that could alter both substrate composition (via increased deposition of sediment) and water quality. Since the Grand River within Grand Rapids is constricted within floodwalls and most of the floodplain is paved, increased sedimentation should be minimal, but increased urban runoff could affect water quality. Unionids as a group are particularly sensitive to contaminants such as ammonia (Augspurger et al., 2003; Wang et al., 2011a; Strayer and Malcom, 2012; Gillis et al., 2017) and heavy metals (Wang et al., 2010, 2011b). Decreased water quality has been implicated in the decline of unionids throughout the country, although additional research is needed to relate laboratory studies and field conditions (Cope et al., 2008).

Changes in habitat due to altered precipitation patterns are driven by slowly rising temperatures. Additionally, the Grand River has snow melt dominated peak flows concentrated around March 15. Climate change may shift the peak flows to be more dominated by rainfall events and have a corresponding shift in water temperature. Increasing water temperatures themselves may affect unionids by influencing factors such as growth, burrowing behavior, byssus production, metabolic rates, and

reproductive success (Hastie et al., 2003; Pandolfo et al., 2009; Archambault et al., 2014; Ganser et al., 2015).

Additionally, temperature may affect some species more than others. Spooner and Vaughn (2008) identified two distinct groups of unionids in their investigations of clearance rates and nutrient excretion at different temperatures. Thermally tolerant species (*A. plicata*, *F. flava*, *Megalonaias nervosa* [Washboard], and *O. reflexa*) had increased clearance rates and were still able to assimilate energy at 35° C (95° F). In contrast, thermally sensitive species (*A. ligamentina*, *L. cardium*, *T. truncata*, and *C. pustulosa*) decreased clearance and depleted their energetic stores at 35°C (95° F). Mortality of three of the four thermally sensitive species was observed at 37-38° C (98.6-100.4° F) (Spooner and Vaughn, 2008).

Rising water temperature associated with climate change could result in a shift in species composition to more thermally tolerant species. All four of the thermally sensitive and two of the thermally tolerant species tested by Spooner and Vaughn (2008) occur in the Project Area (Table 1-2). Thermally tolerant and sensitive species comprise 33.1% and 42.7% of the unionids in the Project Area (Table 1-2). However, increased water temperature is unlikely to cause mortality of the species found in the Grand River. Water temperature rarely exceeds 25° C (77° F) in the Grand River within the Project Area. Lethal effects were not observed for thermally sensitive species in Oklahoma until 37 to 38° C (98.6-100.4° F) (Spooner and Vaughn, 2008), which would require a temperature increase of more than 10° C (18° F) in the Project Area.

Two climate change scenarios were recently evaluated for effects to *E. triquetra* (USFWS, 2022). Risks were based on predicted changes in hydrological regime, landscape alteration, habitat degradation, contaminants, connectivity, and invasive species. Scenario 1 is under high carbon emissions and increasing population growth. Scenario 2 is under medium to low carbon emissions, with population increase, then decline, and the introduction of clean and resource-efficient technology (see USFWS, 2022 for details). Currently, the Grand River *E. triquetra* population is considered to be in a high demographic condition (> 75 individuals, more than 30 river miles, with juveniles <5 years old observed in the past 5 years), but with a moderate risk due to contaminants, landscape alterations, connectivity, and invasive species. Under both scenarios demographic conditions are expected to decline; to low levels under scenario 1 and moderate conditions under scenario 2. Under both scenarios, contaminants (ammonia, chloride, copper, nitrate, and metals) are expected to increase but remain in the moderate range. Landscape changes (urbanization) are expected to increase into the high risk range in Scenario 2.

Alterations in temperature and flow patterns caused by climate change would similarly impact fish species in the Grand River. Climate change would primarily impact the timing of key behaviors (migrations, spawning; Lynch et al., 2016), but may also influence spatial distributions and habitat use/availability. Unionid mussels are dependent on host fish to complete their life cycle, and host fish distribution is an important factor in unionid distribution (Schwalb et al, 2013). However, many mussel species are more thermally tolerant than their fish hosts (Pandolfo et al., 2012), and increasing water temperature may prevent the interaction of mussels with their hosts. Many mussels may be more susceptible to flow alterations than fish (Spooner et al., 2011), which may also influence the presence of host fish at the time of glochidia release. The obligate interaction of mussels and their fish host compounds the effects of climate change on unionid mussels (Pandolfo et al., 2012).

Variation in hydrologic conditions plays an important role in the life cycle of many aquatic species (Poff and Ward 1989; Richter et al., 1996). Seasonal high flows trigger many fish species to migrate to upstream spawning areas. Increases in frequency of high and low discharge levels acts to destabilize streamflow patterns, likely reducing the reproductive success (Starrett, 1951; Coon, 1987; Strange et al., 1992; Bovee et al., 1994; Nuhfer et al., 1994), as well as growth and survival (Coon, 1987; Seelbach, 1986) of many fish species. Additionally, nearly all fish species occurring in the Grand River require a specific range of temperatures at which successful spawning can occur. The expected increase in water temperature may further impede reproductive success by altering the timing of the spawn or shortening the length of time water temperatures are within acceptable spawning ranges.

Further impeding reproductive success is the increased sediment scour and/or sediment loading resulting from increased precipitation. Shifts in bedload components have the potential to alter spawning habitat for many fish species, particularly lithophilous spawners that require clean gravel substrate. While the urban landscape that surrounds the Grand River Project Area is less likely to be impacted by sediment loads, agricultural areas outside of the City of Grand Rapids may experience localized sediment scour/loading.

In addition to disrupting spawning habitat and timing, climate change may decrease the present distribution of certain species based on thermal suitability. Increases in water temperature are expected to impact thermally sensitive fish species most dramatically. The lower Grand River mainstem and tributaries are currently home to 10 species of fish considered cold water preferential (Hanshue and Harrington, 2017; Table 1-2). As water temperatures increase, the thermal microhabitats created from inputs of cold, cold-transitional, and warm-transitional tributaries would likely decrease in size and suitability to these species.

Climate change is expected to impact the state threatened *A. fulvescens* and *M. carinatum* primarily by altering the timing of spawning events. Both threatened species use temperature cues to initiate spawning behavior, with *M. carinatum* spawning when temperatures reach 18-24° C (64-75° F) (Mongeau et al., 1992; Jenkins and Burkhead, 1993) and *A. fulvescens* spawning at temperatures between 9-20° C (48-68° F) (Scott and Crossman, 1973; Ecclestone, 2011). With water temperatures expected to warm earlier in the Spring, spawning events of these species may occur earlier in the year. *Moxostoma carinatum*, which inhabit the entirety of the lower Grand River, may also be influenced by habitat alterations in parts of its range: this species generally occurs in rivers with moderate to swift current and clean, rocky substrates needed for spawning (Scott and Crossman, 1973; Becker 1983; Etnier and Starnes, 1993; Pflieger, 1997; Reid, 2002; Reid, 2003), and increased sediment loading/scour may impact spawning habitat in portions of the lower Grand River.

Climate change may indirectly impact the native fish and mussel assemblages of the Grand River by increasing the probability of *P. marinus* breaching the 6th Street Dam. Warmer Winter temperatures in the Great Lakes are expected to favor expansion of *P. marinus* (Rahel et al., 2008). With warmer temperatures, and potentially longer feeding seasons, *P. marinus* should experience increased growth, resulting in larger lampreys, increased mortality on fish, and increased lamprey fecundity (Hansen et al., 2016). Increased flood events, another consequence of climate change, may benefit *P. marinus* by reducing the effectiveness of low-head barriers that currently impede upstream spawning migrations (Hansen et al., 2016). Under its current configuration, *P. marinus* is most likely to breach the 6th Street

Dam during high flows, which typically occur between March and April when water temperatures are below 10° C (50° F). The swimming performance of *P. marinus* is relatively poor at water temperatures below 10° C (50° F), thus minimizing the likelihood of a high-water breach. However, *P. marinus* swimming performance is dramatically improved at temperatures above 15° C (59° F). Given the expected increase in water temperatures caused by climate change, high water events would be more likely to occur at warmer temperatures; if high water events occur at temperatures optimal for *P. marinus* swimming performance, *P. marinus* would be more likely to pass the 6th Street Dam.

Literature suggests that invasive species would persist, and current ranges may expand under the predicted warmer conditions. With an upper-end thermal tolerance of 33.4° C (92.1° F), *N. melanostomus* is well suited to warmer waters (Kornis and Vander Zanden, 2010). Increased water temperatures would allow the *N. melanostomus* geographic range to shift northwards (i.e., Lake Superior and tributaries) and should benefit it throughout much of its invasive range, as temperatures would approach energetically optimal temperatures. Increased water temperatures may lead to faster growth rates, thereby enhancing its ability to directly compete with native species through resource competition, spawning interference, and displacement (Rahel et al., 2008).

The invasive *D. polymorpha* may also expand in range as colder climates gradually become warmer; however, *D. polymorpha* has a relatively low upper-end thermal tolerance (30° C [86° F]) and increases in temperature beyond this point could result in *D. polymorpha* die-offs (Rahel et al., 2008). Extended periods of high temperature are linked to declines in *D. polymorpha* density; temperature increases that result in mass die-offs can have severe ecological implications, creating a pulse of nutrients into a system and reversing previous large effects on chlorophyll concentrations and water transparency (White et al., 2015). While some studies point out the thermal tolerances of *D. polymorpha* may be range-limiting (Rahel et al., 2008; White et al., 2015), others suggest the adaptability of this organism may enhance its ability to exploit warmer climates (Gallardo et al., 2013). *Dreissena polymorpha* is known to occupy significantly different ecological niches in the Pont-Caspian region, Europe, and North America, providing evidence of its ability to repeatedly adapt to new environmental conditions. Environmental niche models, which include climate models, predict that a progressive spatial temporal stretching of the environmental tolerance limits would lead to continued range expansion of this species (Gallardo et al., 2013).

4.0 SPECIES CONSIDERED

Federal Threatened and Endangered species that could potentially occur in both Project Areas include:

- *Epioblasma triquetra* (Snuffbox Mussel).

Michigan TES that could occur in the Project Area include:

- *Ligumia recta* (Black Sandshell);
- *Toxolasma parvum* (Lilliput);
- *Cyclonaias tuberculata* (Purple Wartyback);
- *Alasmidonta viridis* (Slippershell);
- *Acipenser fulvescens* (Lake Sturgeon);
- *Moxostoma carinatum* (River Redhorse);
- *Pleurobema sintoxia* (Round Pigtoe);
- *Potamilus alatus* (Pink Heelsplitter);
- *Truncilla truncata* (Deertoe);
- *Venustaconcha ellipsiformis* (Ellipse);
- *Cambarunio (Villosa) iris* (Rainbow);
- *Alasmidonta marginata* (Elktoe);
- *Lasmigona compressa* (Creek Heelsplitter);
- *Lasmigona costata* (Fluted Shell); and
- *Utterbackia imbecillis* (Paper Pondshell).

4.1 Federally Endangered Species

Epioblasma triquetra (Snuffbox Mussel)

Epioblasma triquetra was federally listed as an endangered species on February 14, 2012 (77 FR 8632). *Epioblasma triquetra* is a small to medium-sized mussel, with males reaching lengths up to 7 cm (2.8 in) and females reaching only 4.5 cm (1.8 in; USFWS, 2012). The shell is triangular (males) to ovate or oblong (females) with solid thick and inflated valves (Cummings and Mayer, 1992). The anterior part of the shell is rounded, and the posterior end is truncated in males, but expanded in females (WIDNR, 2015). The obvious posterior ridge is high and rounded, and the slope is wide and flat. The posterior ridge in females is covered with small ridges and grooves, and the posterioventral edge of the shell is finely toothed (Cummings and Mayer, 1992). The beak sculpture consists of three or four faint double looped bars. The periostracum is typically yellowish, becoming darker with age, and is marked with dark green rays, blotches, or chevron-shaped markings (Carman and Goforth, 2000; USFWS, 2012). The inside of the shell is white, becoming iridescent posteriorly, with a gray-blue tinge in the beak cavity. The unique shell shape, coloration, and high degree of inflation distinguish *E. triquetra* from other mussel species.

Female *E. triquetra* are bradytictic (long-term brooders), and the brooding period is between September and May (Parmalee and Bogan, 1998). *Epioblasma* spp. are unique in that they "capture" their hosts. Hosts are attracted by a brightly colored mantle in the gaping shell. When a fish investigates, the female snaps her valves shut, trapping the host's head and expelling glochidia while holding the host captive (Barnhart et al., 2008). Recent investigations into the life history of *E. triquetra* indicate that several darter and sculpin species can successfully serve as hosts. Juveniles have been successfully reared from *P. caprodes*, *Percina maculata* (Blackside Darter), *Etheostoma caeruleum* (Rainbow Darter), *Etheostoma exile* (Iowa Darter), *Fundulus olivaceus* (Blackspotted Topminnow), *Cottus bairdi* (Mottled Sculpin), *Cottus carolinae*

(Banded Sculpin), *Cottus hypselurus* (Ozark Sculpin), *Micropterus salmoides* (Largemouth Bass), and *Culaea inconstans* (Brook Stickleback) (Sherman, 1993; Yeager and Saylor, 1995; Barnhart et al., 1998; Hove and Kapuscinski, 1998; Hillegass and Hove, 1997). Of these identified hosts, only four have been collected in the lower Grand River: *P. caprodes*, *P. maculata*, *E. caeruleum*, and *M. salmoides*; all have been observed in Grand Rapids (Table 1-3). *Percina caprodes* appears to be the primary host (USFWS, 2023).

Percina caprodes adults prefer relatively shallow, swift riffles or raceways with gravel substrate, which corresponds with habitat where *E. triquetra* often occurs, but are also common in lakes and impoundments. Adults (spawning and non-spawning) seem to prefer depths <1 m (<3.3 ft) and current velocity near 1 m/sec (3.3 ft/sec) over substrates of sand, gravel, and cobble, whereas young of the year prefer slightly shallower, slower waters over similar substrate (Becker, 1983; Luttrell et al., 1994; Aadland and Kuitunen, 2006). In Winter, adult *P. caprodes* tend to use deeper water. In Wisconsin, *P. caprodes* begin spawning in April, with the spawning season extending into June or July (Becker, 1983).

Percina caprodes have been observed throughout the Project Area, although their preferred habitat is limited. Although preferred habitat for this species has been reported as faster flowing deeper areas, *P. caprodes* was incidentally collected in a slower flowing area adjacent to a wetland during a 2013 mussel survey in the Project Area. It was also collected downstream of low-head dams in 2018-2022. Although some gravel substrate is present, substrate consists primarily of armored/compacted cobble and boulder (Figure 2-1). Softer substrate, slower flowing areas occur near the banks where in-stream or near stream vegetation is present. *Percina caprodes* represented 4.4% of the fish recently collected (2018 to 2022) in the Lower Grand River. They appear to be recruiting, as age 0 to 3 were collected in 2018 and 2022, 1 to 3 in 2020 and 2021 (M. Holtgren, Encompass, personal communication).

Epioblasma triquetra typically occur in small- to medium-sized streams and rivers in the higher flow of riffles and shoals (Cummings and Mayer, 1992; Parmalee and Bogan, 1998). *Epioblasma triquetra* are often deeply buried in the substrate, except during spawning periods (Parmalee and Bogan, 1998). They have been observed more frequently with gravel substrate in the Grand River (Woolnough, 2015).

Epioblasma triquetra range includes most of the Mississippi, Ohio, and Great Lakes Drainages. Although *E. triquetra* was historically known from 211 streams and lakes in 18 states and Canada, the current distribution has been reduced to only 83 streams and lakes in 14 states (Alabama, Arkansas, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Wisconsin) and Ontario, Canada (USFWS, 2022). Of these 83 streams, only eight are considered to harbor stronghold populations (sizable population and generally distributed over a more or less contiguous length of stream of 48 river km [30 miles]): Wolf River (Wisconsin), Bourbeuse River (Missouri), Clinch River (Tennessee and Virginia), Paint Rock River (Alabama), French Creek (Pennsylvania), AuSable River (Ontario), and Sydenham River (Ontario) (USFWS, 2012).

The recent status assessment analyzed stream segments by HUC 8 units (USFWS, 2022). *Epioblasma triquetra* is currently known from 55 HUC 8 units. Only six, Lower Grand River (Michigan), Wolf River (Wisconsin), French Creek (Pennsylvania/New York), Lower St. Croix River (Wisconsin/Minnesota), Bourbuese River (Missouri), and Spring River (Arkansas) are considered to be in high demographic

condition (> 75 individuals, more than 30 river miles, with juveniles <5 years old observed in the past 5 years). Both the Lower Grand, Wolf River, and French Creek are considered at moderate risk, while Lower St. Croix, Bourbeuse, and Spring River are considered high risk (USFWS, 2022).

In Michigan, *E. triquetra* is primarily found in rivers in the eastern and southeastern portions of the state, but also occurs in some western counties such as Kent County. Records of *E. triquetra* exist for the following Michigan counties: Berrien, Gratiot, Huron, Ionia, Kent, Livingston, Macomb, Midland, Monroe, Newaygo, Oakland, Saginaw, St. Clair, St. Joseph, Tuscola, Washtenaw, and Wayne (MNFI, 2018), and live individuals were recently reported in Clinton County (D. Woolnough, Central Michigan University, pers. comm.). *Epioblasma triquetra* were historically known to occur in southeastern rivers in the Lake Erie drainage, northeastern rivers draining into Saginaw Bay (Lake Huron), and the Grand, Muskegon, and St. Joseph Rivers in the Lake Michigan drainage to the west (Mulcrone, 2006a). It is still extant in southeastern rivers of the Lake Erie drainage and in the Grand River drainage (Mulcrone, 2006a). A shell (somewhat fresh) was recently found in the Muskegon River, and they may still be extant (P. Badra, MNFI, pers. comm.). Eight of the 10 Michigan populations are considered significant populations (small, generally restricted to shorter river reaches, with limited recruitment): Grand River, Flat River, Belle River, Clinton River, Huron River, Davis Creek, South Ore Creek, and Portage River (USFWS, 2012). The Lower Grand was considered to be in high demographic condition and at moderate risk (USFWS, 2022). However, this population is predicted to decline under further climate change scenarios (see Section 3.4).

In the Grand River, *E. triquetra* occurs in the middle (Red Cedar River to Maple River) and lower (Maple River to Grand Rapids, MI) sections of the Grand River proper and its tributaries (Table 3-1), with the downstream limit near Fulton Street in Grand Rapids (Hanshue and Harrington, 2017). Neither Coker et al. (1919) or van der Schalie (1948) reported it in the Grand River, although these studies focused primarily on commercial size species. Goforth et al. (2000) found several individuals in the Grand River in the same area surveyed by van der Schalie (Maple River to Grand Rapids), including young individuals. It could have been missed by van der Schalie (1948), as he used a crowfoot bar for collecting, whereas Goforth et al. (2000) hand collected while diving. Since this species is small and tends to bury in the substrate, it could have been missed in previous surveys. It has recently (2013 to present) been collected from near Lyons, MI to Fulton Street in Grand Rapids (Table 3-2), with recruitment reported in several areas (Table 3-3). Since this reach is nearly 85 river km (53 miles), it should be considered a stronghold population.

Epioblasma triquetra occurs throughout the lower Grand River (Table 2-7; Figure 4-1). Within this reach, *E. triquetra* was primarily in areas with cobble, gravel, sand substrate with moderately high current velocity, and was absent from areas with primarily silt and/or sand substrate and swifter riffles with compact boulder/cobble substrate (ESI, 2014, 2016, 2017a; EcoAnalysts, 2018). A very abundant population occurs near Lyons Dam, where it comprised 18.3 and 16.7% of the assemblage in two of the sampled areas (Woolnough and Barnett, 2013). Areas with higher abundance of *E. triquetra* consistently contained more gravel than areas where they were not collected (Woolnough and Barnett, 2013; Woolnough, 2015). A large population also occurs in the Flat River, in the left descending channel between the dam and the confluence with the Grand River (ESI, 2016).

Sites where *E. triquetra* was recently collected alive include Ionia, Saranac, Flat River, Peace Park, Chief Hazy Cloud, Ada, Roselle Park, Upstream, the Project Area, and at the I-196 south bridge (Table 2-7, Figure

4-1). A fresh shell was also collected at Riverside Park. Between 6th Street Dam and Fulton Street, *E. triquetra* was collected on the RDB and mid-channel immediately upstream and under the I-196 Bridge, and on the LDB just upstream of low-head dam upstream of Gillett Bridge (Figure 4-2). Based on their distribution under the I-196 Bridge, they could occur anywhere within the Project Area, but were more abundant near the bank. Some evidence of recruitment has been observed within the Grand River, as juvenile *E. triquetra* were collected at Ionia, Saranac, Flat River, and Ada, Roselle Park, and between 6th Street Dam and Fulton Street (Table 3-3). This species comprised 0.9% of the total number of mussels recently collected between 6th Street Dam and Fulton Street and would be adversely affected by Project construction (Table 2-1). However, the amount of riffle habitat with gravel substrate with project features would improve with the Project (Appendix F).

4.2 Michigan TES Species

Ligumia recta (Black Sandshell) - Threatened

Ligumia recta is a solid, elongate and moderately compressed mussel reaching lengths up to 20 cm (7.9 in). The shell has a smooth, shiny surface that is dark green, brown, or black, with green rays visible on some individuals. The anterior end of the shell is rounded. The posterior of the female has a long, rounded marsupial swelling and ends in a blunt point about two-thirds of the way up the margin, whereas the posterior of the male shell ends in a blunt point near the middle of the margin. The nacre is variable from white, pink, and salmon to deep purple, and is iridescent posteriorly (Parmalee and Bogan, 1998).

Ligumia recta is bradytictic. Numerous papillae along the mantle edge undulate to attract a fish host. This species displays both during the day and night (Corey et al., 2006). Glochidia are released in white conglutinates (Watters et al., 2009). Steg and Neves (1997) reported glochidia of *L. recta* to exhibit a low degree of host specificity in laboratory tests. Reported fish hosts include *Notropis rubellus* (Rosyface Shiner), several Centrarchidae species, *Perca flavescens* (Yellow Perch), *S. vitreus*, and *Sander canadensis* (Sauger) (Young, 1911; Lefevre and Curtis, 1912; Steg and Neves, 1997; Hove et al., 1998; Watters et al., 1999; Khym and Layzer, 2000 *in* Watters et al., 2009). Many fish species identified as suitable hosts for *L. recta* have been collected from the Grand River in Grand Rapids (Table 1-3).

Habitat requirements for these host fish vary. Most Centrarchidae prefer low-velocity pool habitat over substrates ranging from soft silt to boulder (Edwards and Twomey, 1982; Edwards et al., 1982a, 1982b; Stuber et al., 1982a, 1982b; Becker, 1983; Aadland and Kuitunen, 2006). These species also display strong preferences for cover, such as vegetation or woody debris (Edwards and Twomey, 1982; Edwards et al., 1982a, 1982b; Stuber et al., 1982a, 1982b; Aadland and Kuitunen, 2006). Spawning and nesting habitat preferences are similar, with most species spawning in low-velocity areas in or near vegetation. Spawning occurs over a range of substrates, from soft mud (*Pomoxis nigromaculata* [Black Crappie]) to sand and gravel (*Lepomis macrochirus* [Bluegill], *Lepomis cyanellus* [Green Sunfish]; Edwards and Twomey, 1982; Edwards et al., 1982a, 1982b; Stuber et al., 1982a, 1982b; Aadland and Kuitunen, 2006). Spawning water temperature and timing are species specific, but spawning temperatures for Centrarchidae generally occur from May to August in the Grand River. *Sander vitreus* and *P. flavescens* are tolerant of a range of conditions but are most often found in generally low velocities over clean, rocky substrate (McMahon et al., 1984; Aadland and Kuitunen, 2006). Preferred *S. vitreus* spawning habitats are shallow shoreline areas, riffles, and shoals with rocky substrate and good water circulation, whereas *P. flavescens* prefer slow moving water, usually near aquatic vegetation (Becker, 1983; McMahon et al., 1984; Aadland and

Kuitunen, 2006). *Sander vitreus* spawn when water temperatures are between 5.6 and 10.0° C (42 and 50° F) (Becker, 1983), which typically occurs from mid-April to early May in the Grand River. *Perca flavescens* typically spawn between April and early May when water temperatures are between 7.2 and 11° C (45 and 52° F). (Becker, 1983). The Project should improve physical habitat for many of these species.

Ligumia recta occurs in rivers, lakes, and large streams in sandy mud to coarse sand or gravel at depths from a few centimeters to 2 m (6 ft) or more (Parmalee and Bogan, 1998; Watters et al., 2009). Although this species typically occurs in areas with at least moderate current, it has been found in varying conditions from slackwater to swift current (Williams et al., 2008; Watters et al., 2009). *Ligumia recta* range includes much of the eastern and central United States and Canada. *Ligumia recta* occur from the Great Lakes basin south to the Gulf Coast (Parmalee and Bogan, 1998). In Michigan, *L. recta* has been reported from several counties in the southern two-thirds of the state, as well as five counties in the Upper Peninsula (MNFI, 2018).

In the Grand River, *L. recta* has only been found in the middle and lower river (Table 3-1), from Portland, MI to downstream of Grand Rapids (Table 3-2; Figure 4-3). This species likely occurs in low abundance throughout the lower Grand River. It was only found in a few of the recently sampled sites (Saranac, Flat River, Ada, Roselle Park, Upstream, Project Area, Plaster Creek, and I-196 south; Table 2-7), although most of the sites upstream of the Project Area were only sampled with quantitative methods, and additional species would likely be collected with qualitative methods (Dunn, 2000). *Ligumia recta* was collected alive and scattered between 6th Street Dam and Fulton Street in 2013, 2016, 2017, and 2020 and several were also found throughout the I-196 translocation area (Cardno, 2017) (Table 1-2; Figure 4-4). It was also found downstream of Fulton Street within the indirect impact area (Table 2-7). Live juveniles of this species were collected from Ada, Roselle Park, and the Project Area, indicating that some recruitment is occurring within the lower Grand River (Table 3-3). This species comprised 2.9% of the mussels collected between 6th Street Dam and Fulton Street (Table 1-2). It would be adversely affected by Project construction, but the amount of physical habitat suitable for this species in the Project Area is expected improve with the Project.

<u>*Toxolasma parvum* (Lilliput) – Endangered</u>

Toxolasma parvum is a small elliptical or cylindrical mussel, reaching a length of up to 3.8 cm (1.5 in). The shell is relatively solid and inflated, and the anterior and posterior ends are rounded (Cummings and Mayer, 1992; Mulcrone, 2005). The umbos are inflated and slightly elevated above the hinge line (Cummings and Mayer, 1992). Beak sculpture consists of several angled concentric ridges (Cummings and Mayer, 1992; MNFI, 2018). The periostracum has a cloth-like texture and ranges in color from dark green to dark brown with no rays. The nacre is silvery or bluish-white and iridescent (Cummings and Mayer, 1992; Mulcrone, 2005).

Toxolasma parvum is bradytictic. Glochidia are released in July and spawning likely occurs soon after. Gravid individuals have been observed throughout the year (Mulcrone, 2005; MNFI, 2018). Glochidia are released in club-shaped conglutinates. Females possess a caruncle on the mantle margin that likely acts as a lure to attract host fish. Reported hosts include several Centrarchidae species and *Etheostoma nigrum* (Johnny Darter) (Watters et al., 2009). Most of these potential host species have been observed in the Grand River within Grand Rapids (Table 1-3). Centrarchidae species are most often associated with low-

velocity pools and cover such as submerged vegetation or woody debris. Spawning occurs in similar habitats over substrates ranging from soft mud to sand and gravel (Edwards et al., 1982a; Stuber et al., 1982a, 1982b; Aadland and Kuitunen, 2006). Spawning water temperature and timing are species specific, but Centrarchidae hosts generally spawn from May to August (Becker, 1983). In contrast, *E. nigrum* adults (spawning and non-spawning) prefer slow riffles (velocities 30-59 cm/sec [1-2 ft/sec]) over sand, gravel, and cobble substrate (Aadland and Kuitunen, 2006). *Etheostoma nigrum* typically spawn between April and June when water temperatures are between 11.7 and 21.1° C (53 and 70° F) (Becker, 1983). Slower current velocity areas of the Project Area (particularly areas near the bank) may be suitable for *E. nigrum* but only a few have been found in the project area (M. Holtgren, Encompass, personal communication). Low velocity pools suitable for Centrarchidae species are lacking in the Project Area; however, several Centrarchidae species have been collected in the lower river. *Lepomis macrochirus* comprised 16% of the fish collected in recent surveys (M. Holtgren, Encompass, personal communication). More slow flowing areas for these species would be available with the Project (Table 2-5; Appendix F).

Toxolasma parvum occurs in lakes, ponds, and slow flowing reaches of streams and rivers (Parmalee and Bogan, 1998; Mulcrone, 2005; Williams et al., 2008). It is most commonly found in soft substrates such as mud, sand, or fine gravel (Parmalee and Bogan, 1998; Watters et al., 2009). The range for this species includes the Great Lakes and Mississippi River drainages from New York to southern Canada and south to Louisiana. It also occurs in the Rio Grande system in Texas (NatureServe, 2015). In Michigan, *T. parvum* has been reported from only 10 counties, primarily in the southern half of the state (MNFI, 2018). This species was not reported from any of the historic surveys of the Grand River (Coker et al., 1919; van der Schalie, 1948; Goforth et al., 2000; Badra and Goforth, 2002; Badra and Goforth, 2003), but was recently collected live in the Grand River near Lyons Dam (Woolnough and Barnett, 2013; Woolnough, 2015), and at Ionia, Flat River, and Riverside Park, and as a weathered shell at Peace Park (Table 2-7; Figure 4-5).

Although it has not been collected between the 6th Street Dam and Fulton Street (Table 1-2), it could occur at a very low frequency in slower flowing areas. Its rarity in samples may be due to its affinity for slower, siltier areas on the edges of mussel assemblages, and its small size rather than its actual rarity in the Action Area. Given the rarity of this species in recent surveys, the status of *T. parvum* recruitment within the Action Area cannot be determined; however, juveniles were observed at Riverside Park (Table 3-3). It could be adversely affected by Project construction, but the amount of slow flowing near bank habitat for this species in the Project Area is expected to improve with the Project (Table 2-5, Appendix F).

<u>*Cyclonaias tuberculata*</u> <u>(Purple Wartyback) – Threatened</u>

Cyclonaias tuberculata shells are round, heavy, and compressed to moderately inflated (Cummings and Mayer, 1992). Shells may reach a length of 12.7 cm (5 in). The anterior end of the shell is rounded, while the posterior end is somewhat truncated, with a wing behind the umbo. The beaks are relatively small and low, and beak sculpture consists of numerous wavy ridges (Cummings and Mayer, 1992; MNFI, 2018). Most of the surface of the shell is covered with bumps or tubercles that are an extension of the beak sculpture. The periostracum is yellowish-brown or greenish brown in younger individuals, becoming darker brown in older individuals. The nacre is typically deep purple but may be white with a purple tinge (Cummings and Mayer, 1992; MNFI, 2018).

Cyclonaias tuberculata is tachytictic (short-term brooder). Glochidia are typically present in the gills between May and late August (Haggerty et al., 1995 *in* Watters et al., 2009). Glochidia are released in white oblong conglutinates (Watters, 2008 *in* Watters et al., 2009). This species displays inflated mantle tissue to attract host fish (Sietman et al., 2012). All reported hosts for *C. tuberculata* are Ictaluridae, and include *Ameiurus melas* (Black Bullhead), *Ameiurus natalis* (Yellow Bullhead), *Ictalurus punctatus* (Channel Catfish), and *Pylodictis olivaris* (Flathead Catfish) (Hove, 1997; Hove and Kurth, 1997 *in* Watters et al., 2009). Of these, *A. natalis*, *I. punctatus* and *P. olivaris* have been reported from the lower Grand River (Table 1-3). Ictaluridae habitat preferences vary among life stages. Adults are typically found in deep pools with cover such as large rocks or woody debris (McMahon and Terrell, 1982; Lee and Terrell, 1987; Aadland and Kuitunen, 2006). Young individuals also prefer some cover but are more commonly found in shallower areas with moderate flow and rocky substrate (McMahon and Terrell, 1982; Lee and Terrell, 1987; Aadland and Kuitunen, 2006). Nests are typically located in holes in the streambank, rock crevices, or near submerged debris, and an absence of cover may inhibit reproductive success (McMahon and Terrell, 1982; Lee and Terrell, 1987). All three Ictaluridae host fish found in the Grand River typically spawn between May and July, when water temperatures are above 22.0° C (72° F). Deeper slow flowing pools with cover are lacking in the Project Area, as are shallow riffles. Both of these habitat types would be more abundant with the Project (Table 2-5, Appendix F).

Cyclonaias tuberculata is found in large creeks to large rivers, typically in coarse sand or gravel substrate (Parmalee and Bogan, 1998; Watters et al., 2009; MNDNR, 2015). Although it is often found in moderate to swift current, it may inhabit slower-flowing areas (Parmalee and Bogan, 1998; Williams et al., 2008; Watters et al., 2009). *Cyclonaias tuberculata* primarily occurs in the Mississippi River drainage, but is also found in the Lake St. Clair, Lake Michigan, and Lake Erie drainages (Parmalee and Bogan, 1998; MNFI, 2018). Their range includes the Mississippi River and Great Lakes drainages from Virginia and North Carolina northwest to Minnesota, and south to Mississippi and Arkansas (NatureServe, 2015). In Michigan, *C. tuberculata* was historically found in the St. Joseph, Kalamazoo, Upper and Lower Grand, Huron, Raisin, and Detroit Rivers, as well as Lake St. Clair (Badra, 2010). It has been collected from the middle and lower Grand River from the early 1900's to recent studies, from Lyons, MI to downstream of Fulton Street (Table 3-1 and 3-2).

Cyclonaias tuberculata likely occurs throughout the lower Grand River; it has been recently found alive or as a fresh shell in most of the sampled sites (Ionia, Saranac, Peace Park, Ada, Roselle Park, Upstream, 6th Street Dam to Fulton Street, and between Fulton and Plaster Creek; Table 2-7; Figure 4-6). Between 6th Street Dam and Fulton Street, *C. tuberculata* was primarily found along the LDB upstream of Gillett Bridge in 2013, 2017, and 2020 (Figure 4-7) and was scattered throughout the I-196 bridge area in 2016/2017 (Cardno, 2017). This species appears to be actively reproducing within the lower Grand River, as live juveniles were collected from the Ionia, Peace Park, and Roselle Park, as well as between 6th Street Dam and Fulton Street (Table 3-3). It comprised 2.9% of the unionid mussels recently collected in the between 6th Street Dam and Fulton Street (Table 1-2). This species would be adversely affected by Project construction, but the amount of swift run habitat for this species in the Project Area is expected to improve with the Project (Table 2-5, Appendix F).

Alasmidonta viridis (slippershell) – Threatened

Alasmidonta viridis have thin shells as juveniles and become thick, inflated and quadrate with age. Shells may reach a length of 60 mm (2.4 in), but most are smaller. Each margin is either straight or broadly rounded making the overall lateral view shape quadrate. The umbo presents wide and low with a beak sculpture of two or three irregular ribs shaped in double looped patterns (Watters et al., 2009). The periostracum is a waxy yellow, green, or tan that darkens with age. Notable bold green rays appear at all ages, are varied in width, and commonly cover the entire periostracum. Growth lines are clearly marked by concentric grooves and wrinkles (Clarke, 1981). The nacre is white and often iridescent posteriorly.

Alasmidonta viridis is most likely a bradytictic (long-term) brooder that keep their glochidia in marsupia over Winter until released in Spring. Outer gills of the female fill with glochidia that turn brown as they mature. Glochidia are released from the outer gills by broadcast with no containment and connect with their host fish through passive entanglement (Watters, 2008; Haag, 2012).

Reported potential host fish include *C. bairdi*, *C. carolinae*, and *E. nigrum* (Clarke and Berg, 1959; Zale and Neves, 1982). *Cottus bairdi* has been reported in tributaries to the lower Grand River, and *E. nigrum* have been reported from the Grand River within Grand Rapids (Hanshue and Harrington, 2017*). Etheostoma nigrum* is common and widespread throughout streams from clear to turbid with varying silt loads, and is considered a pioneer species, as it establishes itself in disturbed areas (Becker, 1983). Slower current velocity areas of the Project Area (particularly areas near the bank) may be suitable for *E. nigrum*. More of this habitat type would be available with the Project (Table 2-5, Appendix F).

Alasmidonta viridis is a small mussel typically found in small creeks and headwaters of larger rivers. *Alasmidonta viridis* occurs in a wide variety of substrate, but is considered intolerant to impoundment (Watters et al., 2009; Haag 2012). It is frequently found buried in sand substrate near large boulders (Dunn, pers. obs.). Its range includes the Mississippi River, Lake Michigan, Lake Huron, Lake St. Clair, and Lake Erie drainages (Clarke, 1981). In Michigan, it is found throughout the state (MNFI, 2018), and has been reported from the Au Gres-Rifle, Au Sable, Case, Clinton, Huron, Kalamazoo, Little Calumet-Galien, Manistique, Maple, Muskegon, Pigeon-Wiscoggin, Pine, Raisin, Shiawassee, St. Clair, St. Joseph (Maumee River and Lake Michigan drainages), St. Mary's, Thornapple, Tiffin, and Upper and Lower Grand Rivers (Badra and Goforth, 2001; Carman, 2002; Badra, 2010).

Dead shells have been found in the upper and middle Grand River, and one was collected alive within the Project Area in 2017 (Table 1-2, Table 2-7, Figure 4-8 and 4-9). This is the only recent live record in the Grand River. This species is not typical of large rivers such as the lower Grand River (MNFI, 2018). The presence of only one individual suggests that a population may not occur in the Grand, but that this is a stray individual washed in from a tributary stream or dropped from a host fish that strayed into the river. However, to be conservative, it is included in this analysis. Its host fish, *E. nigrum*, occurs in the Grand River (Hanshue and Harrington, 2017) and was collected in recent surveys (Table 1-3). This species could be adversely affected by Project construction, but the emergent boulder habitats (large rocks in slower velocity) could provide physical habitat for this species (Appendix F).

Acipenser fulvescens (Lake Sturgeon) - Threatened

Acipenser fulvescens is Michigan's only native sturgeon species and is characterized by a large, torpedo-shaped body covered by rows of bony plates (scutes). *Acipenser fulvescens* has a heterocercal tail (asymmetric with a longer upper lobe), and a single dorsal fin (Auer, 1999). The snout is pointed with a ventral, protrusible mouth with four barbels (Auer, 1999). Young *A. fulvescens* have large, asymmetric dark patches while adults are uniform in color, ranging from dark slate to light brown or yellowish olive (Smith, 1979; Pflieger, 1997). *Acipenser fulvescens* can be long-lived and individuals greater than 40 years old are common, with individuals reported to be up to 150 years old (Scott and Crossman, 1973; Pflieger, 1997). Females have a longer life span and attain greater sizes than males and can reach sizes greater than 91 kg (200 pounds [lbs]) and lengths greater than 2.4 m (8 ft) (Scott and Crossman, 1973; Pflieger, 1997).

Like other sturgeon species, *A. fulvescens* exhibits delayed maturation (Priegel and Wirth, 1974). Males mature between 12 - 16 years and females mature at 20 - 26 years. Males migrate to spawning sites before females (Priegel and Wirth, 1977) and females spawn every 2 - 7 years (Priegel and Wirth, 1977; Lyons and Kempinger, 1992) and exhibit spawning site fidelity (Lyons and Kempinger, 1992; Ecclestone, 2011; Welsh et al., 2010). Spawning is initiated when water temperatures reach 9 to 20° C (48 to 68° F) and spawning occurs between 11 and 18° C (52 and 64° F) (Scott and Crossman, 1973; Ecclestone, 2011; Chiotti et al., 2008); in the Grand River, the temperature range for initiation of spawning occurs between mid-March and early May. They spawn in or before rapids and at the base of dams (Hanshue and Harrington, 2017). Spawning sites are characterized by depths of 0.2 - 4.6 m (2 - 15 ft) with water current up to 3 m/sec (10 ft/sec) (Scott and Crossman, 1973, Bruch and Binkowski, 2002; Hanshue and Harrington, 2017) over clean rocky substrate in turbulent streams or rocky shoals in lakes in areas of sufficiently oxygenated water (Scott and Crossman, 1973; Kempinger, 1988; Pflieger, 1997; Bruch and Binkowski, 2002; Ecclestone, 2011). Females may release up to 700,000 eggs (Becker, 1983; Pflieger, 1997). The black, adhesive eggs hatch between 5 - 18 days depending on water temperature and larvae drift downstream without parental care (Kempinger, 1988; Chiotti et al., 2008). Young-of-year *A. fulvescens* occupy their river of origin during the first few months of life and use shoal, run, and pool areas of large rivers with gravel and sand substrate (Holtgren and Auer, 2004; Mann et al. 2011; Hanshue and Harrington, 2017). Juveniles in the Grand River seem to prefer shallow areas with sand substrate and moderate flow along river edges (Hanshue and Harrington, 2017).

Acipenser fulvescens has historically been found throughout the upper and middle Mississippi River basin and the Great Lakes and Hudson Bay drainages south to the Tennessee River and its tributaries and Coosa River to west in the Missouri River (Etnier and Starnes, 1993). *Acipenser fulvescens* is presumed to be extirpated in Alabama, North Carolina, North Dakota, and West Virginia, and possibly extirpated in Georgia and Kansas. *Acipenser fulvescens* occurs at variable degrees in Arkansas, Indiana, Iowa, Kentucky, Missouri, Nebraska, Pennsylvania, Tennessee, Vermont, Michigan, Wisconsin, Minnesota, and South Dakota.

In Michigan, *A. fulvescens* occurs in the Great Lakes (Lake Michigan, Lake Superior, and Lake Huron), and several inland lakes and rivers. In Michigan it is known from 23 counties in Michigan's upper and lower peninsulas (MNFI, 2018). Self-sustaining populations are found in the Sturgeon River, Menominee River, St. Clair River, and Detroit River (Hayes and Cafoffino, 2012). An additional 19 populations are known to occur in Michigan, at population sizes of <25 adults to over 15,000 adults.

A small *A. fulvescens* population is known to occur in the mainstem of the lower Grand River and the mouth of the Grand River, and adults have been observed during spawning season below the 6th Street dam (M. Holtgren, Encompass, personal communication). Within the Action Area**,** it is restricted to downstream of the 6th Street Dam (Figure 4-10, Hanshue and Harrington, 2017). The Grand River population has been placed into the 'small declining' category based on a low estimated adult population size (n = 103) and declining population trajectory over the past 15 years (Hayes and Carrofino, 2012). The 6th Street Dam is a barrier to spawning grounds of several Lake Michigan fish species, including *A. fulvescens* (Hanshue and Harrington, 2017). MDNR biologists have reported adult and juvenile *A. fulvescens*, and incidental catch by anglers has occurred near the 6th Street Dam. A population of between 66 and 130 fish of primarily older (>36 years) adults is estimated to occur in the lower Grand River (Hanshue and Harrington, 2017). This species should not be adversely affected by Project construction, as it would likely stay out of the area with construction activity. *Acipenser fulvescens* migration routes at least up to I-196 would be available with the Project (Holtgren, 2024; Appendix E). Turbidity may increase during construction within the indirect impact area; however, *A. fulvescens* is known to occur in a wide range of turbidity, clarity, and oxygen levels (COSEWIC, 2017). If they are temporarily displaced by turbidity, they are likely to seek nearby clear water (in Plaster Creek) until suitable conditions exist. Additionally, temperature suitable for spawning generally occurs in the Grand River in the Spring under turbid conditions. However, BMPs would be used to reduce turbidity as much as practicable, and turbidity would be monitored and adaptively managed.

<u>*Moxostoma carinatum* (River Redhorse) – Threatened</u>

Moxostoma carinatum is a large-bodied sucker with a brown or olive coloration dorsally to brassy sides and white ventrally (Pflieger, 1997; COSEWIC, 2006). Crescent shaped dark spots are present on each dorso-lateral scale, caudal and dorsal fins are bright red in color, with pelvic and pectoral fins orange to red (Etnier and Starnes, 1993; Pflieger, 1997; COSEWIC, 2006). Adults commonly reach 500 mm (1.5 ft) and up to 2 kg (4 lbs) (Pflieger, 1997; Campbell, 2001) and can weigh up to 7.7 kg (17 lbs) (Pflieger, 1997) and reach ages between eight and approximately 30 years (Etnier and Starnes, 1993; Campbell, 2001). The lower lips are broken into parallel folds (plicae) without papillae (Pflieger, 1997; COSEWIC, 2006). The lower lip has a straight to slightly obtuse posterior margin, forming a slightly v-shaped angle, and the dorsal fin is straight to slightly concave (Pflieger, 1997; COSEWIC, 2006). *Moxostoma carinatum* differs from other *Moxostoma* spp. In having a heavy pharyngeal arch bearing molariform teeth rather than comb-like teeth (Etnier and Starnes 1993; Jenkins and Burkhead, 1993; Pflieger, 1997). Breeding males develop small tubercles on head, body, and fins (Etnier and Starnes, 1993; Pflieger, 1997)

Moxostoma carinatum reaches sexual maturity between three and five years (Etnier and Starnes, 1993; Huston, 1999) with northern populations reaching maturity later (COSEWIC, 2006). Adults spawn each year, at temperatures between 18 and 24° C (64 and 75° F) (Mongeau et al., 1992; Jenkins and Burkhead, 1993), which occurs between mid-May and late July in the Grand River. MNFI (2018), however, reports the spawning season from late July to late August. Evidence suggests that males excavate spawning redds tended by individual males (Hackney et al., 1967; Etnier and Starnes, 1993; Pflieger, 1997) and exhibit ritualized spawning displays (Hackney et al., 1967; Etnier and Starnes, 1993). Females release between 9,000 and 23,000 yellow, adhesive eggs (Etnier and Starnes, 1993; Campbell, 2001). Hatching occurs between five and six days post-fertilization (Jenkins, 1970).

Moxostoma carinatum is found throughout the central and eastern Mississippi River system north from the Great Lakes Basin to the Gulf Slope from Florida to Louisiana (Etnier and Starnes, 1993; COSEWIC, 2006). This species is known from 24 states and two Canadian provinces (COSEWIC, 2006). *Moxostoma carinatum* is known to inhabit lakes and rivers, but generally occurs in rivers with moderate to swift current and clean, rocky substrates needed for spawning (Scott and Crossman, 1973; Becker 1983; Etnier and Starnes, 1993; Pflieger, 1997; Reid, 2002; Reid, 2003), with spawning individuals commonly collected within 100 m (325 ft) of rapids (Campbell, 2001).

Moxostoma carinatum inhabits rivers in 14 counties in Michigan's lower peninsula (MNFI, 2018). *Moxostoma carinatum* occurs throughout the entire Lower segment of the Grand River, from near Lyons to Grand Haven near the mouth of Lake Michigan and upstream into the Maple River (Hanshue and Harrington, 2017; Figure 4-11). They were recently collected between 6th Street Dam and Fulton Street (Table 1-3) and were recently observed in spawning condition within the Project Area (S. Hanshue, MDNR, personal communication). They also spawn in the Flat River, Maple River, and Fish Creek (S. Hanshue, MDNR, personal communication). This species would likely avoid the Project Area during Project construction, although spawning typically occurs in Spring when water levels would likely be too high for project construction to occur. Turbidity may increase at the downstream end of the indirect impact area, where *M. carinatum* has been known to spawn (S. Hanshue, MDNR, personal communication). BMPs would be used to reduce turbidity as much as practicable, and turbidity would be monitored and adaptively managed. This species may experience reduced recruitment during the 2-year period in which construction activities are planned (July 2021 – June 2023), but across the Grand River watershed, loss of year classes should be buffered by spawning that occurs outside of the Project Area. Habitat for *M. carinatum* should be improved with the completion of the Project (Appendix F).

Pleurobema sintoxia (Round Pigtoe) – Species of Special Concern

Pleurobema sintoxia shells are generally triangular, but frequently nearly round. The dorsal margin is nearly straight, ventral margin gently curved, anterior end broadly rounded, and posterior end truncated above and rather pointed ventrally. Shells are stout and thicker anteriorly. Shells are to 9.5 cm (3.7 in) long and are compressed (smaller streams) to inflated (larger rivers); the posterior ridge is rounded and flattened but not prominent. Beaks are broad, high, and directed forward with sculpture consisting only of a few small tubercles on the posterior ridge. The periostracum is light reddish-brown becoming dark brown with age and usually without rays. The nacre is white, pink, or salmon and iridescent posteriorly (Oesch, 1984).

Pleurobema sintoxia is tachytictic (short-term brooder); it is gravid as early as May until late July. Glochidia are released in white leaf-shaped conglutinates (Watters et al., 2009). Reported host fish are primarily Cyprinidae and *Lepomis* sp., and include *Campostoma anomalum* (Central Stoneroller), *Cyprinella spiloptera* (Spotfin Shiner), *Phoxinus eos* (Northern Redbelly Dace), *Phoxinus erythrogaster* (Southern Redbelly Dace), *Pimephales notatus* (Bluntnose Minnow), and *L. macrochirus* (Hove, 1995; Watters et al., 2005 *in* Watters et al., 2009). *Cyprinella spiloptera, P. notatus,* and *L. macrochirus* have recently been collected between 6th Street Dam and Fulton Street (Table 1-3). *Cyprinella spiloptera* and *P. notatus* have similar habitat preferences; although preferences vary somewhat with life stage, both species appear to prefer slow to moderate current with silt, sand, and gravel substrate (Aadland and Kuitunen, 2006). Both

Cyprinidae species spawn between May and September when water temperature is above 21.1° C (70° F). In contrast, *L. macrochirus* prefer low-velocity pools with cover such as vegetation or woody debris (Stuber et al., 1982b; Aadland and Kuitunen, 2006). *Lepomis macrochirus* typically spawn between May and August, when water temperatures are above 19.4° C (67° F) (Becker, 1983). Within the Project Area, shallow near-bank areas containing smaller substrate constituents (silt, sand, gravel) seem to be suitable for *C. spiloptera* and *P. notatus*. This habitat would be increased with the Project (Table 2-5, Appendix F).

Pleurobema sintoxia is found in medium to large rivers in mixed mud, sand, and gravel (Cummings and Mayer, 1992). In Tennessee, this species was most abundant in medium-sized and large rivers in current on a firm substrate of coarse gravel and sand at depths of less than 1 m (3 ft) to more than 6 m (20 ft). (Parmalee and Bogan, 1998). *Pleurobema sintoxia* was historically distributed from New York and Ontario west to South Dakota, Kansas, and Oklahoma, and south to Louisiana and Alabama. This species is considered vulnerable to critically imperiled in most of the states in which it occurs (NatureServe, 2015).

Pleurobema sintoxia has been observed in most of the major drainages in the southern portion of the Lower Peninsula, including the Cass, Clinton, Huron, Kalamazoo, Muskegon, Pine, Raisin, Shiawassee, St. Clair, St. Joseph (Lake Michigan and Maumee), Thornapple, Tiffin, and Upper and Lower Grand watersheds (Badra, 2010). In the Grand River, it historically occurred throughout the river, but now seems to occur only in the middle and lower river (Table 3-1). It has recently (since 2013) been found alive from Lyons Dam downstream through Grand Rapids (Table 3-2). It was collected alive in most of the sampled sites: Ionia, Saranac, Flat River, Peace Park, Chief Hazy Cloud, Ada, Riverside Park, Roselle Park, Upstream, and between 6th Street Dam and Fulton Street in low numbers (Table 2-7; Figure 4-12). A few were collected immediately downstream of the 6th Street Dam (Figure 4-13), and a few were found scattered under the I-196 Bridge (Cardno, 2017). This species appears to be actively reproducing within the lower Grand River, as live juveniles were collected from Ionia, Saranac, Peace Park, Ada, Roselle Park, and Upstream (Table 3-3). Frequency between 6th Street Dam and Fulton Street averaged 0.4% (Table 1-2). *Pleurobema sintoxia* would be adversely affected during Project construction, but physical habitat should be improved with the Project (Appendix F).

<u>*Potamilus alatus* (Pink Heelsplitter) – Species of Special Concern</u>

Potamilus alatus is a relatively large species, reaching lengths of up to 20 cm (8 inches). The shell is somewhat rectangular, laterally compressed, and thin in young and moderately thick in older shells (Cummings and Mayer, 1992; Mulcrone, 2018a). The anterior end of the shell is rounded, while the posterior end is bluntly squared or truncated. The umbos are slightly above the hinge line and flattened. Beak sculpture is fine, concentric lines (Mulcrone, 2018a). Posterior to the umbos, a large wing is typically present. The periostracum varies in color from dark green to dark brown to black in older individuals. Younger individuals commonly have green rays that fade with age. The nacre is purple or pinkish purple but rarely white and highly iridescent (Cummings and Mayer, 1992).

Potamilus alatus is bradytictic. Gravid females have been reported from June to October and again from May to July (Watters et al., 2009). *Aplodinotus grunniens* was recently confirmed as a host fish (Sietman et al., 2018) and was recently collected between the 6th Street Dam and Fulton Street (Table 1-3). *Aplodinotus grunniens* are bottom dwellers that feed on mollusks. They can be found in a range of habitats but appear to prefer deeper pools of rivers, and low-velocity areas of medium to large rivers over mixed

sand and silt (Smith, 1979; Aadland and Kuitunen, 2006; Hanshue and Harrington, 2017). *Aplodinotus grunniens* are pelagic spawners that typically spawn when water temperatures are between 18.9 and 22.2° C (35 and 72° F) (Becker, 1983), which occurs from mid-May to late June in the Grand River. The distribution of *A. grunniens* in the Grand River appears to be primarily downstream of the 6th Street Dam (Hanshue and Harrington, 2017). Some habitat for this species is available in the Project Area, and habitat should also be available with the Project (Table 2-5, Appendix F).

Potamilus alatus typically occurs in medium to large rivers, lakes, and impoundments, but rarely in smaller systems (Watters et al., 2009). It is most often found in silty sand and mud but can be found in mixed mud, sand, and gravel (Cummings and Mayer, 1992) and also in slower moving waters (Oesch, 1984). *Potamilus alatus* is found throughout the Mississippi River system as well as the upper St. Lawrence River and Lakes Erie and St. Clair and the lower reaches of rivers in the lower peninsula. It ranges from western Pennsylvania to Minnesota stretching west to Kansas and Nebraska then south to Arkansas (NatureServe, 2018). In Michigan, *P. alatus* is found at the lower stretches of rivers in the lower peninsula, and in Lakes Erie and St. Clair (Burch, 1975). *Potamilus alatus* has not been reported in the headwaters, upper, or middle reaches of the Grand River (Table 3-1). A few individuals were collected between 6th Street Dam and Fulton Street during 2013 and 2016 sampling (Figure 4-14), under the I-196 Bridge (Cardno, 2017), and between Fulton Street and the M-11 Bridge, but not at any of the sites upstream of the 6th Street Dam (Table 2-10; Figure 4-15). Their distribution is likely limited by the inability of *A. grunniens* to travel upstream of the 6th Street Dam. Between the 6th Street Dam and Fulton Street, they occur at a frequency of 0.5% (Table 1-2). Given the rarity of *P. alatus* in recent surveys, the recruitment status of this species cannot be determined. *Potamilus alatus* would be adversely affected during Project construction, but physical habitat should be improved with the Project (Appendix F).

Truncilla truncata (Deertoe) – Species of Special Concern

Truncilla truncata is a relatively small species, reaching lengths up to 5 cm (2 in). The shell is triangular, somewhat inflated, and relatively thick (Cummings and Mayer, 1992; Mulcrone, 2006b). The anterior end of the shell is rounded, while the posterior end is bluntly pointed or truncated. A shallow sulcus is present anterior to the posterior ridge, which is sharply angled. The umbos are prominent and raised above the hinge line. Beak sculpture consists of three to five fine double-looped ridges. The periostracum varies in color from yellow or green to dark brown and is typically marked with numerous green rays of varying width. Rays may be composed of fine broken lines or chevron-shaped markings. The nacre is typically white, but may occasionally be pink (Cummings and Mayer, 1992; Mulcrone, 2006b).

Truncilla truncata was thought to be bradytictic but was recently reported as tachytictic (short-term brooder; Sietman et al., 2018). Gravid females have been reported from April or May to July (Watters et al., 2009; Sietman et al., 2018). Potential host fish may include *A. grunniens* and *S. canadensis* (Wilson, 1916 *in* Watters et al., 2009), and *A. grunniens* has been confirmed as a suitable host (Marshall et al., 2018; Sietman et al., 2018). *Aplodinotus grunniens* is known to occur in the Grand River downstream of the 6th Street Dam, while *S. canadensis* has not been reported from the lower Grand River (Hanshue and Harrington, 2017). *Aplodinotus grunniens* are bottom dwellers that feed on mollusks. They can be found in a range of habitats but appear to prefer low-velocity areas of medium to large rivers over mixed sand and silt (Smith, 1979; Aadland and Kuitunen, 2006). *Aplodinotus grunniens* are pelagic spawners that typically spawn when water temperatures are between 18.9 and 22.2° C (35 and 72° F) (Becker, 1983),

which occurs from mid-May to late June in the Grand River. Most of the *T. truncata* in the Grand River occur downstream of the 6th Street Dam (Hanshue and Harrington, 2017). Although *A. grunniens* primarily occurs downstream of the 6th Street Dam, a few have been collected above the dam (S. Hanshue, MDNR, personal communication) and a few *T. truncata* have also been found above the dam.

Truncilla truncata typically occurs in medium to large rivers, though they may be found in smaller rivers and creeks as well as lakes (Parmalee and Bogan, 1998; Williams et al., 2008; Watters et al., 2009). It occurs in a variety of substrates, including sand, gravel, and mud (Cummings and Mayer, 1992; Parmalee and Bogan, 1998; Williams et al., 2008). *Truncilla truncata* is found throughout the Mississippi River system, as well as the Lake Michigan, Lake Erie, and Lake St. Clair drainages. It ranges from New York to Virginia in the east and from North Dakota to Texas in the West, and from Canada south to Louisiana (NatureServe, 2015). In Michigan, *T. truncata* is primarily found in the southern half of the Lower Peninsula. It occurs in the Detroit, Huron, Kalamazoo, Pere Marquette-White, St. Clair, St. Joseph (Lake Michigan), Tittabawassee, and the Lower Grand (Badra, 2010).

Truncilla truncata was not reported in the Grand River by Coker et al. (1919) or van der Schalie (1948), but Goforth et al. (2000) found multiple age classes in the middle and lower river. More recently (2013 to 2022), it was collected alive near Lyons Dam (Woolnough and Barnett, 2013), near Saranac, between the 6th Street Dam and Fulton Street, and downstream to the M-11 Bridge (Table 2-7; Figure 4-16 and 4-17). Both the Saranac Site and the area between the 6th Street Dam and Fulton Street contained live juveniles, suggesting *T. truncata* is actively reproducing within the lower Grand River (Table 3-3). *Truncilla truncata* frequency averaged 1.7% between 6th Street Dam and Fulton Street (Table 1-2). *Truncilla truncata* would be adversely affected during Project construction, but physical habitat should be improved with the Project (Appendix F).

<u>*Venustaconcha ellipsiformis* (Ellipse) – Species of Special Concern</u>

Venustaconcha ellipsiformis is a small mussel, reaching lengths up to 7.5 cm (3 in). The shell is solid, moderately compressed, and elliptical in shape (Cummings and Mayer, 1992; Badra, 2007a). The anterior end is rounded, and the posterior end is bluntly pointed and often pinched. The umbos are low and raised only slightly above the hinge line. Beak sculpture consists of three to four fine double-looped ridges (Cummings and Mayer, 1992; Badra, 2007a). The periostracum is yellow, green, or dark tan, with dark green rays that become wavy toward the posterior end of the shell. The nacre is white, occasionally tinged with orange in the beak cavity (Cummings and Mayer, 1992; Badra, 2007a).

Venustaconcha ellipsiformis is bradytictic. Spawning is reported to occur in July and August (Watters et al., 2009). Potential host fish include *Cottus* spp., *P. caprodes*, and *Etheostoma* spp. (Watters et al., 2009). *Percina caprodes* and *E. caeruleum* have similar habitat preferences: adults prefer relatively shallow, swift riffles or raceways with gravel substrate. Adults (spawning and non-spawning) seem to prefer depths near 1 m (3 ft) and current velocity near 1 m/sec (3 ft/sec) over substrates of sand, gravel, and cobble, whereas young of the year prefer slightly shallower, slower waters over similar substrate (Becker, 1983; Aadland and Kuitunen, 2006). In Wisconsin, both *P. caprodes* and *E. caeruleum* begin spawning in April, with the spawning season extending into June or July (Becker, 1983). *Etheostoma nigrum* adults (spawning and non-spawning) prefer slow riffles (velocities 30-59 cm/sec [1-2 ft]) over sand, gravel, and cobble substrate (Aadland and Kuitunen, 2006). *Etheostoma nigrum* typically spawn between April and June when water

temperatures are between 11.7 and 21.1° C (53 and 70° F) (Becker, 1983). The Project Area currently offers limited habitat for *P. caprodes, E. nigrum,* and *E. caeruleum*, although some primarily gravel substrate is present (Figure 2-1), and all three species were collected in recent surveys (Table 1-3). Slower current velocity areas of the Project Area (particularly areas near the bank) may be suitable for *E. nigrum*. Physical habitat for all *Etheostoma* sp. and *Percina* sp. would be expanded with the Project (Table 2-5; Appendix F).

Venustaconcha ellipsiformis is typically found in small to medium streams in sand and gravel substrate (Cummings and Mayer, 1992; Watters et al., 2009). It is limited to the Interior Basin and occurs from Michigan and Indiana west to Minnesota and south to Missouri and Oklahoma (Badra, 2007a; NatureServe, 2015). In Michigan, *V. ellipsiformis* has been reported from the Cass, Kalamazoo, Maple, Pigeon-Wiscoggin, Raisin, Shiawassee, St. Joseph (Lake Michigan and Maumee drainage), Thornapple, and Grand River basins (Badra, 2010). *Venustaconcha ellipsiformis* historically occurred throughout the Grand River and has more recently been found in the middle and lower Grand (Table 3-1). Although rare, one individual was recently found alive near Lyons Dam (Woolnough, 2015). A few were also found at Peace Park, Ada, and Roselle Park, and they were the dominant species in the Flat River (Table 2-7; Figure 4-18). Mostly weathered shells have been found between the 6th Street Dam and Fulton Street, but one live individual was collected in August 2017 (Figure 4-19) and one live individual was collected under the I-196 bridge (Cardno, 2017). One live juvenile was collected from Ada, and several were found in the Flat River (Table 3-3). They may be more abundant in tributaries within the lower Grand, as they comprised 33% of the community in the lower Flat River (ESI, 2016). Between the 6th Street Dam and Fulton Street, frequency averaged 0.1% (Table 1-2). *Venustaconcha ellipsiformis* would be adversely affected during Project construction, but physical habitat should be improved with the Project (Appendix F).

Cambarunio iris (Rainbow) – Species of Special Concern

Cambarunio (Villosa) iris is a small mussel typically found in small to medium sized streams. It occurs in the eastern portion of the United States in the Ohio and Upper Mississippi River basins, and the Great Lakes system from Lake Huron to Lake Ontario (Parmalee and Bogan, 1998; Badra, 2007b). In Michigan, *C. iris* is primarily found in the southern portion of the state. It has been reported from the Cass, Clinton, Detroit, Huron, Kalamazoo, Maple, Muskegon, Pigeon-Wiscoggin, Pine, Raisin, Shiawassee, St. Clair, St. Joseph (Lake Michigan and Maumee drainage), Thornapple, Tiffin, and Grand River systems (Badra, 2010). Dead shells have been found in the lower Grand River and were collected between 6th Street Dam and Fulton Street (Table 1-2). The only live recent record for this species is the one individual collected below Lyons Dam (Woolnough, 2015). Since this species does not appear to be extant in the Action Area, it would not be adversely affected by the Project and is not included in this analysis.

Alasmidonta marginata (Elktoe) – Species of Special Concern

Alasmidonta marginata is a medium-sized mussel, reaching lengths up to 10 cm (3.9 in) (Cummings and Mayer, 1992). The shell is triangular or trapezoidal, inflated, and thin. The anterior end is rounded, and the posterior end is bluntly pointed, with a prominent posterior ridge (Cummings and Mayer, 1992). The posterior slope is covered with fine ridges. The umbos are large and located near the center of the shell. Beak sculpture consists of three to four heavy double-looped ridges (Cummings and Mayer, 1992; MNFI, 2018). The periostracum is smooth, greenish yellow in color, with numerous dark green rays and dots

(Cummings and Mayer, 1992; MNFI, 2018). The nacre is bluish white and may occasionally have salmon near the beaks, and the foot is bright orange (Cummings and Mayer, 1992; MNFI, 2018).

Alasmidonta marginata is bradytictic. Spawning typically occurs in June. Glochidia are found in September and overwinter until the following May or June (Watters et al., 2009). Potential host fish include *C. commersonii*, *H. nigricans*, *Moxostoma macrolepidotum* (Shorthead Redhorse), *Ambloplites rupestris* (Rock Bass), and *Lepomis gulosus* (Warmouth) (Howard and Anson, 1923 *in* Watters et al., 2009). However, these potential hosts were observed as natural infestations, and transformation has not been observed (Host fish database, accessed 2024). More recently Bloodsworth et al. (2013) transformed this species in the laboratory on *C. commersoni*, *H. nigricans*, *Erimyzon oblongus* (Eastern Creek Chubsucker), *M. macrolepidotum*, *Moxostoma erythrurum* (Golden Redhorse), *M. anisurum*, *Luxilus zonatus* (Bleeding Shiner), *Luxilus chrysocephalus* (Common Shiner), *Luxilus cornutus* (Striped Shiner), *Margariscus margarita* (Allegheny Pearl Dace), *Notemigonus crysoleucas* (Golden Shiner), *Nocomis biguttatus* (Hornyhead Chub), *Fundulus catenatus* (Northern Studfish), *Fundulus diaphanus* (Banded Killifish), *Fundulus olivaceus* (Blackspotted Topminnow), *Poecilia reticulata* (Guppy), *Culaea inconstans* (Brook Silverside), *C. bairdi*i, and *C. carolinae*, suggesting they are host generalists similar to other Anodontini. Many of these potential hosts were recently collected within Grand Rapids (Table 1-3)

Alasmidonta marginata is found in large creeks to medium rivers. It most often occurs in reaches with relatively fast current and substrates of mixed sand, gravel, and/or cobble (Parmalee and Bogan, 1998; Williams et al., 2008; Watters et al., 2009; MNFI, 2018). This species is found in the Mississippi River and Great Lakes drainages, as well as the Susquehanna River in Pennsylvania (Atlantic Slope drainage) (Watters et al., 2009). It ranges from Canada in the north to Alabama in the south and is found from New York to Virginia in the east and North Dakota to Oklahoma in the west (NatureServe, 2015). In Michigan, *A. marginata* is found in both the Upper and Lower Peninsulas, though it appears to be absent from the northern portion of the Lower Peninsula (MNFI, 2018). This species is known to occur in the upper (historical), middle, and lower Grand River (Table 3-1). It has been collected live or as a fresh shell from Lyons Dam to downstream of Fulton Street in Grand Rapids (Table 3-2). Within recently sampled areas, a few live individuals were collected from Ionia, Saranac, Flat River, Chief Hazy Cloud, Ada, and at the I-196 south bridge (Table 2-7; Figure 4-20); recent recruitment was evident, as live juveniles were collected at each of these sites (Table 3-3). Fresh shells were also found at Peace Park, Roselle Park, Upstream, and within the downstream indirect impact area (Table 2-10). Between the 6th Street Dam and Fulton Street, fresh shells were found near the dam and along the left descending bank (Figure 4-21), and live individuals were collected under the I-196 Bridge (Cardno 2017). Frequency of *A. marginata* between 6th Street Dam and Fulton Street averaged 0.7% (Table 1-2). *Alasmidonta marginata* would be adversely affected during Project construction, but physical habitat should be improved with the Project (Appendix F).

<u>*Lasmigona compressa* (Creek Heelsplitter) – Species of Special Concern</u>

Lasmigona compressa shell is small to medium sized with lengths up to 8 cm (4 in), elongate, and relatively thin (Cummings and Mayer, 1992) but becomes moderately thick with age (Watters et al., 2009). The anterior of the shell is rounded while the posterior end is bluntly pointed with a squared tip. The posterior ridge is prominent, and the slope is formed into a small, sculptureless wing. Umbos are slightly above the hinge line and beak sculpture is heavy double-loops (Mulcrone, 2018b). The periostracum is yellow, tan, and/or greenish, frequently with rays in young individuals, turning brown to black with age (Watters et

al., 2009; Cummings and Mayer, 1992). Shell nacre is white with often a salmon, yellow, or greenish tint under the hinge; most specimens have gold or brown Tulberg layers (Watters et al., 2009).

Lasmigona compressa is bradytictic. Spawning is reported to occur in May (Ortmann, 1919; Baker, 1928) but individuals may spawn from June to July in Michigan (Mulcrone, 2018b). More than 20 host fish species from several families, including *Lepisosteus* sp. (Gar), Cyprinidae, Catostomidae, Ictaluridae, *Lepomis* sp., and Percidae, have been reported. Many of these potential hosts have been reported from the Grand River within Grand Rapids (Table 1-3). Since preferred habitat varies for these fish species, it may be assumed host fish occur throughout the Grand River.

Lasmigona compressa can be found throughout a watershed but is usually in creeks and headwaters of small to medium rivers (Cummings and Mayer, 1992). It was found in pools above and below riffles with compact sand and gravel, or mud patches near shore on the Huron River (Mulcrone, 2018b). In larger rivers it occupies soft mud bottoms in slow-moving currents near the edge of the river (Cummings and Mayer, 1992; van der Schalie, 1938; Watters, 1995). This species is found in the Canadian Interior Basin, the Upper Mississippi, Ohio, and St. Lawrence River systems extending from Saskatchewan to Nebraska and eastward to Vermont and Quebec, and the Hudson River system in New York (Mulcrone, 2018b). In Michigan, this species is found in creeks, headwater streams and small rivers throughout drainages in the lower and upper peninsula (Burch, 1975; van der Schalie, 1938). It was historically found in the Grand River headwaters and upper and middle reaches but has only been found in the lower reach in recent years (Table 3-1). It was recently found in the Flat River, at Roselle Park, and at the I-196 south bridge (Table 2-7; Figure 4-22). Juveniles were found in the Flat River, and one juvenile was collected at Roselle Park in 2017 (Table 3-3), which suggests some reproduction may be occurring in the lower Grand River. It was not found at any other sites, including between the 6th Street Dam and Fulton Street (Table 2-7). However, there is a chance that it could occur in the Project Area at a very low frequency. It could be adversely affected during construction if it occurs in the Project Area, but slower flowing areas near the bank preferred by this species should increase with the Project (Appendix F).

<u>*Lasmigona costata* (Flutedshell) – Species of Special Concern</u>
Lasmigona costata is a moderately sized unionid with lengths up to 18 cm (7 in) and is ovate and elongate in shape. The shell is moderately thick, compressed to moderately inflated. The anterior end is uniformly rounded, the posterior end is truncated above and angular where the posterior ridge meets the margin of the shell. The dorsal and ventral margins are straight to slightly curved. Umbos are low and not raised above the hinge line. Beak sculpture is composed of three or four concentric and sometimes sinuate ridges. The periostracum is smooth, and younger individuals often have green and brown rays while aged individuals lose color and become browner (Mulcrone, 2018c). The shell's posterior slope has prominent sculpturing consisting of about 10 – 12 heavy, rounded ridges or folds while more sculpturing is present on the lateral surface near the middle of the shell (Cummings and Mayer, 1992).

Lasmigona costata is bradytictic. Gravid females have been observed from early August to late May in the Huron River (Michigan) and likely spawn from June to July in Michigan (Lefevre and Curtis, 1912; Watters, 1995). Two glochidia forms have been observed for *L. costata* with one presumably being able to forego the parasitic stage (Watters et al., 1998). Over 25 host fish species from several families have been reported. Many of these potential hosts have been reported from the Grand River within Grand Rapids

(Table 1-3). Since preferred habitat varies for these fish species, it may be assumed host fish are present in the Grand River and the Project Area.

Lasmigona costata is in the Mississippi River system, including the Tombigbee River system. To the north it occurs in the St. Lawrence system from north of Lake Superior to Lake Champlain and the Ottawa River. In the Hudson Bay drainage, it is found in the Red and Winnipeg systems (Watters et al., 2009; Mulcrone, 2018c). *Lasmigona costata* is generally sporadic in distribution where it is found. In Michigan, it generally occurs in small to medium sized rivers in both the upper and lower peninsulas (van der Schalie, 1938; Burch, 1975; Watters, 1995). Historically, *L. costata* was found in the headwaters and upper reach of the Grand River and has recently been collected in the middle and lower reaches (Table 3-1). It was relatively abundant in the Flat River, Upstream, and between the 6th Street Dam and Fulton Street, but few individuals were collected at other surveyed sites (Table 2-7; Figure 4-23). Recent recruitment was evident, as live juveniles were collected at Ionia, Flat River, Chief Hazy Cloud, Riverside Park, Upstream, and between the 6th Street Dam and Fulton Street (Table 3-3). *Lasmigona costata* was found throughout the area between 6th Street Dam and Fulton Street (Figure 4-24), and frequency averaged 4.0% (Table 1-2). *Lasmigona costata* would be adversely affected during Project construction, but physical habitat should be improved with the Project (Appendix F).

Utterbackia imbecillis (Paper Pondshell) - Species of Special Concern

Utterbackia imbecillis is a small- to medium-sized mussel, reaching lengths up to 10 cm (3.9 in) (Cummings and Mayer, 1992). The shell is elongate, compressed in young individuals, becoming inflated in older individuals. The anterior end is rounded, and the posterior end is somewhat pointed (Cummings and Mayer, 1992). The shell is very thin and may be transparent in younger individuals. The umbos are positioned anteriorly, flattened, and do not extend above the hinge line. Beak sculpture is double-looped, with several fine wavy ridges (Cummings and Mayer, 1992; Mulcrone, 2016). The periostracum is smooth, yellow in younger individuals and on the beaks of older individuals, becoming brownish green in older individuals. The nacre is white to bluish white (Cummings and Mayer, 1992; Mulcrone, 2016).

Utterbackia imbecillis is bradytictic. Gravid females have been observed from April through September (Watters et al., 2009), and MNFI (2018) reports the active gravid period as year-round. Potential host fish are primarily Centrarchidae, but glochidia have been successfully transformed in the laboratory on some Cyprinidae, non-fish species (*Ambystoma tigrinum* [Tiger Salamander], *Rana catesbeiana* [Bullfrog]), and numerous non-native fish species (Watters et al., 2009; Mulcrone, 2016). Many of these potential hosts have been reported from the Grand River within Grand Rapids (Table 1-3). Habitat preferences of Centrarchidae hosts are generally similar; most prefer low velocity pools and spawn over sand or gravel substrate (Edwards et al., 1982b; Stuber et al., 1982a, 1982b; Aadland and Kuitunen, 2006). Slow moving, relatively deep, pool-type habitat that may be suitable for centrarchid species is currently lacking in the Project Area but would be improved with the Project.

Utterbackia imbecillis typically occurs in slow-flowing pools and impoundments in soft sand and mud substrate (Parmalee and Bogan, 1998; Williams et al., 2008; Watters et al., 2009). This species is found in the Mississippi River, Great Lakes, and Atlantic slope drainages. It is found throughout the eastern half of the United States and portions of Canada, from Ontario south to Alabama, and as far west as New Mexico (NatureServe, 2015). In Michigan, *U. imbecillis* is found in the Kalamazoo, Manistique, Pere Marquette-

White, St. Claire, and St. Joseph (Lake Michigan) (Badra, 2010), as well as in Lake Erie (Mulcrone, 2016). This species was not reported by van der Schalie (1948) or Coker et al. (1919) but was found in the middle and lower river in more recent surveys (Table 2-7). It has been found either alive or as a fresh shell from Lyons through Grand Rapids (Table 3-2). The only site where this species was found alive in recent surveys was within the mussel bed at Saranac (Table 2-7). However, shells were found at Riverside Park, Roselle Park, Upstream, between the 6th Street Dam and Fulton Street, and at the I-196 south bridge (Table 2-7; Figure 4-25 and 4-26). It may occur in slow flowing areas along the RDB in the Project Area, but at a low frequency. No live juveniles have been collected in recent surveys (Table 3-3); given the rarity of *U. imbecillis*, the recruitment status of this species cannot be determined. If it occurs within the Project Area, it would be adversely affected during construction. Slow flowing near bank habitat area would improve with the Project, but soft sand and silt substrate are not expected (Appendix F).

4.3 Species Considered in the BA

The primary species considered for both projects in this BA is the federally endangered mussel *E. triquetra*.

Michigan TES could potentially be listed as federally threatened or endangered within the life of both projects. Freshwater mussel species that occur in the Action Area and are listed in Michigan (*L. recta*, *T. parvum*, *C. tuberculata*, *A. viridis*, *P. sintoxia*, *P. alatus*, *T. truncata*, *V. ellipsiformis*, *A. marginata*, *L. compressa*, *L. costata*, and *U. imbecillis*) are considered in this BA. Freshwater fish species listed in Michigan that occur in the Action Area (*A. fulvescens* and *M. carinatum*) are also considered in this BA. *Cambarunio* (*Villosa) iris* is not considered, as this species has not been found alive in the lower Grand River.

5.0 EFFECTS OF PROPOSED ACTION

The construction area for the NRCS project spans from 91 m (300 ft) upstream of Bridge Street to Fulton Street, 127,600 m^2 (31.5 acres). Of this 45,445 m^2 (11 acres) would be directly impacted during construction, and the areas between direct impact areas (82,155 m^2; 20 acres) would be indirectly impacted by temporary increases in turbidity and changes in flow patterns associated with causeways and features constructed in the river. Scouring of the existing riverbed outside of direct impact areas is not anticipated during construction. Upstream indirect impacts during construction (38,420 m^2; 9.5 acres) would be limited to slight changes in depth and velocity depending on what construction and project features are in the river. Construction sequencing has been developed to ensure increases in modeled tailwater levels are avoided and minimized during *P. marinus* migration. Barrier criteria for *P. marinus* would be maintained through construction and post-construction, and Great Lakes Fish Commission (GLFC) who monitors the Grand River for *P. marinus*, have been notified of the project.

Downstream indirect impacts (282,600 m^2; 70 acres) are expected to be minor. Turbidity may increase between Fulton Street and Plaster Creek during construction. To minimize turbidity, BMPs would be implemented where appropriate as approved by EGLE, and turbidity would be monitored and adaptively managed. A turbidity monitoring and an adaptive management plan would be developed during the permitting process. The exact construction methods used by the contractor would not be known until the contractor is selected. The construction methods presented in Section 2 describe a feasible construction configuration and represent the maximum allowable take of unionid mussels, but the contractor would be encouraged to develop methods that would affect fewer unionid mussels. Take is estimated on construction described in Section 2:

The Project would be constructed from causeways constructed in the river or with equipment tracking on the river bottom. One small area within the Dam 2 direct impact area would be isolated from the flow of the river for construction. All unionids, and any fish that do not leave the direct impact areas, outside the isolation area may be crushed under causeways or by tracking equipment, excavation, grading, and placement of rock. To minimize mortality of unionid mussels, mussels would be collected and translocated from as much area as practicable within direct impact areas under the Grand Rapids/GRWW project. If an equal mussel density of 0.3 unionids/m^2 is assumed throughout the direct impact areas (45,445 m^2), approximately 123 *E. triquetra*, 1,800 Michigan TES, and 11,711 other mussels occur in direct impact areas (Table 5-1). If mussels can be translocated from all of the direct impact area (best case), with a collection efficiency of 85% and 5% mortality due to handling, take would only be from translocation and is expected to include 19 *E. triquetra*, 283 Michigan TES, and 1,845 common species (Table 5-2). This would be the minimum Take (Table 5-4).

Under worst case conditions (maximum Take), mussels would at least be translocated from within the small, isolated area (3,285 m^2). The construction team would need to wait for fish and unionids to be moved from within the isolated area before construction. A maximum of 10 days of mussel translocation is allocated for this effort. Approximately 9 *E. triquetra*, 130 TES, and 847 common species occur in the isolated area (Table 5-1). Collection efficiency in this area is expected to be 85%; however, up to 5% mortality could occur from handling. Take from the translocation effort is expected to include 1 *E. triquetra*, 21 TES, and 133 common species (Table 5-2). Worst case, mussels would only be collected from the isolated area, mussels in other parts of the direct impact area would be negatively impacted. Take

from direct impact areas where mussels are not translocated would include 114 *E. triquetra*, 1,670 Michigan TES, and 10,865 common species (Table 5-3). Total take (uncollected direct impact areas + translocation Take) would include 115 E. *triquetra*, 1,690 Michigan TES, and 10,998 other mussels (Table 5-4).

The most likely scenario is if river conditions permit, mussels should be translocated from the isolated area and all areas with ≤0.6 m/sec (2 ft/sec) velocity. The estimated number of mussels in low velocities areas combined includes 31 *E. triquetra*, 456 Michigan TES, and 2,966 other individuals. Translocation Take would include 3 *E. triquetra*, 51 Michigan TES, and 334 other individuals (Table 5-2). An additional 88 *E. triquetra*, 1,298 Michigan TES, and 8,445 other mussels would be killed in areas where collection could not occur due to unsafe conditions (Table 5-3). Total take under this scenario (direct impact areas >0.6 m/sec [not translocated] + translocation take) would be 92 *E. triquetra*, 1,349 Michigan TES, and 8,779 common mussels (Table 5-4).

Mussels may also be temporarily affected by increased turbidity and changes in local hydraulic conditions in Construction Area indirect impact areas. No scour holes are expected to develop during construction outside of direct impact areas. Host fish activity in these areas may be altered. Turbidity would be monitored and adaptively managed to minimize these effects. The area of construction indirect impact area is approximately 82,155 m^2 (Table 5-5). Approximately 21,171 mussels, including 222 *E. triquetra* and 3,253 Michigan TES could occur in the Construction Area indirect impact area (Table 5-5). These mussels could be temporarily stressed during construction or host fish may not be available during glochidial release, and a few year classes may be lost.

Approximately 11,526 mussels including 104 *E. triquetra* and 1,521 Michigan TES could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes in the upstream indirect impact area (6th Street Dam to 91 m [300 ft.] upstream of Bridge Street) are not expected to have an adverse effect on unionid mussels.

Approximately 28,260 mussels including 55 *E. triquetra* and 9,510 Michigan TES could occur in the downstream indirect impact area (Table 5-5). Although mussel density within the downstream indirect impact area (Fulton Street to Plaster Creek) is very low (approximately 0.1/m^2), increased turbidity during construction may cause nutritive stress and potentially reproductive failure in some areas during construction. Turbidity plumes would be temporary and are not expected to cause mortality. Additionally, turbidity would be monitored and adaptively managed to reduce impacts.

Most fish should vacate the Project Area due to construction activity and as many as practicable would be salvaged from within the isolated area. However, some mortality of small fish (Cyprinidae, Percidae, juvenile fish) is expected. Some of these species may be unionid hosts; however, this should not affect the reproductive success of mussels in direct impact areas during construction, as no mussels would be in the area to reproduce. Mussels in Construction Area indirect impact areas may lose a few year classes.

Most fish species that might use the Project Area for spawning (*S. vitreus* and *Moxostoma* spp.) typically spawn during the high-water periods of April through early June, construction would be limited to lower water levels. *Acipenser fulvescens* may not use the Project Area for spawning (S. Hanshue, MDNR,

personal communication), but would likely move to other reaches of the Grand River during construction. *Moxostoma carinatum* may use the Project Area for spawning (S. Hanshue, MDNR, personal communication), but *M. carinatum* spawns in the Spring during high water and would not be expected to spawn while construction is occurring.

Both *M. carinatum* and *A. fulvescens* may spawn within the downstream indirect impact area near Plaster Creek. Increases in turbidity that might occur should not impact spawning, as these species typically spawn during high water when turbidity is high. *Moxostoma carinatum* also spawns in other areas of the Grand River.

Some impacts to mussels could also occur if OMRRR is needed. The maximum amount of area needed for OMRRR is expected to be 10,000 m^2 if equipment needs to track into the river. Approximately, 27 *E. triquetra*, 396 Michigan TES, and 2,577 common mussels could be within the area affected by tracking (Table 5-6). If possible, mussels would be translocated from any areas that might be impacted to minimize Take.

Once the project is complete, habitat would be available for most fish and mussel species that occurred prior to the project. A few areas of scour forming deeper holes may occur downstream of the Dam 2 diversified boulder arches, but holes would be within the area previously affected by construction. Overall, current velocity would be greater upstream of I-196 and depth would be shallower. Within emergent habitat boulder fields, depth would increase, velocity would be slower and flow refugia would be provided behind boulders. More slow flowing area would also be available along banks. Habitat for host fish should improve. Mussel habitat may also improve, as less area would have scouring flows and more flow refugia would be available.

Most of the fish species that occur in the Project Area, including those that serve as hosts for TES, also occur upstream and downstream of the Project Area (Table 1-3). Colonization by mobile fish species should occur within a few years of completed construction and use by migratory fish species would be expected soon after construction is complete. Although *P. caprodes* are considered sedentary, they can travel long distances (Schwalb et al., 2011). *Percina caprodes* and other *Percina* and *Etheostoma* species were found over 2 km (1.2 miles) upstream of a dam removal on Mill Creek, a Huron River tributary, within four years after dam removal and installation of a rock arch structure (Braunscheidel, 2014; MDNR, unpublished data).

The actions and time required for unionids to successfully utilize created habitat is largely experimental. Natural recolonization by unionid mussels could require several years due to the need for biofilm and bacteria to colonize within the substrate, invertebrates to colonize, and host fish to colonize, particularly sedentary host fish such as *P. caprodes*. Although literature on fish and invertebrate colonization of created habitat is available, little is known on recolonization by unionid mussels. Fish and invertebrate colonization of restored river areas often occurs within a few years depending on mobility of species, proximity to a seed source, food source availability, and availability of suitable habitat (Malmqvist et al., 1991; Detenbeck et al., 1992; Peterson and Baylay, 1993; Miller, 2006; Stoll et al., 2014; Li et al., 2016), although maturation of an invertebrate assemblage after restoration may require decades (Winking et al., 2016). Unionid mussel recolonization rates are not well documented but appear to be a function of

hydrophysical habitat (substrate, flow) stability, host fish mobility, and proximity to a seed source (Eckblad, 1999; ESI, 2000; Haag, 2012; J. Clayton, WVDNR, personal communication; Dunn, personal observation). It may require decades to establish a species rich, reproducing assemblage.

A few unionid habitat creation projects (Miller, 2006; Kelner, 2015) and recolonization studies (ESI, unpubl. data; J. Clayton, WVDNR, unpubl. data) have been documented. An artificial riffle/pool sequence was constructed in a side channel below a dam in the Tombigbee River in early 1980's. Invertebrates colonized the riffle in the Tombigbee River within three months, and invertebrate density and diversity were similar to nearby natural gravel bars within one year (Miller, 2006). Fish also recolonized within one year. In the year following construction, 39 fish species were collected in the riffle, including Cyprinidae, *Etheostoma* sp., and *Percina* sp. Juveniles of a few common unionid species (*O. reflexa*) were collected in invertebrate samples immediately following construction. However, intensive unionid sampling was not conducted until 16 years later, lending scant information on unionid recolonization rates.

A unionid habitat creation project was also conducted in Pool 11 of the Mississippi River in an area where unionids previously did not reside (USACE, 1989). The project goal was to establish a self-sustaining unionid assemblage by creating both fish and unionid habitat using host fish and unionid habitat criteria. A dense, species rich unionid assemblage (31 unionids/m^2, 26 live species; ESI, 2013) occurred approximately 8 km (5 miles) upstream of the project (seed source). The project was completed in 1992 and qualitatively assessed in 2000, and unionids were observed in depositional areas among large boulders; however, no quantitative information was provided. The area was not quantitatively monitored for unionids until 2014 (Kelner, 2015). In 2014, density ranged from 0.8 to 4.8 unionids/m^2 and 14 species were collected. All unionids were ≤10 years old, indicating they colonized >10 years post-construction (Kelner, 2015).

A few recolonization studies are currently being conducted in areas where unionids were removed for construction or were removed during cleanup efforts. Unionids are recolonizing a bridge construction area on the New River in West Virginia (ESI, 2017b) and in a coal spill area in the Mississippi River (ESI, unpubl. data). In both cases, juvenile unionids and opportunistic unionid species were present within a few years; within three years on the New River and one year in the Mississippi River. Within four years, unionid density in the Mississippi River area was approximately the same as the reference assemblage, and other metrics (rarefaction richness, % fresh dead shells, % ≤5 years old, % tolerant species, % Tribe Lampsilini, species evenness, tribe evenness, 75th percentile abundance) were similar to the reference assemblage. However, in both areas, unionid assemblages (seed sources) were present immediately adjacent to the affected site (affected site was within the mussel bed area).

After 10 years, a unionid assemblage on the Ohio River has recolonized with similar species and density to pre-mussel kill (ESI, 2002; Janet Clayton, WVDNR, pers. comm.). In this area, other mussel beds occurred within a few kilometers upstream and natural recolonization was supplemented with propagated individuals. Other killed-off unionid beds within the same pool but further away from good seed sources did not recolonize as quickly, although other stressors may have contributed to the lack of recolonization (Janet Clayton, WVDNR, personal communication).

From these examples, it can be concluded that initial colonization by unionids requires a few years with a unionid assemblage immediately adjacent to the site to over 10 years with farther removed seed sources and no addition of unionids from propagation or other sources. A diverse unionid assemblage occurs upstream of the Project Area, which should supply a natural recolonization source for Project Area colonization. Unionids and host fish within the upstream and construction indirect impact areas would also be available to facilitate recolonization. However, the time required for substrate to acquire necessary biotic components for unionid survival and for a mussel assemblage to become established is unknown.

Once construction is complete, recreational use of the Project Area may increase. Shallow, slow flowing areas near the banks would be more accessible to waders and anglers, and canoeing and kayaking would be more frequent. Unionid mussels that recolonize the area may be stressed by handling and/or boaters dragging boats over shallow areas. Post-project harm could be partially mitigated through educational programs by project partners that would be developed in the future.

6.0 CUMULATIVE EFFECTS

At EGLE's request, the City provided a list of Projects planned along the Grand River. The submittal letter along with descriptions of the projects and potential impacts of the projects to TES is provided in Appendix G. These projects would be consulted on separately and are not part of the projects discussed above. Updates since that memo was compiled are mentioned here. The 14 projects include:

- Corps of Engineers Project of replacing the the 6th Street Dam with an Adjustable Hydraulic Structure. This is a federal project and not considered in Cumulative Effects for this BA.
- Lyon Edge Project- This project is in the conceptual design phase. No work is proposed in the Grand River. Mussel and fish would not be affected.
- East River Edge Project (Campau)- The project is along the east bank, upstream of Fulton St. *E. triquetra* and *L. recta* may be in the project area. MDNR and USFWS coordinated on this project. USFWS concluded there was no reasonable certainty of take to *E. triquetra*, as the project was above the low water 890 CFS mark.
- GRPM Riverfront- Work only extends 0.3 m (1 ft) into the river and is expected to have minimal impact on fish and freshwater mussels. MDNR and USFWS coordinated on this project. USFWS concluded there was no reasonable certainty of take to *E. triquetra*, as the project was above the low water 890 CFS mark.
- Leonard St. to Ann St. Trail- No work will be in the river.
- Coldbrook Water Pump Station- This project is in the master plan stage. Project is upstream of the 6th Street Dam, where mussel density is approximately 1.7/m^2. TES mussels could potentially be affected by this project. Mussel translocation is planned to minimize impacts. USFWS and MDNR would be coordinating on this project.
- Fish Ladder Park- This project is in the master plan stage. Project is upstream of the 6th Street Dam, where mussel density is approximately 1.7/m^2. TES could be in the river near this area. The project is only in the Master Plan phase.
- Wealthy St. Access- This project is a concept design. It is downstream of Fulton St., where no *E. triquetra* have been found and mussel density averages 0.1/m^2. Michigan TES mussels could be affected. Mussels would be translocated to minimize impacts.
- 201 Market Ave. (updated)- This project is expected to submit for a permit application to EGLE in Spring 2024. The proposed project does not extend past the 890 CFS line, and no equipment is expected in the river. Therefore, no direct impacts to mussels are anticipated. Appropriate soil erosion and sedimentation control BMPs would be installed to minimize any potential indirect impacts to mussels.
- Canal Park (updated)- No activity would be in the river. A removable kayak dock would be added to this park and would be anchored to the floodwall. There would be no direct placement onto the riverbed. Minor impacts from shading of the riverbed from the kayak dock are expected.
- 6th St. Park- This project is a conceptual design and is upstream of the 6th Street Dam where mussel density is approximately 1.7/m^2. TES could be impacted. A mussel translocation is planned.
- Riverside Park- This project is only in the Master Plan phase. It would impact approximately 4,046 m^2 of river, where mussel density is approximately 3/m^2. TES could be impacted, and a mussel translocation is planned.
- Ah-Nab-Awen Park south- No impacts on wildlife and habitat, including TES, as this project is out of the river and within current park space.

7.0 CONCLUSION AND DETERMINATION OF EFFECTS

The Project may affect and is likely to adversely affect *E. triquetra* under Section 7 of the ESA, and result in take of *E. triquetra*, *L. recta*, *C. tuberculata*, *A. viridis*, *P. sintoxia*, *P. alatus*, *T. parvum*, *T. truncata*, *V. ellipsiformis*, *A. marginata*, *L. compressa*, *L. costata*, and *U. imbecillis* as defined in NREPA part 365. Effects would be minimized through collection and translocation; however, all individuals would be harmed and considered take, and some stress and possibly mortality of those translocated may occur. Temporary turbidity may have temporary effects on mussels within the Construction Area indirect impact area and downstream indirect impact areas. Turbidity would be minimized through use of BMPs, monitoring, and adaptive management. Increases in tailwater elevations at the 6th Street Dam would be avoided and minimized during construction and avoided after construction to maintain the *P. marinus* barrier. An 18 inch vertical barrier to *P. marinus* would be maintained during and after construction at similar flow rates as existing conditions. The Project would not jeopardize the continued existence of *E. triquetra*, as it is not endemic to the Grand River, populations occur throughout the lower Grand River and the Midwest, and aquatic habitat is designed to be improved with the Project.

The Project could result in take of *A. fulvescens* and *M. carinatum* under NREPA part 365. They may be prevented from using the Project Area during construction, but habitat is designed to be improved by the Project. They may be temporarily affected by increased downstream turbidity. Both species may spawn near Plaster Creek (S. Hanshue, MDNR, personal communication). Plaster Creek is approximately 2.5 km (1.5 miles) downstream of the Project Area and increases in turbidity would be minimal in this area. Additionally, these species spawn in the Spring, when turbidity is normally high, and construction would not occur during their spawning season.

Five of the non-federal projects planned (or being planned) near or within Grand Rapids could impact mussel and fish species. Riverside Park is in a high density unionid area (3/m^2) and could affect *E. triquetra* and Michigan TES. Fish Ladder Park and 6th Street Park are all upstream of the 6th Street Dam, where mussel density is approximately 1.7/m^2 and *E. triquetra* and Michigan TES could be affected. East River Edge Project is just upstream of Fulton St. along the east bank; this is within the Project Area and could affect *E. triquetra* and Michigan TES. Wealthy Street access project is downstream of Fulton Street and could affect *E. triquetra* and Michigan TES. USFWS and MDNR would be consulted on these projects as they progress.

7.1 Federal Endangered Species

Epioblasma triquetra (Snuffbox)

The NRCS Project may affect and is likely to adversely affect *E. triquetra*, but would not jeopardize the continued existence of this species. *Epioblasma triquetra* occur at a low frequency (0.9%) within the Project Area. An estimated 123 *E. triquetra* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *E. triquetra* from within at least the isolated area to minimize harm and 5% mortality is expected during translocation (Table 5-2). At a minimum, 19 *E. triquetra* would be directly harmed during translocation if all unionids in direct impact areas are translocated (Table 5-4). If only mussels in the isolated area are translocated, 115 *E. triquetra* could be directly harmed (Table 5-4). An additional 27 could be harmed by OMRRR activities (Tables 5-6). OMRRR take would be reduced by translocation if practical. Approximately 104 *E. triquetra* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not

expected to adversely affect *E. triquetra*. Approximately 222 *E. triquetra* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. Based on relative abundance at the I-196 bridge, approximately 55 *Epioblasma triquetra* may occur downstream of Fulton Street and could be indirectly affected by any downstream increased turbidity.

The Grand River harbors a stronghold population of this species between Lyons, MI to Fulton Street, approximately 85 river km (53 river miles), and harbors one of the few populations with a high demographic status (reproducing population) in the United States or Canada (USFWS, 2012, 2022). The Project may temporarily shorten this stretch of habitat to 84 river km (52.4 river miles), and not jeopardize the continued existence of this species. Habitat created by the Project between Bridge Street and Fulton Street is expected to improve habitat for *E. triquetra* and its host *P. caprodes*. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

7.2 Michigan Endangered Species

Toxolasma parvum (Lilliput)

The Project could result in take of *T. parvum*. *Toxolasma parvum* has not been collected within the Project Area. However, they were collected upstream at the Riverside Park and Ionia sites. *Toxolasma parvum* have not recently been collected from the downstream indirect impact area, but a few individuals could be affected by increased turbidity. A few *T. parvum* could be adversely affected by this Project. This species is fairly common in other areas of its range, although only in its preferred habitat.

7.3 Michigan Threatened Species

Cyclonaias tuberculata (Purple Wartyback)

The NRCS Project would result in take of *C. tuberculata*. *Cyclonaias tuberculata* occur at a frequency of 2.9% within the Project Area. An estimated 390 *C. tuberculata* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *C. tuberculata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 61 *C. tuberculata* could be negatively impacted during translocation (Table 5-4). If only mussels in the isolated area are translocated, 366 *C. tuberculata* could be negatively impacted (Table 5-4). An additional 86 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 330 *C. tuberculata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *C. tuberculata*. Approximately 705 *C. tuberculata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Cyclonaias tuberculata* has been collected downstream of Fulton Street and an estimated five could be indirectly affected by any downstream increased turbidity (Table 5-5).

The Grand River harbors a reproducing population of *C. tuberculata* at least from Lyons, MI to downstream of Fulton Street, over 85 river km (53 river miles). The Project may temporarily shorten this stretch of habitat by 880 m (2,894 ft). This species occurs in many other rivers in the Midwest. Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *C. tuberculata* and its Ictaluridae hosts. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Ligumia recta (Black Sandshell)

The NRCS Project would result in take of *L. recta*. *Ligumia recta* occur at a frequency of 2.9% within the Project Area. An estimated 394 *L. recta* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *L. recta* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). At a minimum, 62 *L. recta* would be directly impacted during translocation if all unionids in direct impact areas are translocated (Table 5-4). If only mussels in the isolated area are translocated, 370 *L. recta* could be directly impacted (Table 5-4). An additional 87 could be directly impacted by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 333 *L. recta* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *L. recta*. Approximately 712 *L. recta* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Ligumia recta* has been collected downstream of Fulton Street and an estimated 255 could be indirectly affected by any downstream increased turbidity.

The Grand River harbors a reproducing population of *L. recta* at least from Lyons, MI to downstream of Fulton Street, over 85 river km (53 river miles). The Project may temporarily shorten this stretch of habitat by 880 m (2,894 ft). This species occurs in many other rivers in the Midwest. Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *L. recta* and its hosts. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Alasmidonta viridis (Slippershell)

The Project could result in take of *A. viridis*. *Alasmidonta viridis* historically occurred throughout the Grand River, but only one individual has been reported since 1950. This individual was collected within the Project Area. This species is typically found in small streams and may have been a stray individual dropped from a host fish. It may be more common in tributary streams within the Grand River watershed. There is a chance that a few *A. viridis* would be adversely affected by this Project (Tables 5-4, 5-5, 5-6).

Although rare in the Grand River, it has been reported in several Michigan rivers and occurs throughout the Great Lake and Mississippi River basin.

Acipenser fulvescens (Lake Sturgeon)

The Project could result in take of *A. fulvescens*. *Acipenser fulvescens* occur from the mouth of the Grand River to the 6th Street Dam. They would not have use of parts of the Project Area during construction.

They have been observed within the Project Area, but the closest suspected spawning area is in Plaster Creek, 2.5 km (1.6 miles) downstream of the Project Area. Additionally, *A. fulvescens* spawns in the Spring, when turbidity is normally high, and construction would not occur during their spawning season. The Project would not directly or indirectly affect *A. fulvescens* spawning.

Moxostoma carinatum (River Redhorse)

The Project may result in take of *M. carinatum*. *Moxostoma carinatum* occur from the mouth of the Grand River to at least Lyons, MI and in the Maple River. They would not have use of parts of the Project Area during construction. They have been recently collected within the Project Area and may spawn in the Project Area. Recruitment of this species in the Grand River may be reduced during Project construction; however, project construction is not expected to occur during their spawning season. They should return after the Project is completed. They have also been reported to spawn near Plaster Creek, 2.5 km (1.6 miles) downstream of the Project Area. Increases in turbidity near Plaster Creek should be minimal and spawning should not be affected.

7.4 Michigan Species of Special Concern

Pleurobema sintoxia (Round Pigtoe)

The NRCS Project would result in take of *P. sintoxia*. *Pleurobema sintoxia* occur at a frequency of 0.4% within the Project Area. An estimated 59 *P. sintoxia* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *P. sintoxia* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 9 *P. sintoxia* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 55 *P. sintoxia* could be directly affected (Table 5-4). An additional 13 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 50 *P. sintoxia* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *P. sintoxia*. Approximately 106 *P. sintoxia* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Pleurobema sintoxia* has not been collected downstream of Fulton Street, but may occur there and a few could be indirectly affected by any downstream increased turbidity.

The Grand River harbors a reproducing population of this species at least from Lyons, MI to Fulton Street, over 85 river km (53 miles). The Project may temporarily shorten the stretch of *P. sintoxia* habitat by 880 m (2,894 ft), but this species occurs throughout the Midwest. Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *P. sintoxia* and its Cyprinidae hosts. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Potamilus alatus (Pink Heelsplitter)

The NRCS Project would result in take of *P. alatus*. *Potamilus alatus* occur at a frequency of 0.5% within the Project Area. An estimated 74 *P. alatus* occur in the direct impact area (Table 5-1). The Grand

Rapids/GRWW relocation project would translocate 85% of *P. alatus* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 12 *P. alatus* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 69 *P. alatus* could be directly affected (Table 5-4). An additional 16 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 62 *P. alatus* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *P. alatus*. Approximately 133 *P. alatus* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Potamilus alatus* was collected downstream of Fulton Street, approximately 705 could be indirectly affected by any downstream increased turbidity.

This species appears to be limited to downstream of the 6th Street Dam along with its host *A. grunniens*. They have been found at several sites downstream of Fulton Street and are fairly common in the Mississippi River basin. Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *P. alatus* and *A. grunniens*. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Truncilla truncata (Deertoe)

The NRCS Project would result in take of *T. truncata*. *Truncilla truncata* occur at a frequency of 1.7% within the Project Area. An estimated 230 *T. truncata* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *T. truncata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 36 *T. truncata* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 216 *T. truncata* could be directly affected (Table 5-4). An additional 51 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 195 *T. truncata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *T. truncata*. Approximately 417 *T. truncata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Truncilla truncata* has been collected downstream of Fulton Street and an estimated 8,530 could be indirectly affected by any downstream increased turbidity.

This species appears to primarily occur downstream of the 6th Street Dam along with its host *A. grunniens*. They have been found downstream of Fulton Street and a few have been found upstream of the Project Area. They are fairly common in the Mississippi River basin. Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *T. truncata* and *A. grunniens*. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Venustaconcha ellipsiformis (Ellipse)

The NRCS Project would result in take of *V. ellipsiformis*. *Venustaconcha ellipsiformis* occur at a frequency of 0.06% within the Project Area. An estimated 8 *V. ellipsiformis* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *V. ellipsiformis* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 1 *V. ellipsiformis* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 8 *V. ellipsiformis* could be directly affected (Table 5-4). An additional 2 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 7 *V. ellipsiformis* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *V. ellipsiformis*. Approximately 15 *V. ellipsiformis* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Venustaconcha ellipsiformis* has not been collected downstream of Fulton Street, but may occur there and a few could be indirectly affected by any downstream increased turbidity.

They have been found in the Grand River at least from Lyons, MI to Fulton Street, over 85 river km (53 river miles). The Project would temporarily shorten their stretch of habitat by 880 m (2,894 ft). Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *V. ellipsiformis* and its *Percina* sp. and *Etheostoma* sp. hosts. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Alasmidonta marginata (Elktoe)

The NRCS Project would result in take of *A. marginata*. *Alasmidonta marginata* occur at a frequency of 0.7% within the Project Area. An estimated 98 *A. marginata* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *A. marginata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 15 *A. marginata* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 92 *A. marginata* could be directly affected (Table 5-4). An additional 22 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 83 *A. marginata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *A. marginata*. Approximately 177 *A. marginata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. A few *A. marginata* were collected downstream of Fulton Street at the I-196 bridge, and a few could be indirectly affected by any downstream increased turbidity.

The Grand River harbors a reproducing population of this species at least from Lyons, MI to Fulton Street, over 85 river km (53 river miles). The Project would temporarily shorten this stretch of habitat by 880 m (2,894 ft), but this species occurs throughout the Midwest. Habitat created by the Project between Bridge

and Fulton Street is expected to improve habitat for *A. marginata* and its hosts. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Lasmigona compressa (Creek Heelsplitter)

The Project may result in take of *L. compressa*. *Lasmigona compressa* has not been collected within the Project Area or in the indirect impact areas, but a few were collected during a survey of the I-196 bridge downstream of Plaster Creek. They were also collected upstream at the Roselle Park site. There is a chance that a few *L. compressa* would be adversely affected by this Project. This species typically occurs in creeks and headwaters of small to medium streams throughout the Midwest.

Lasmigona costata (Flutedshell)

The NRCS Project would result in take of *L. costata*. *Lasmigona costata* occur at a frequency of 4.0% within the Project Area. An estimated 543 *L. costata* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *L. costata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 85 *L. costata* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 510 *L. costata* could be directly affected (Table 5-4). An additional 119 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 459 *L. costata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *L. costata*. Approximately 981 *L. costata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Lasmigona costata* has not been collected downstream of Fulton Street, but may occur there and a few could be indirectly affected by any downstream increased turbidity.

The Grand River harbors a reproducing population of this species at least from Ionia, MI to Fulton Street. The Project would temporarily shorten this stretch of habitat by 880 m (2,894 ft), but this species occurs throughout the Midwest. Habitat created by the Project between Bridge and Fulton Street is expected to improve habitat for *L. costata* and its hosts. However, habitat creation for unionid mussels is experimental and colonization of the Project Area could take several years.

Utterbackia imbecillis (Paper Pondshell)

The Project Could result in take of *U. imbecillis*,. A fresh shell of *U. imbecillis* was collected within the Project Area, and shells or live individuals have been recently collected from Lyons, MI to the Project Area. There is a chance that a few *U. imbecillis* would be adversely affected by this Project. This species typically occurs in backwater or muddy near bank areas that are not common in the Project Area. A few may be collected during the translocation, and a few could be affected by this Project. This species has not recently been collected within the indirect impact area, but a few individuals could be affected. Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize downstream turbidity. This species has been recently collected live or as a fresh shell from Lyons to Fulton Street, and it is common in other parts of its range.

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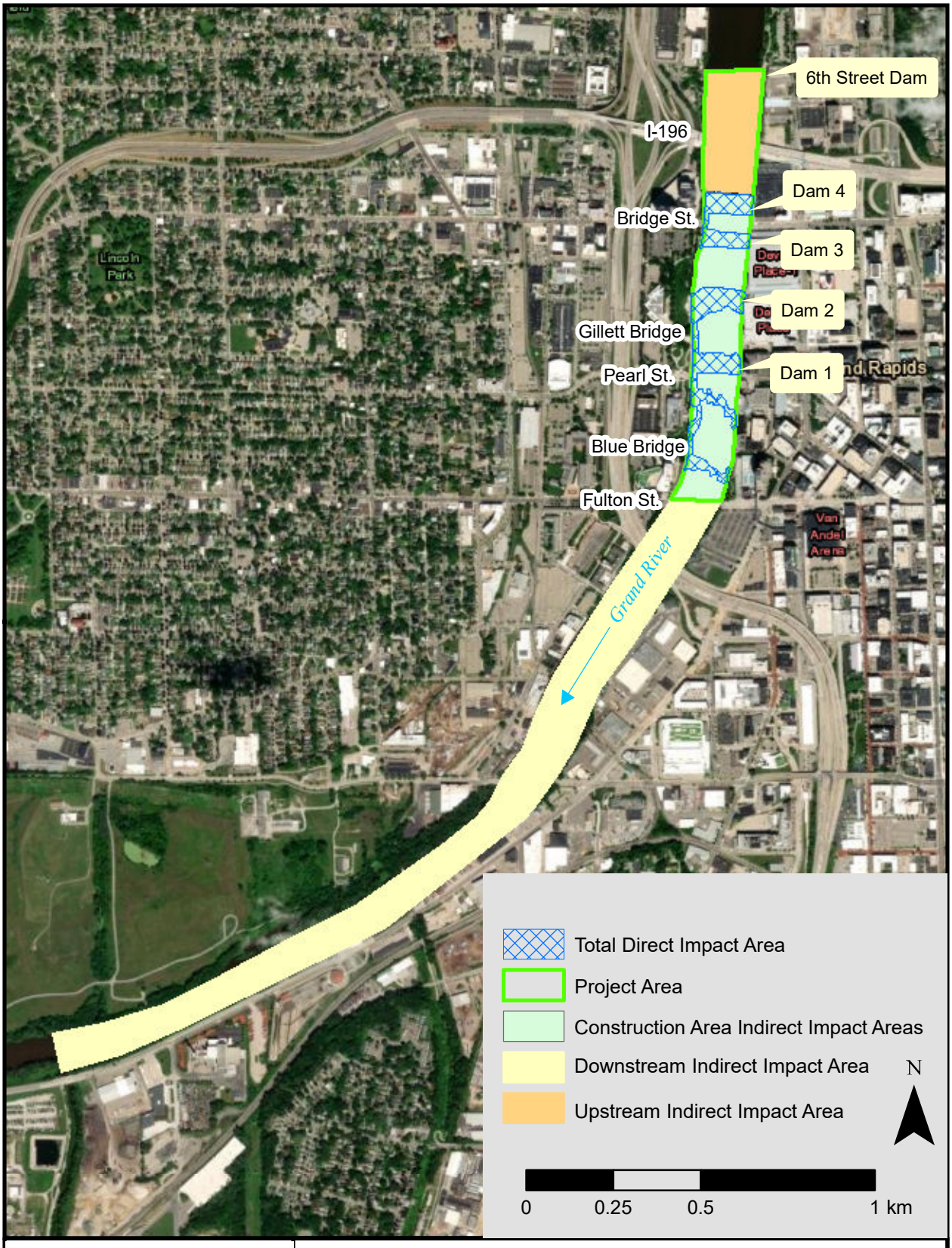

Figure 1-1. Components of the Project Area, Direct and Indirect Impact Areas.

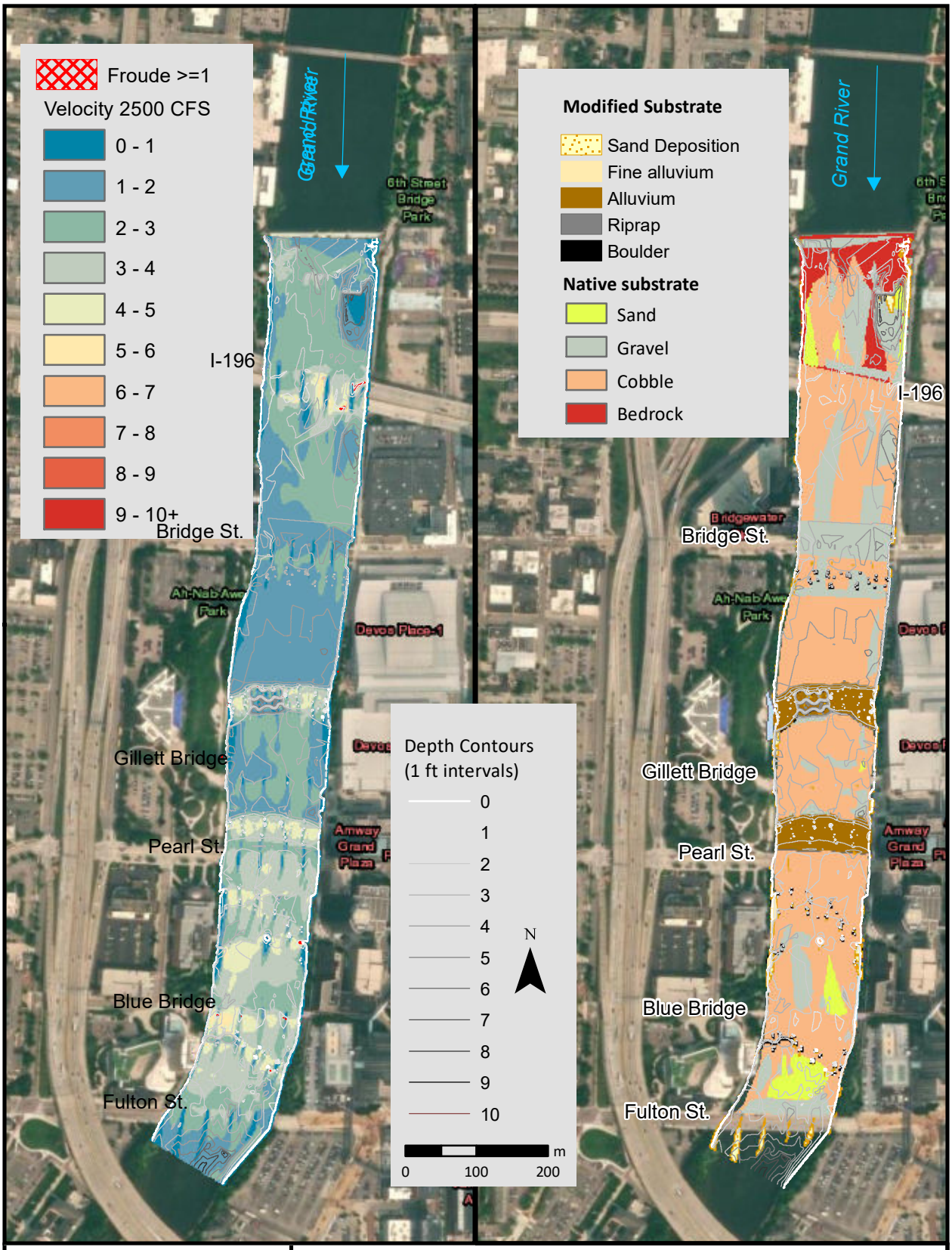

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Figure 1-2. Project Area features, velocity, depth, and substrate.

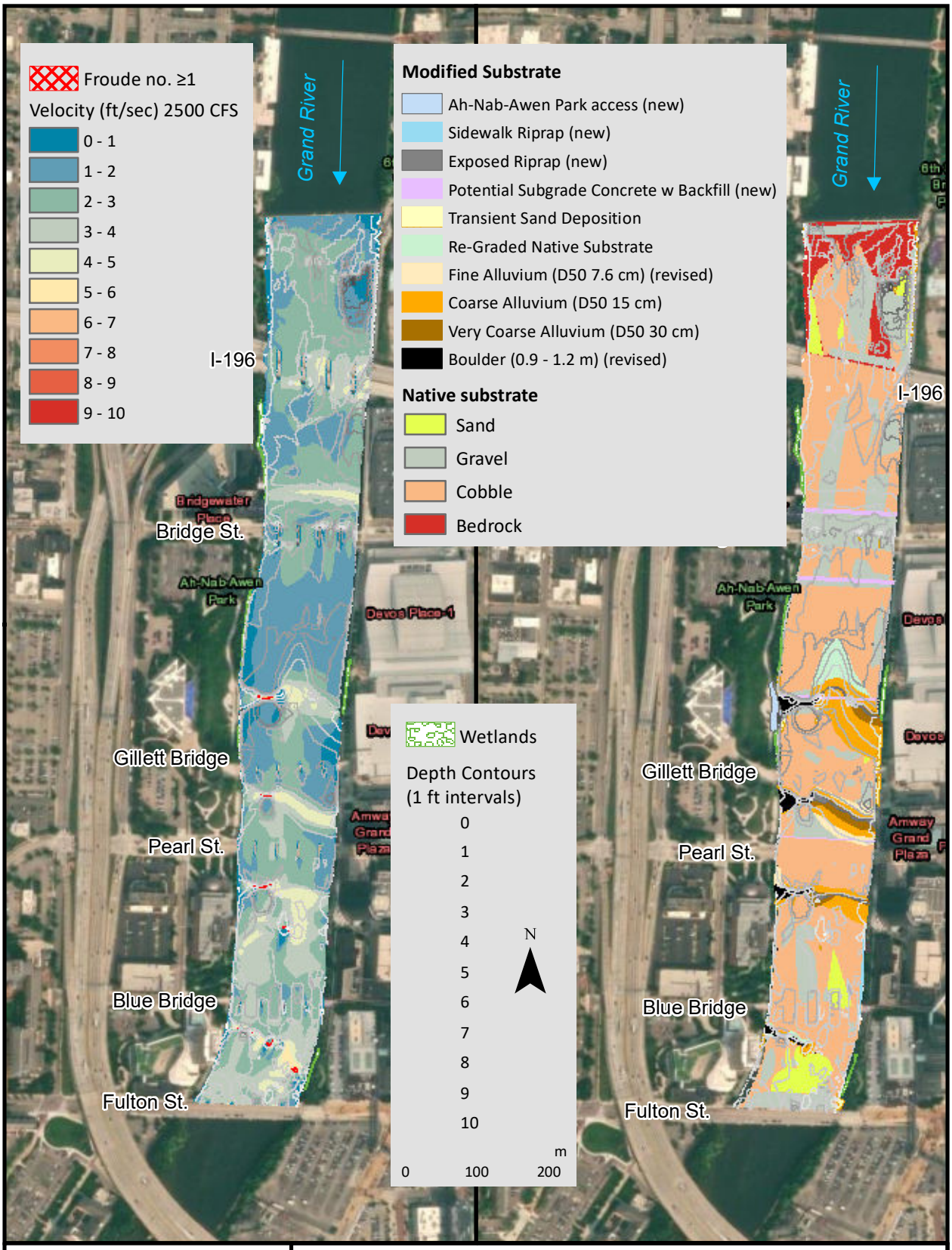

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Figure 1-3. 2020 Project Area features, velocity, depth, and substrate.



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Figure 1-4. Project Action Area, Grand River.

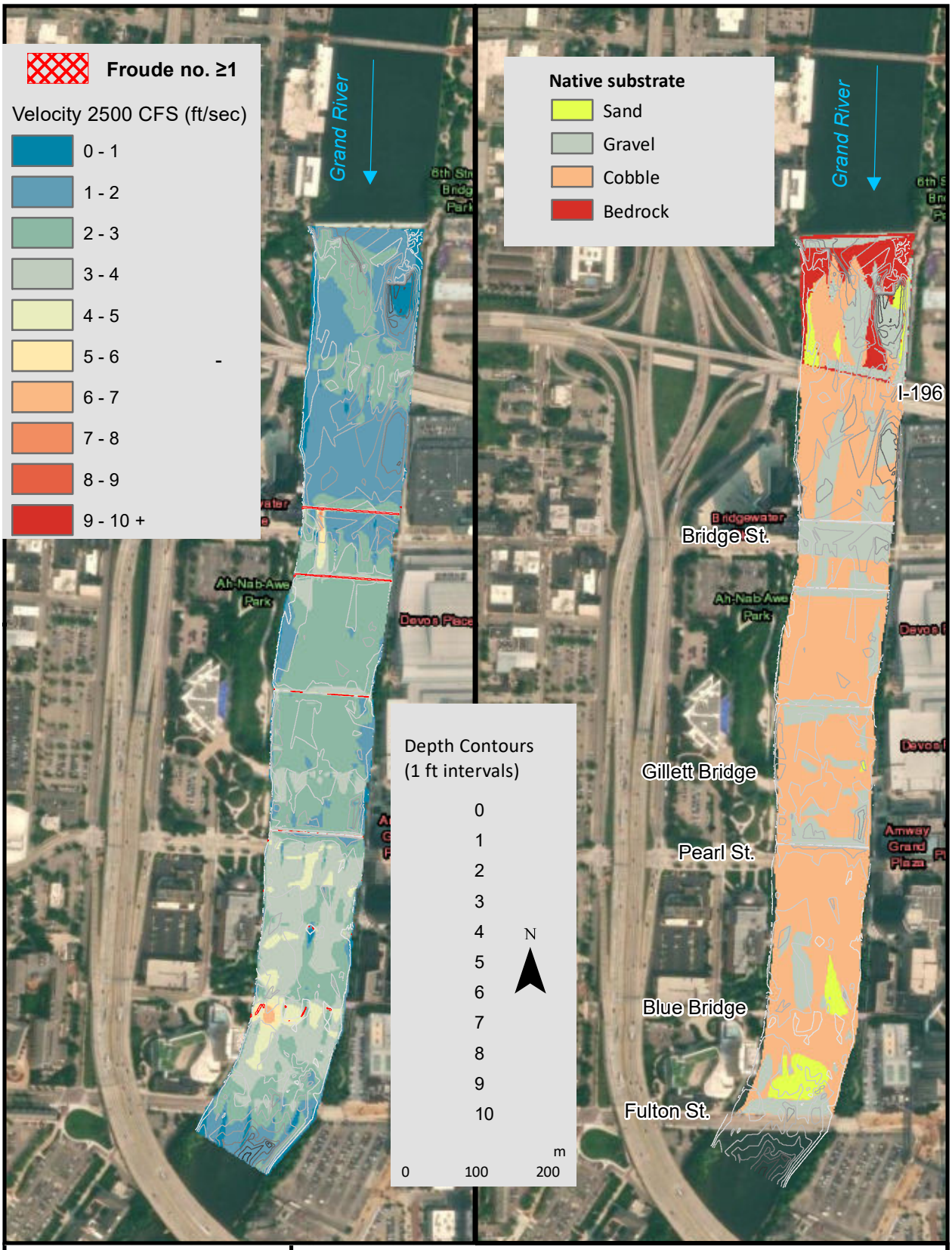

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Figure 2-1. Existing features, velocity, depth, and substrate.

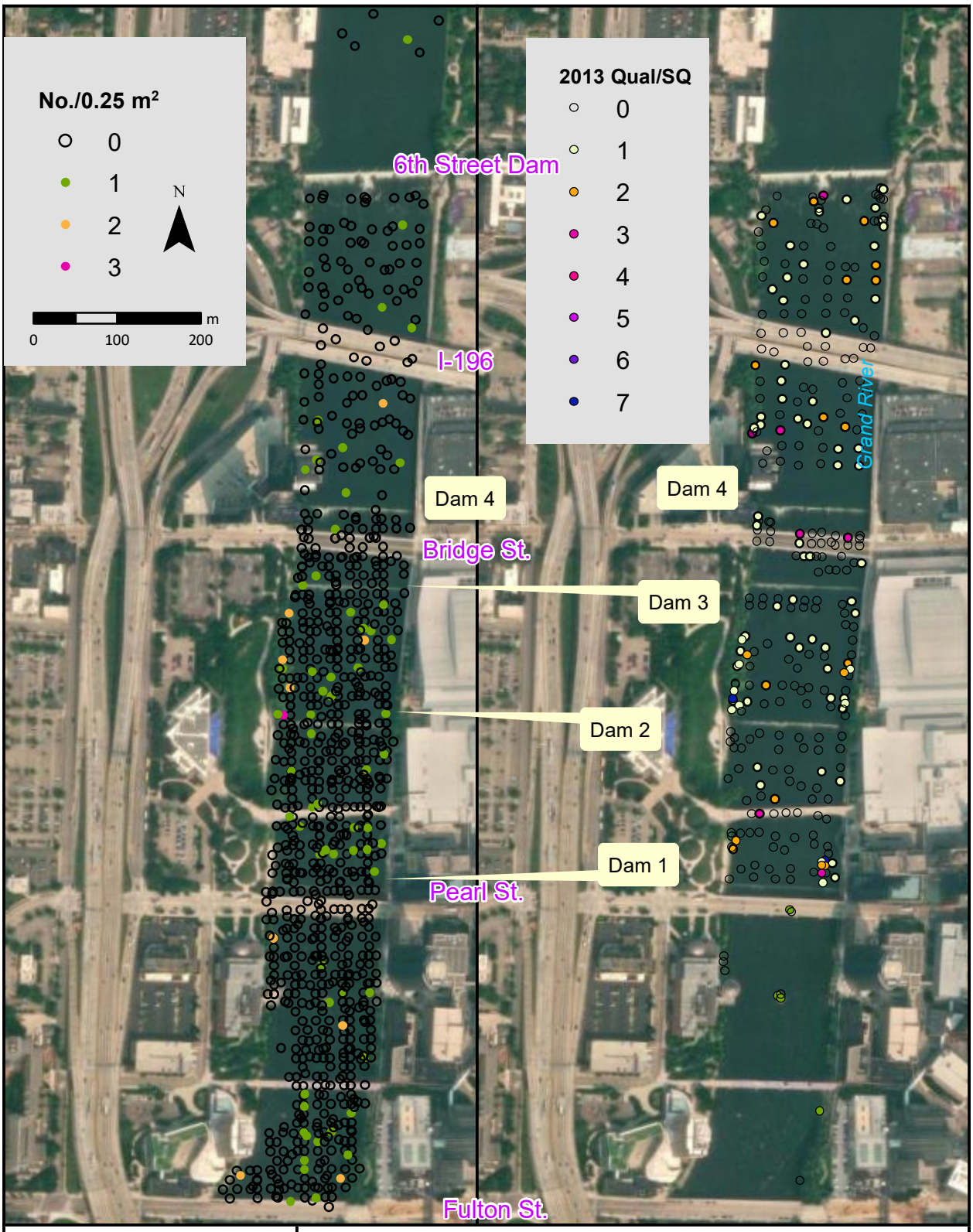

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Figure 2-2. Unionid mussel distribution based on quantitative sampling (2013, 2016, 2017, and 2020) and qualitative and semiquantitative sampling (2013).

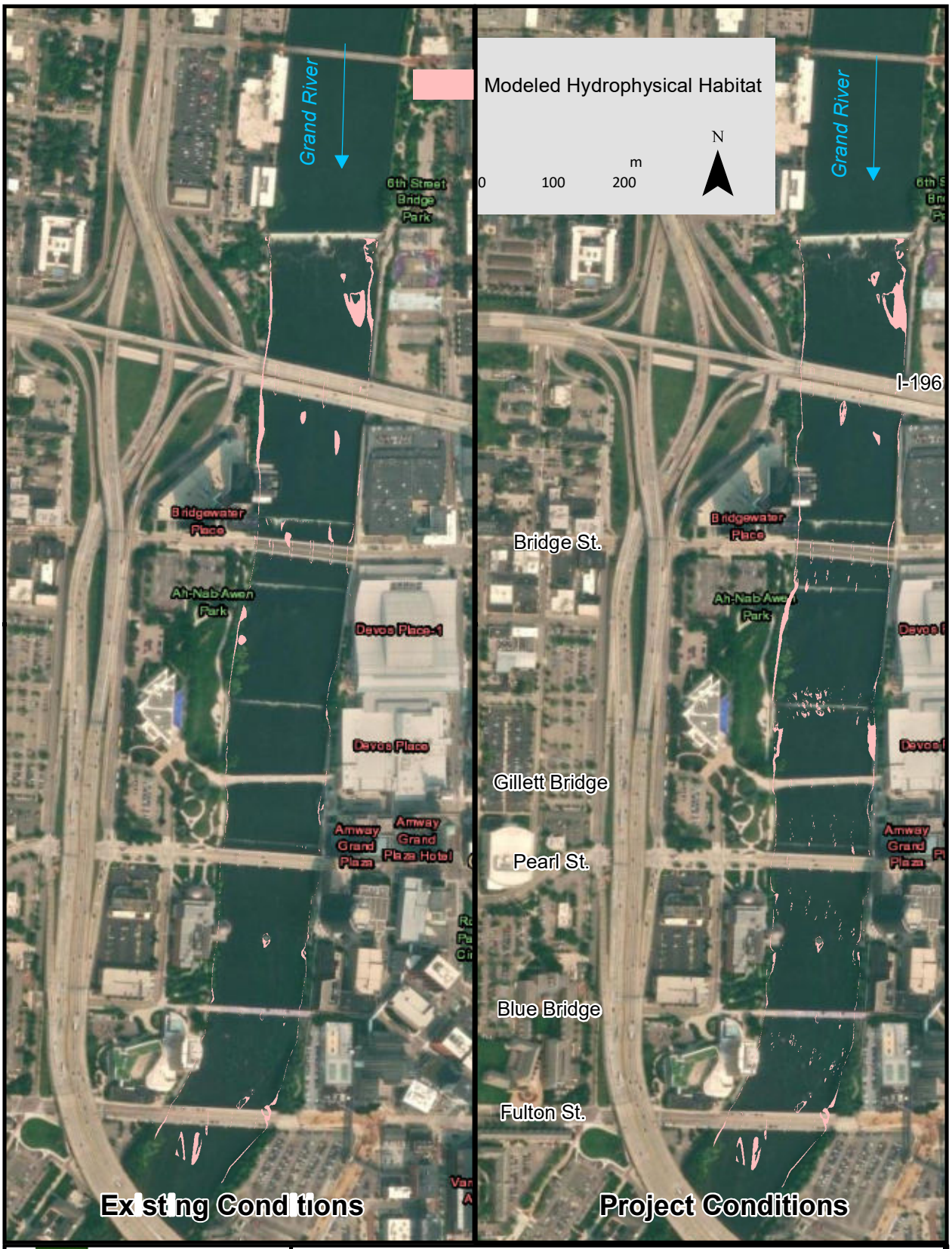

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Figure 2-3. Comparison of Modeled Hydrophysical Habitat (MHH) between Existing and Project conditions.

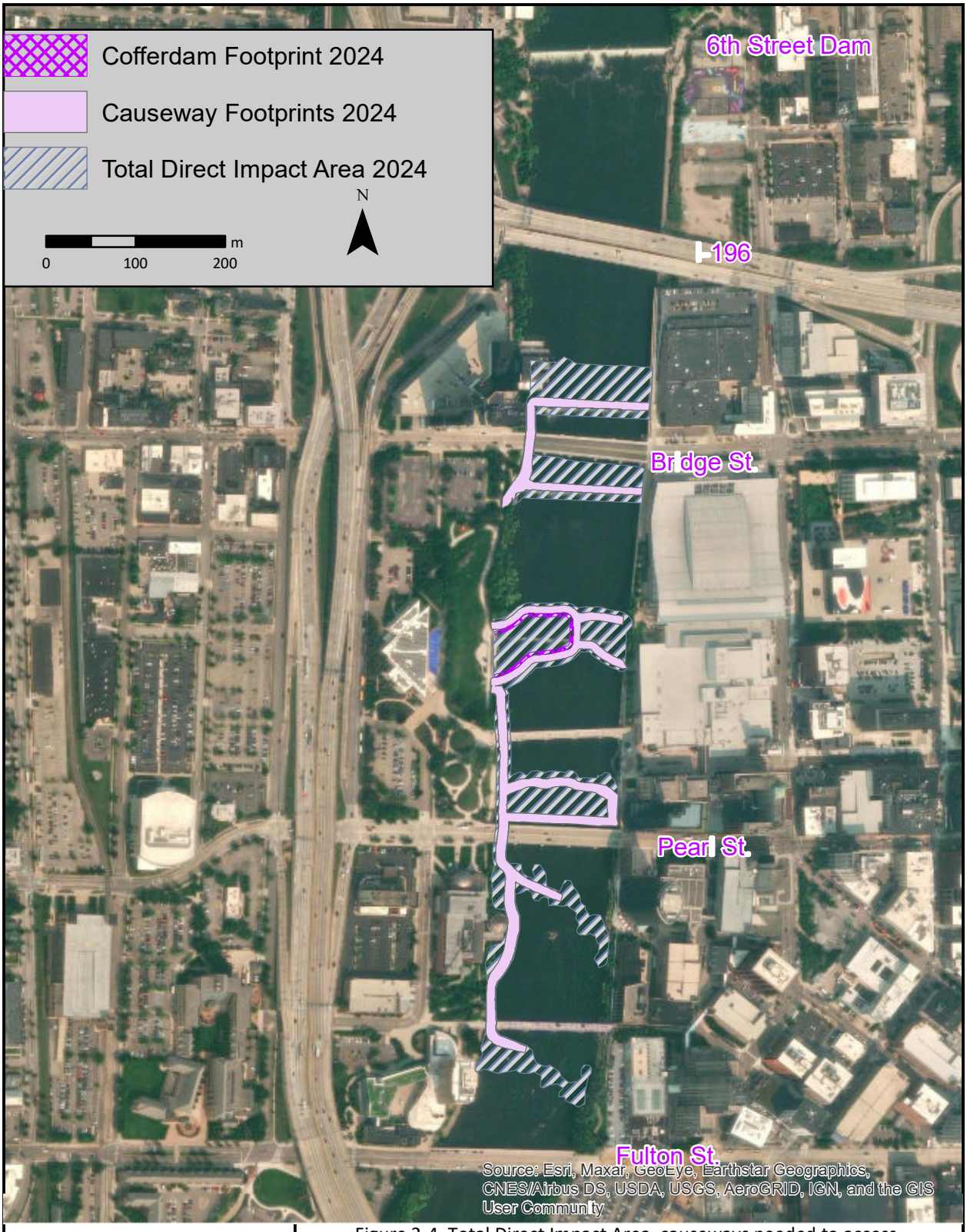

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Figure 2-4. Total Direct Impact Area, causeways needed to access impact areas, and cofferdam needed for construction of Dam 2 diversified boulder arches.

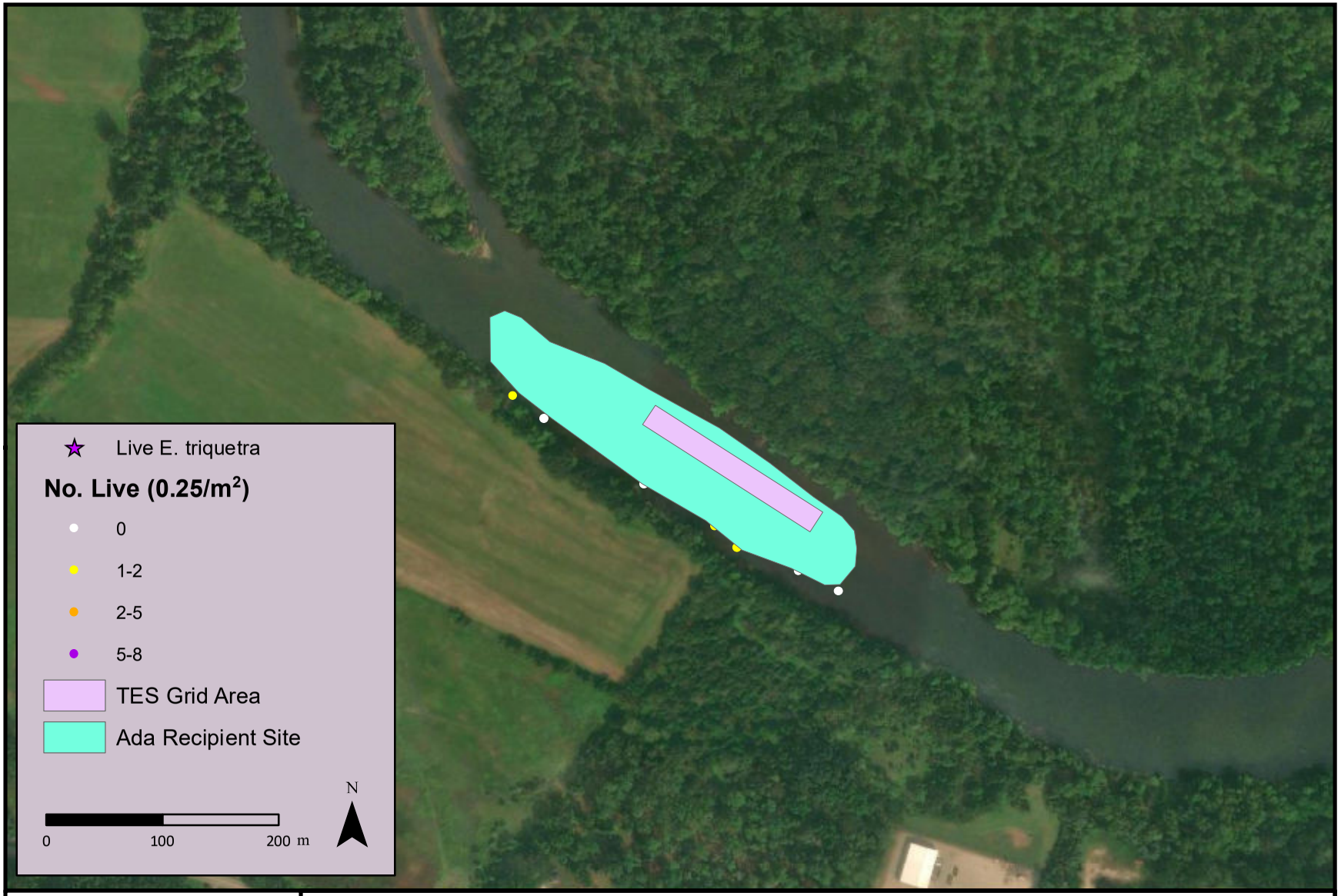

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Figure 2-5. Ada recipient site.

Figure 2-6. Plaster Creek recipient site.



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Figure 2-7. Riverside Park recipient site.

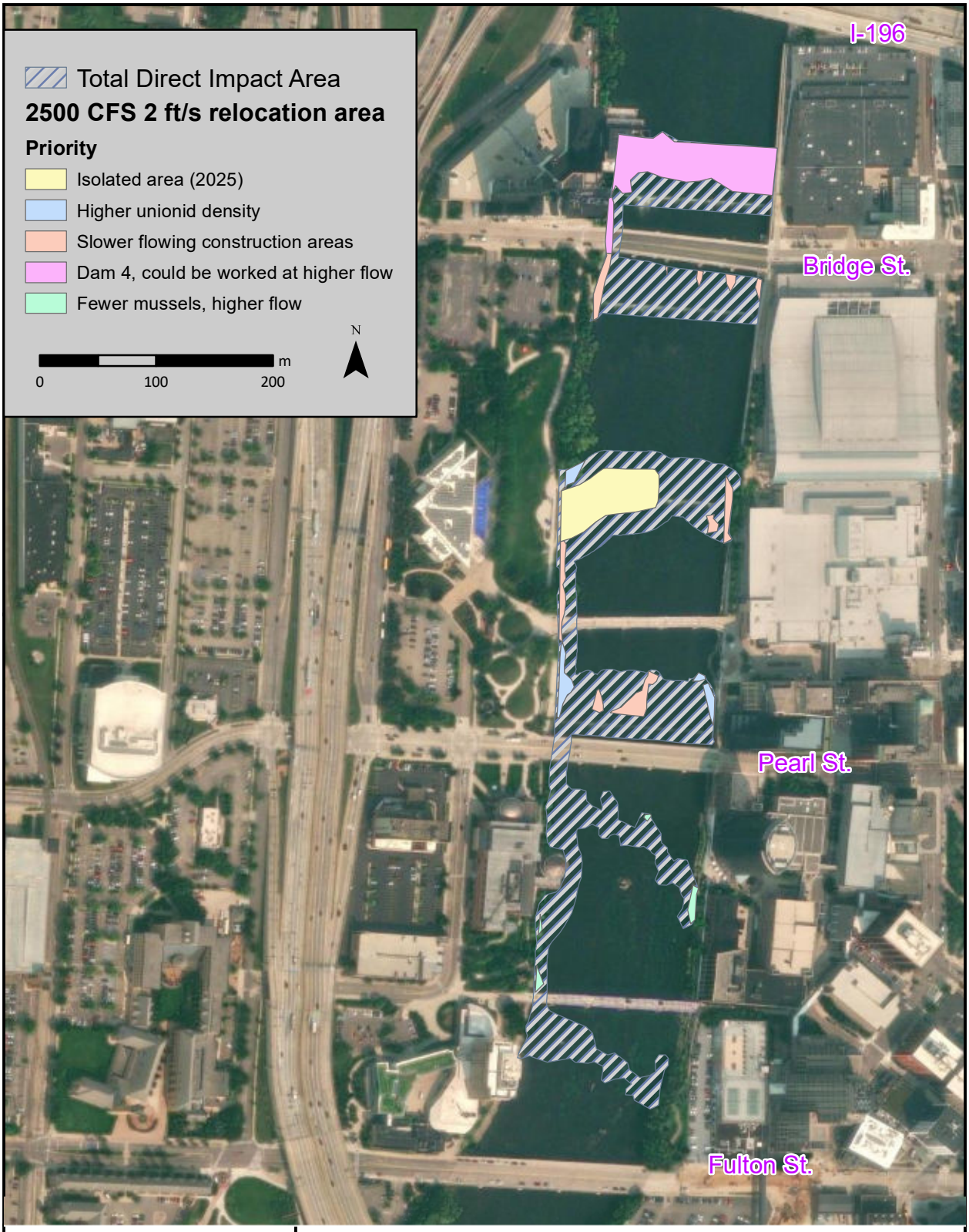

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Figure 2-8. Unionid mussel translocation priorities within Direct Impact Areas.

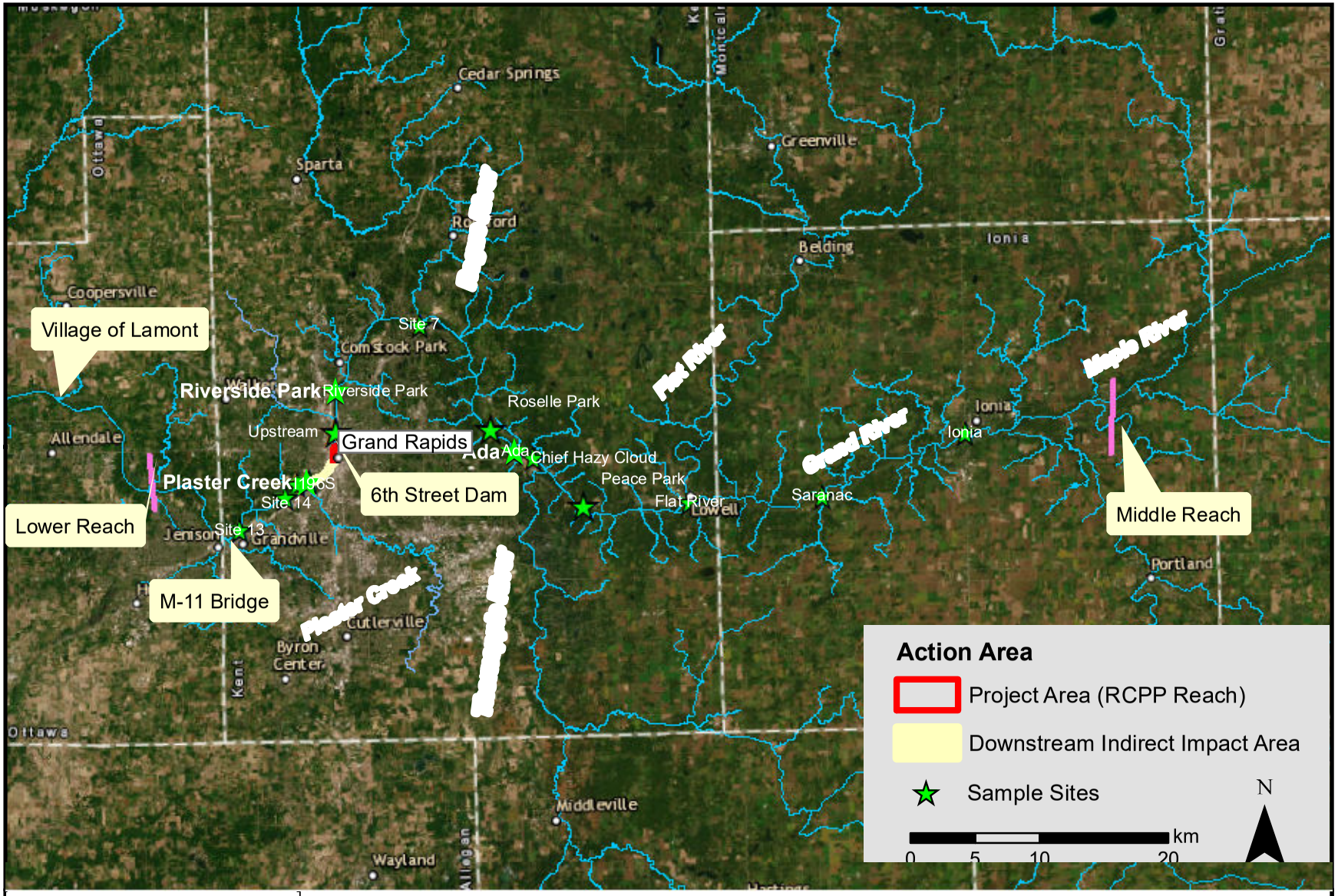

Figure 3-1. Sites recently sampled by Ecological Specialists/EcoAnalysts between Ionia and the M-11 Bridge, 2013 to 2020.

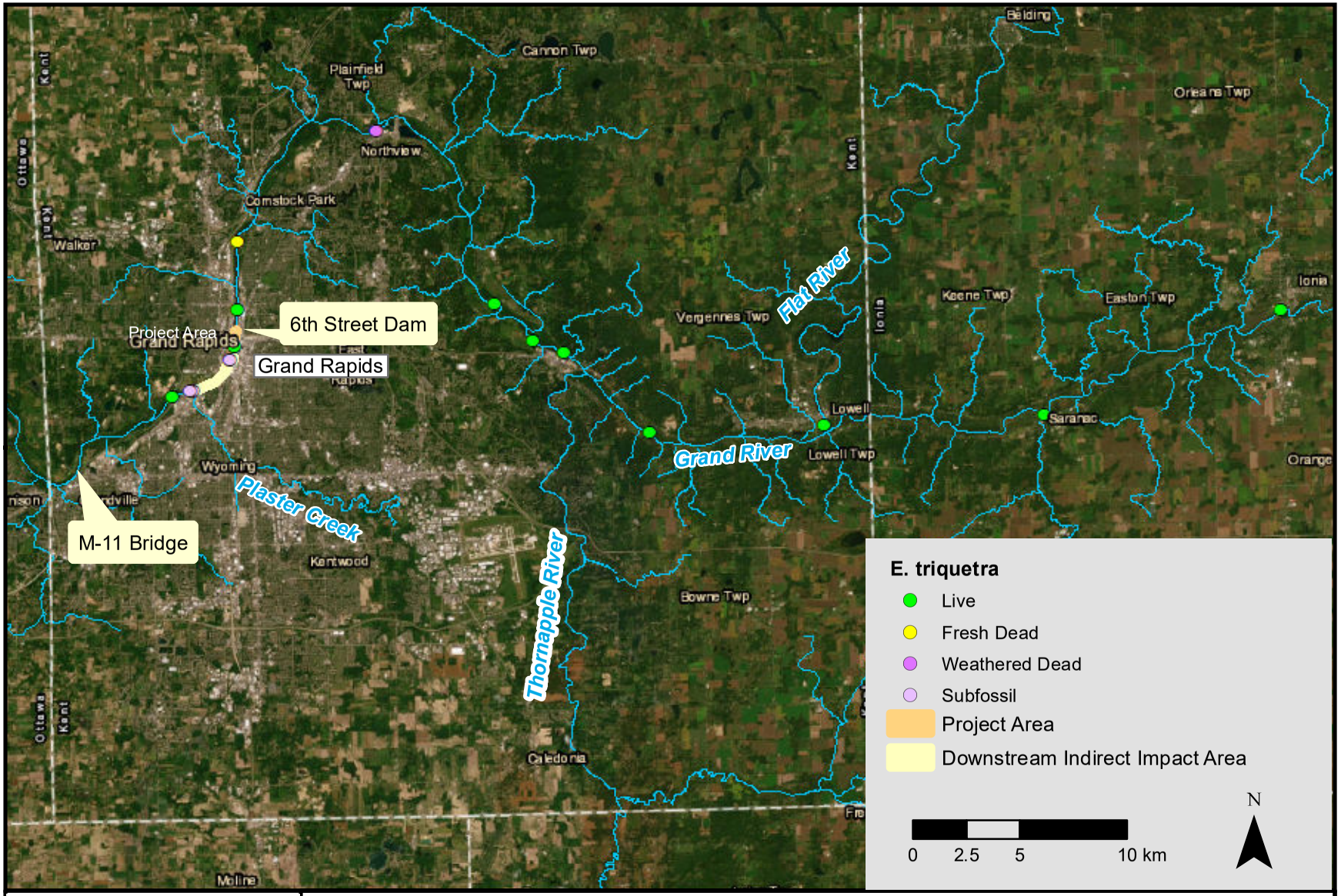

Figure 4-1. Distribution of *Epioblasma triquetra* in recent surveys, 2013-2022.

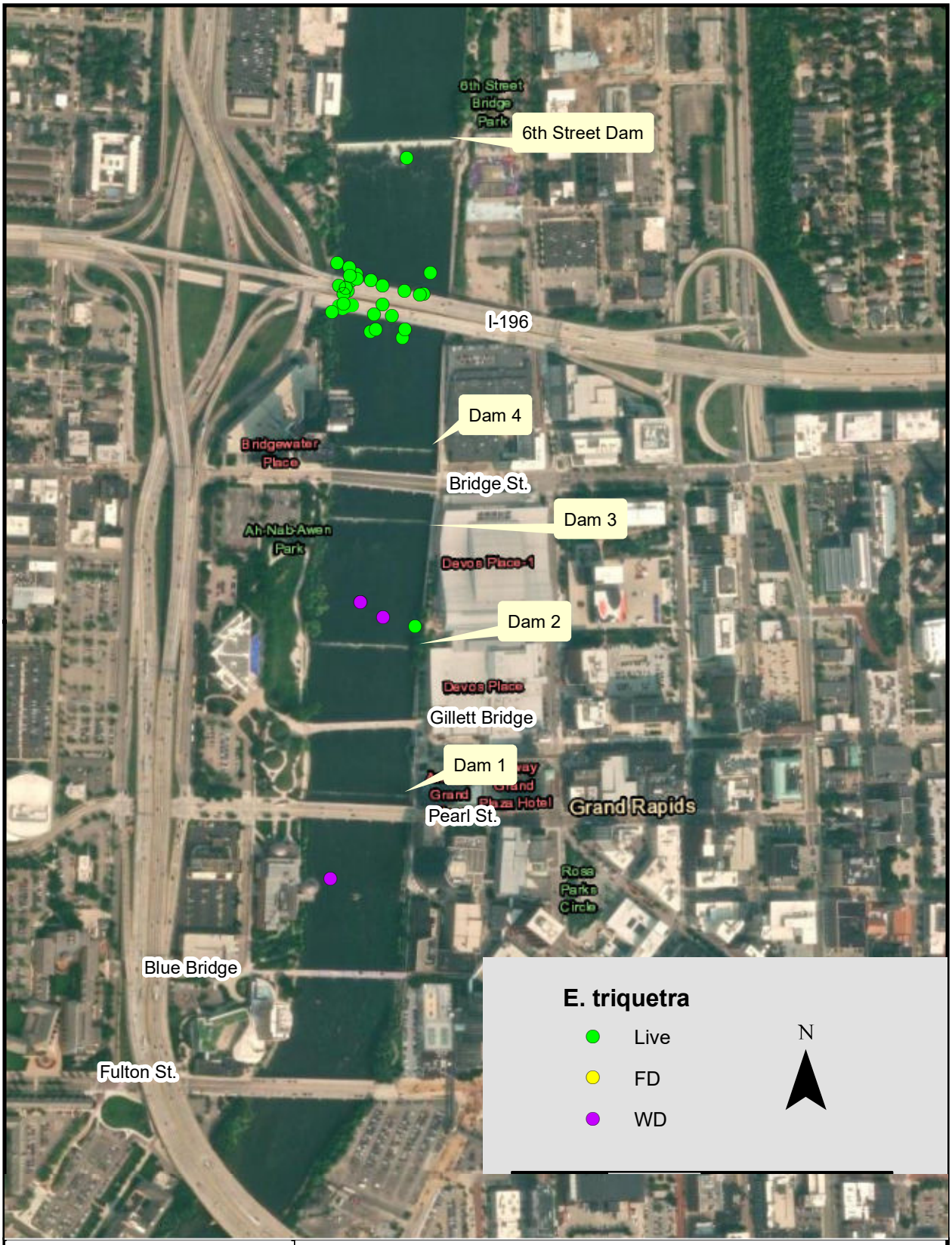

Figure 4-2. *Epioblasma triquetra* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

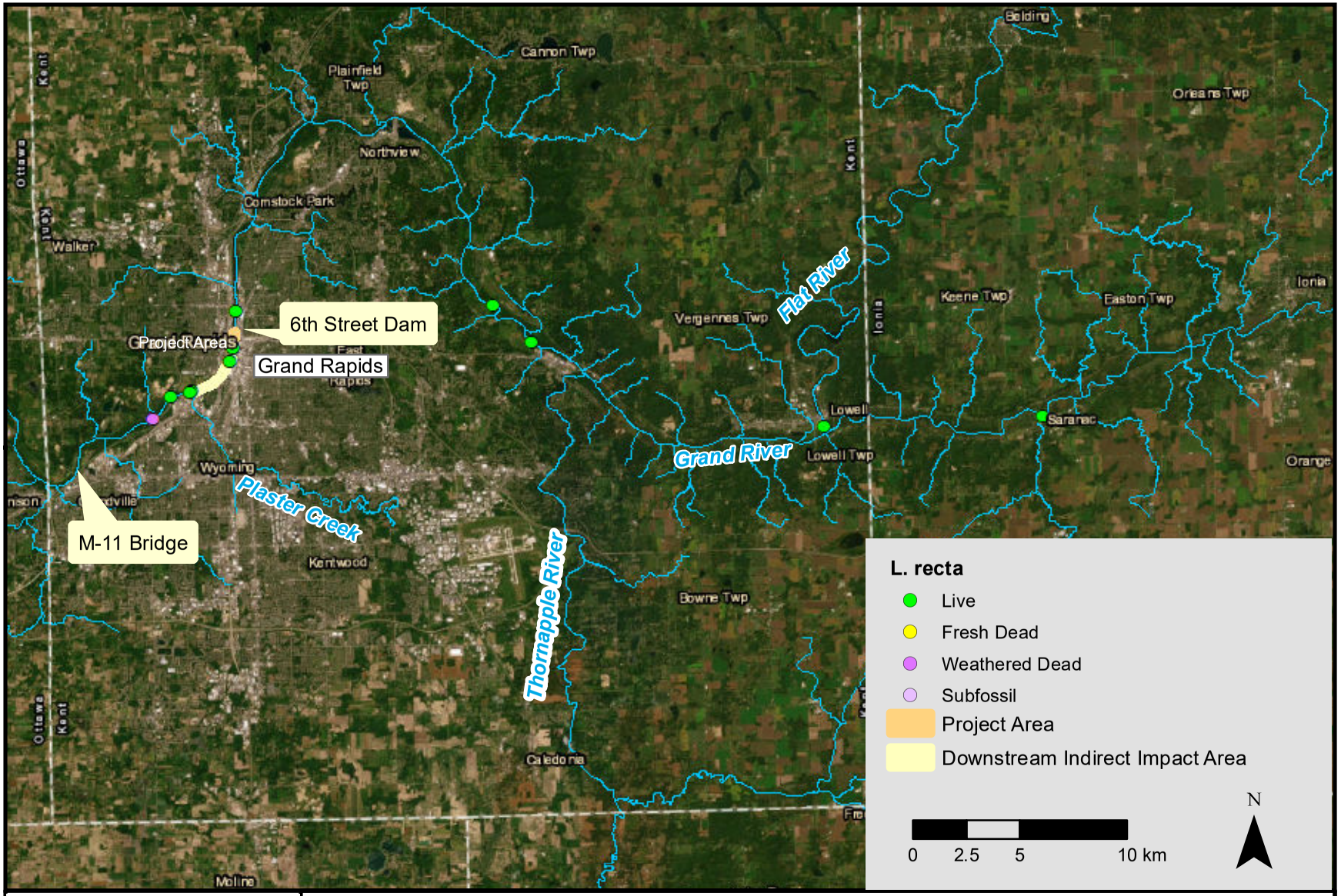

Figure 4-3. Distribution of *Ligumia recta* in recent surveys, 2013-2022.

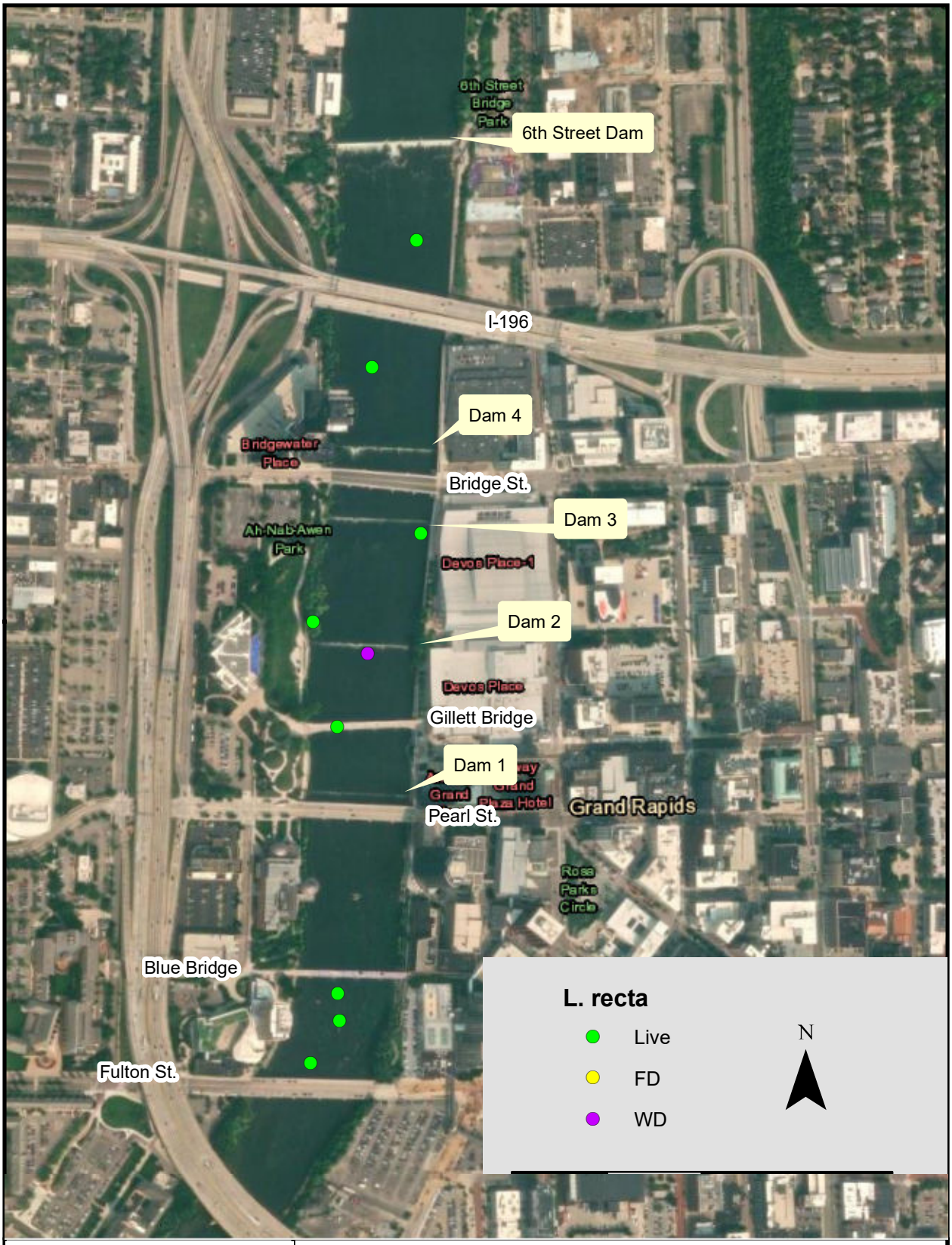

Figure 4-4. *Ligumia recta* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

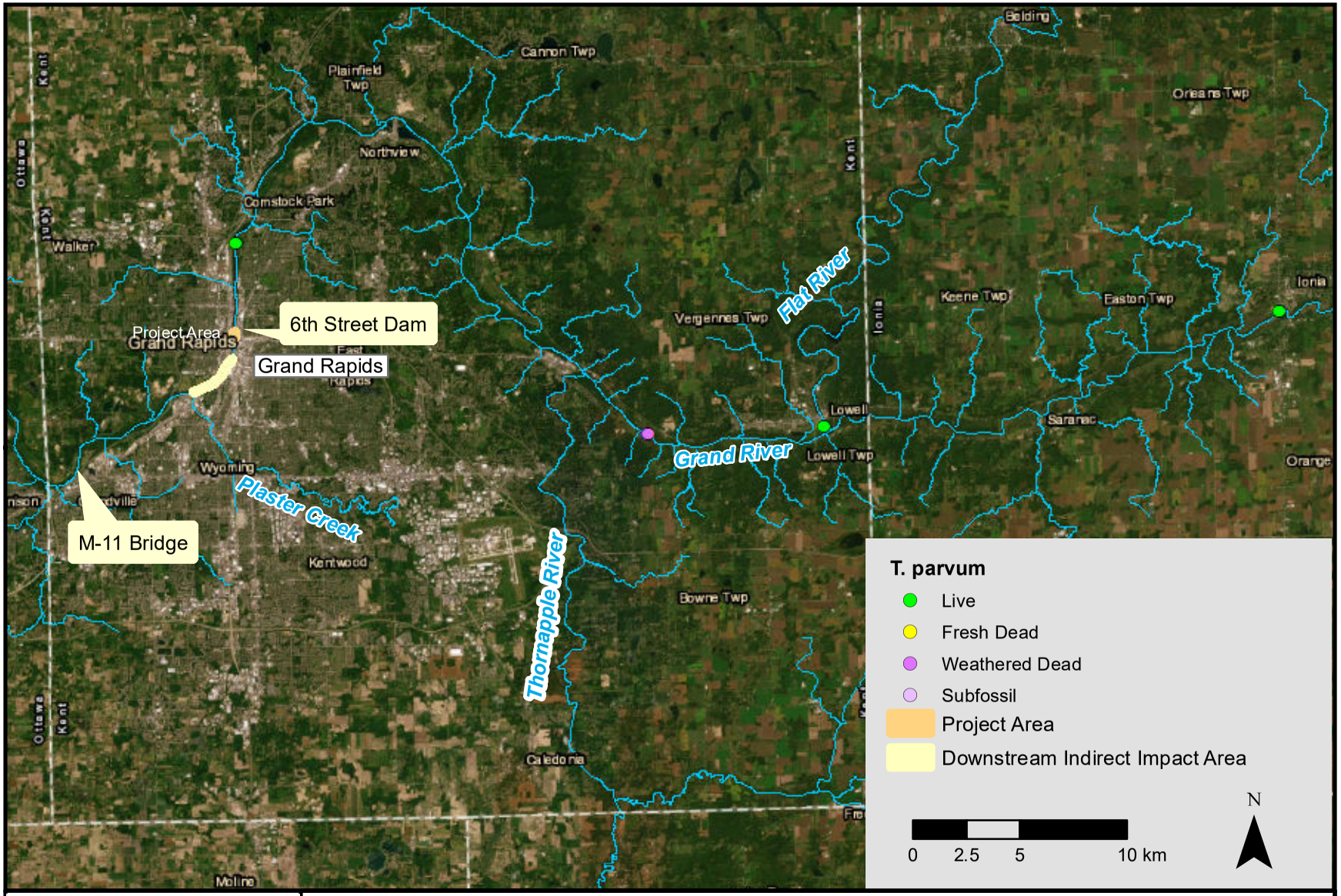

Figure 4-5. Distribution of *Toxolasma parvum* in recent surveys, 2013-2022.

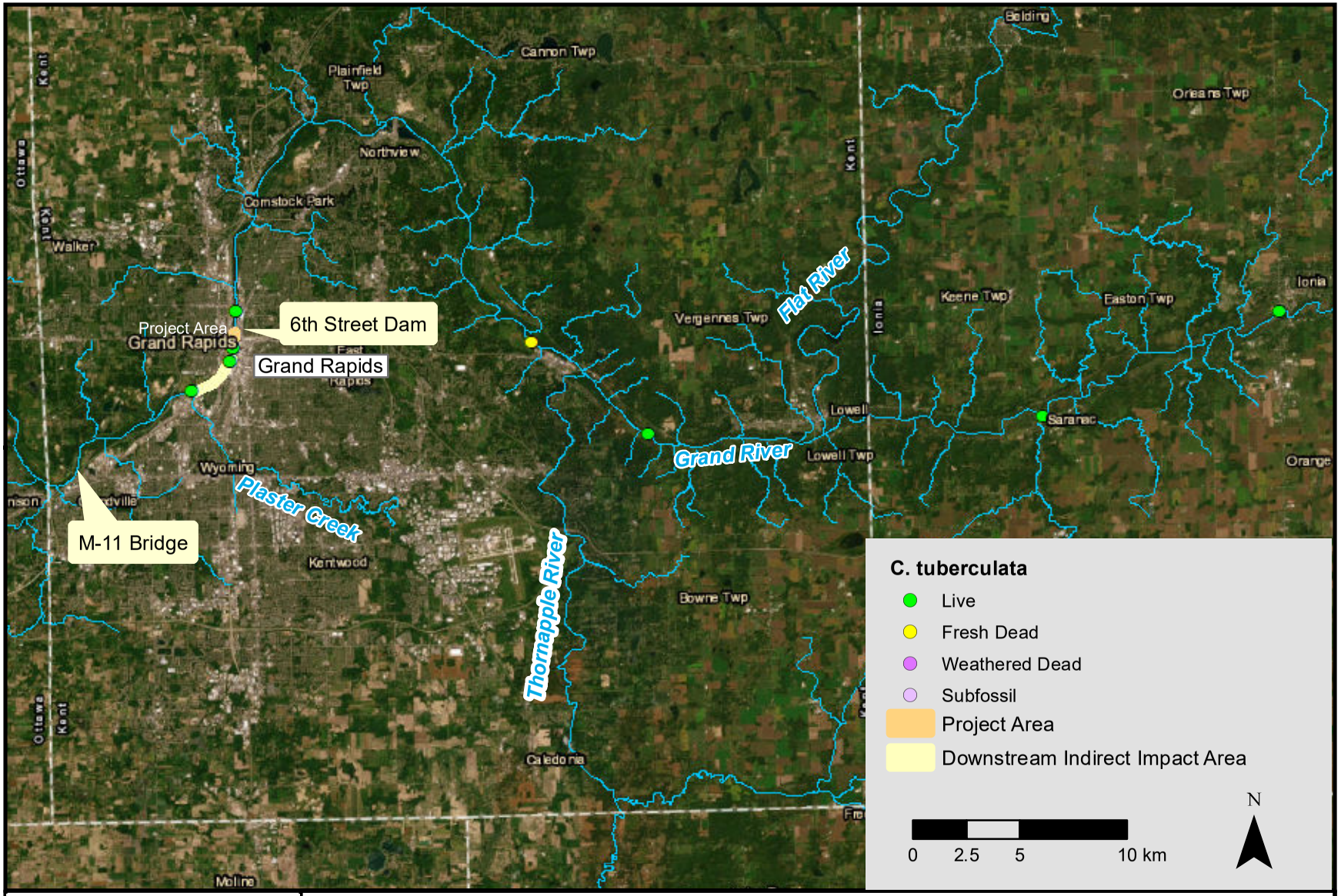

Figure 4-6. Distribution of *Cyclonaias tuberculata* in recent surveys, 2013-2022.



Figure 4-7. *Cyclonaias tuberculata* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

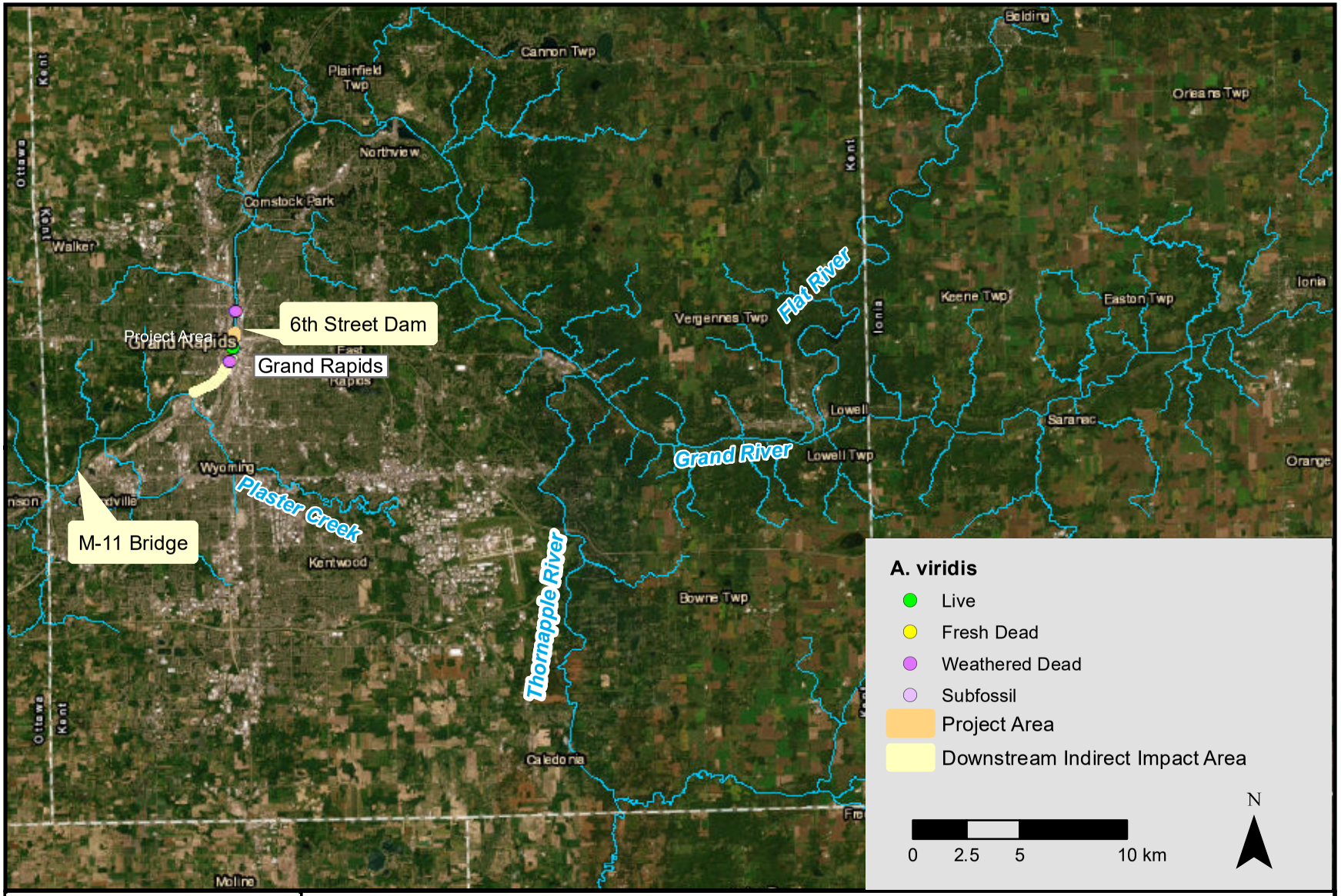

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Figure 4-8. Distribution of *Alasmidonta viridis* in recent surveys, 2013-2022.



Figure 4-9. *Alasmidonta viridis* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

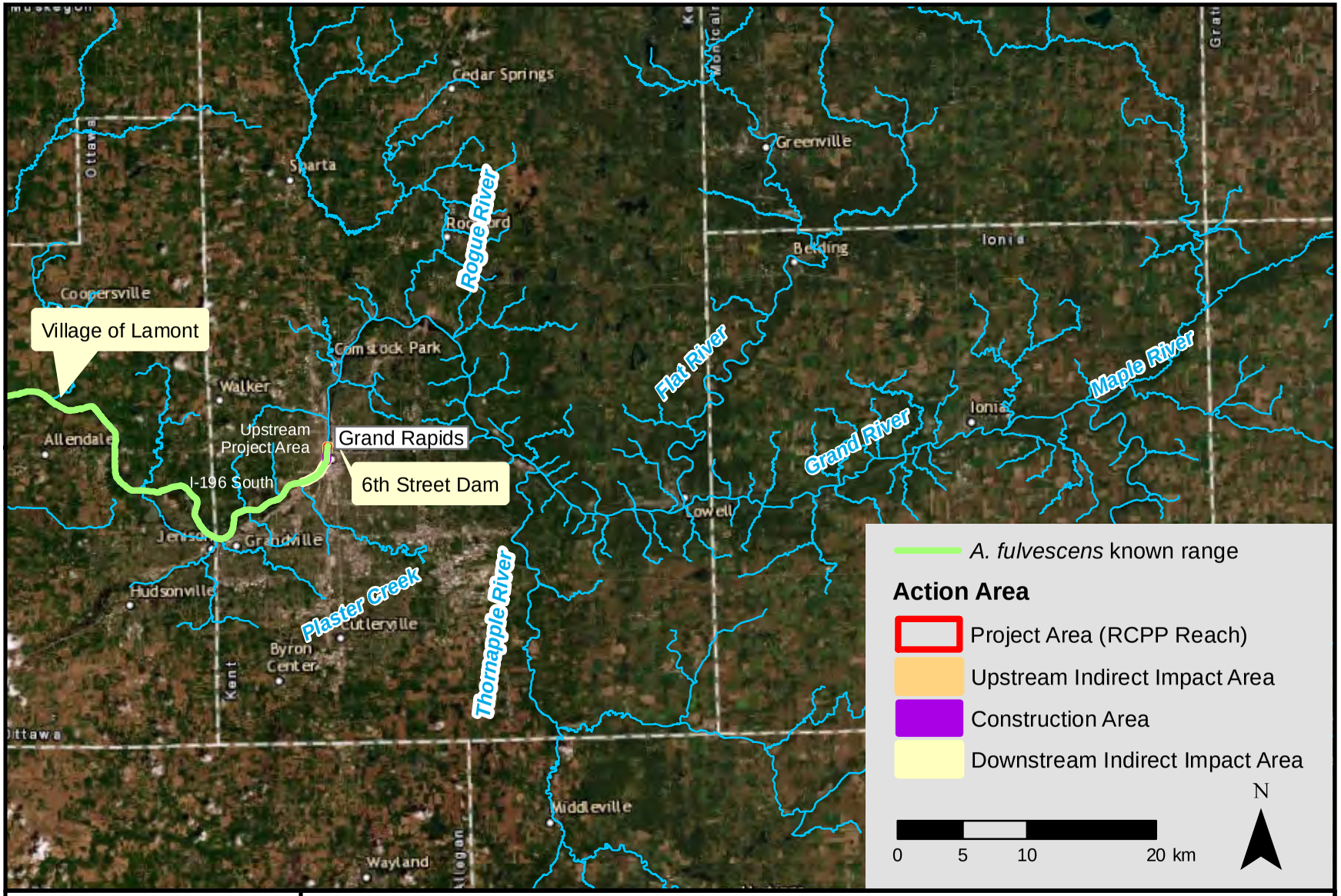

Figure 4-10. Distribution of *Acipenser fulvescens* in the lower Grand River (modified from Hanshue and Harrington, 2017).

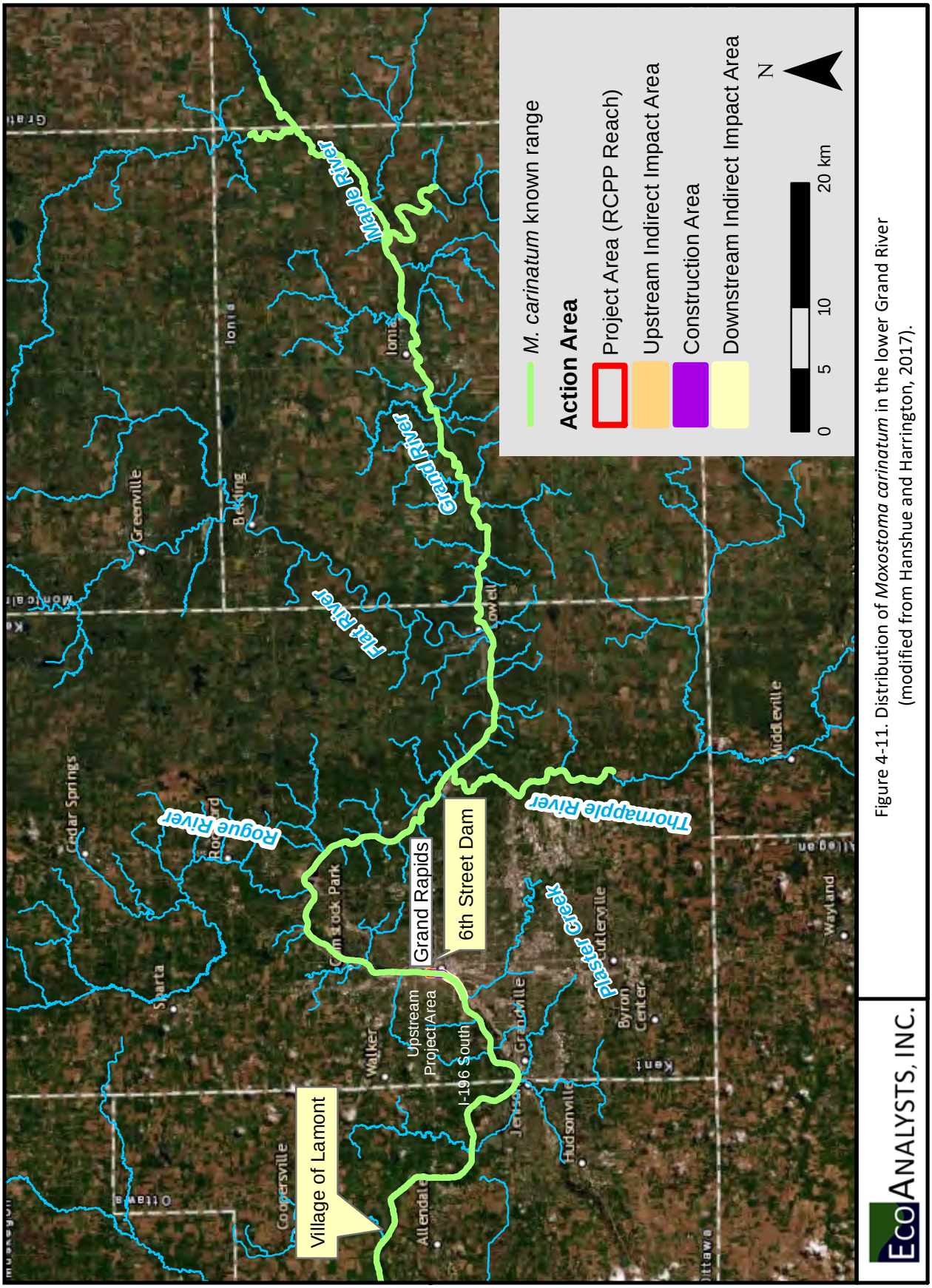

Figure 4-11. Distribution of *Moxostoma carinatum* in the lower Grand River (modified from Hanshue and Harrington, 2017).

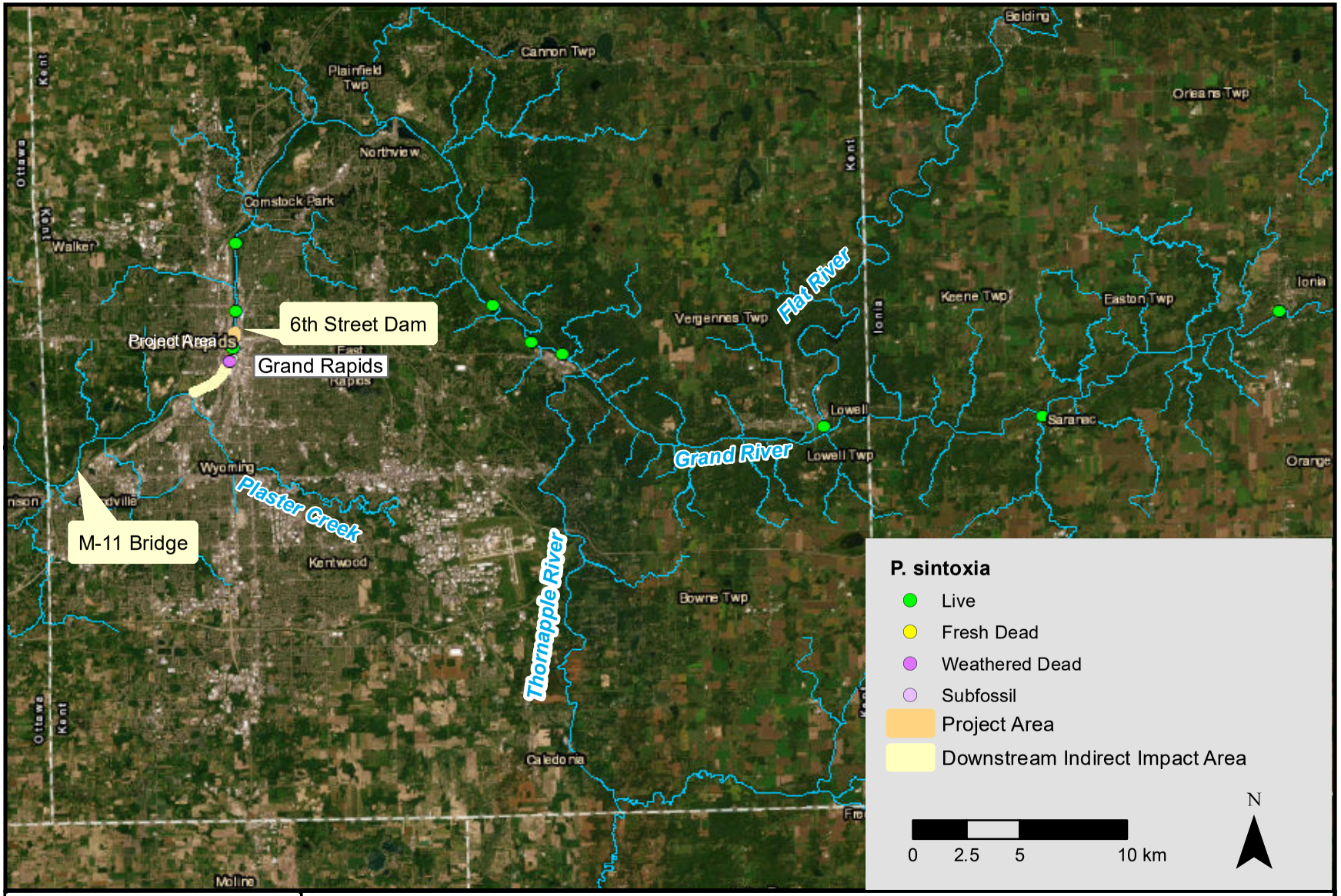

Figure 4-12. Distribution of *Pleurobema sintoxia* in recent surveys, 2013-2022.

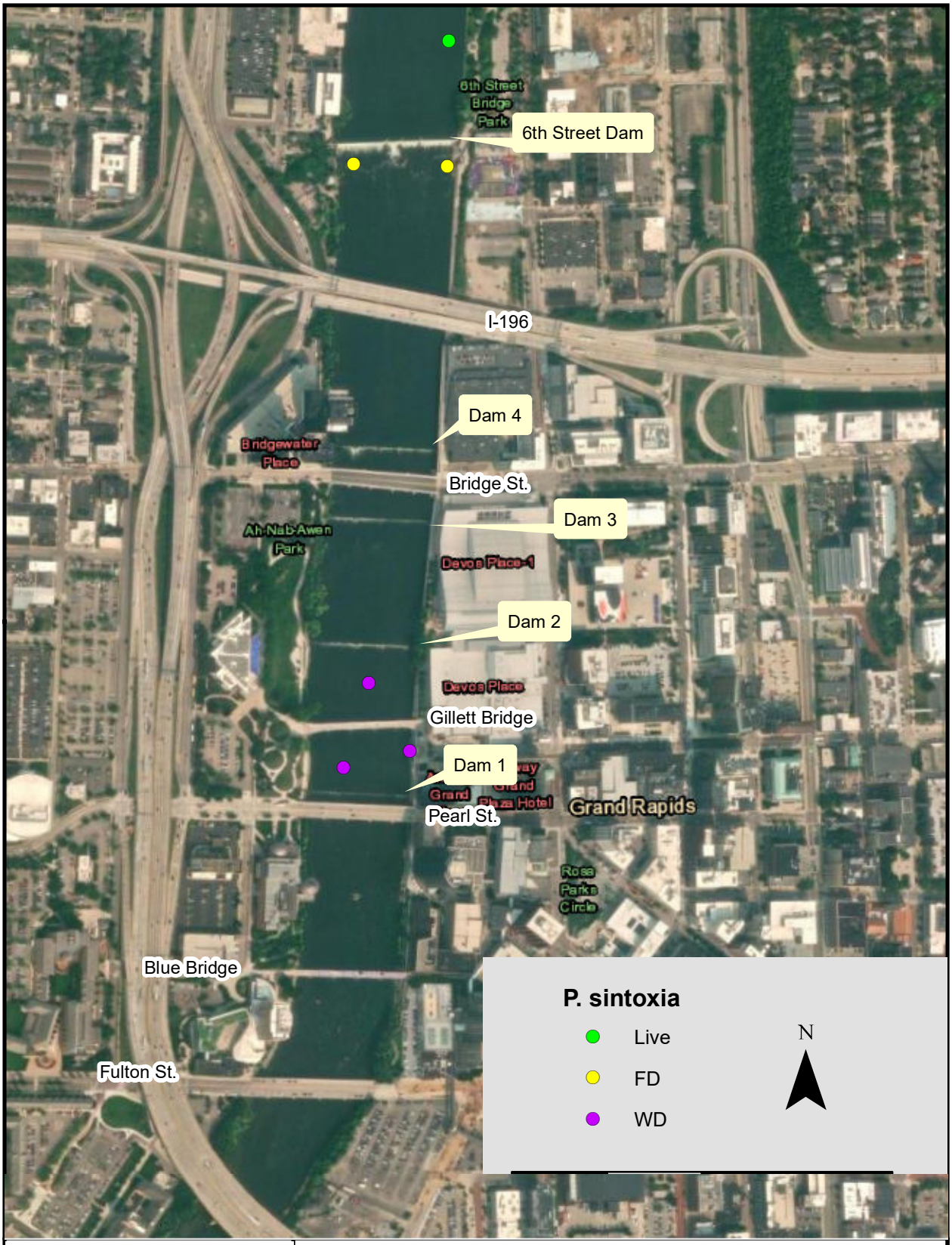

Figure 4-13. *Pleurobema sintoxia* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

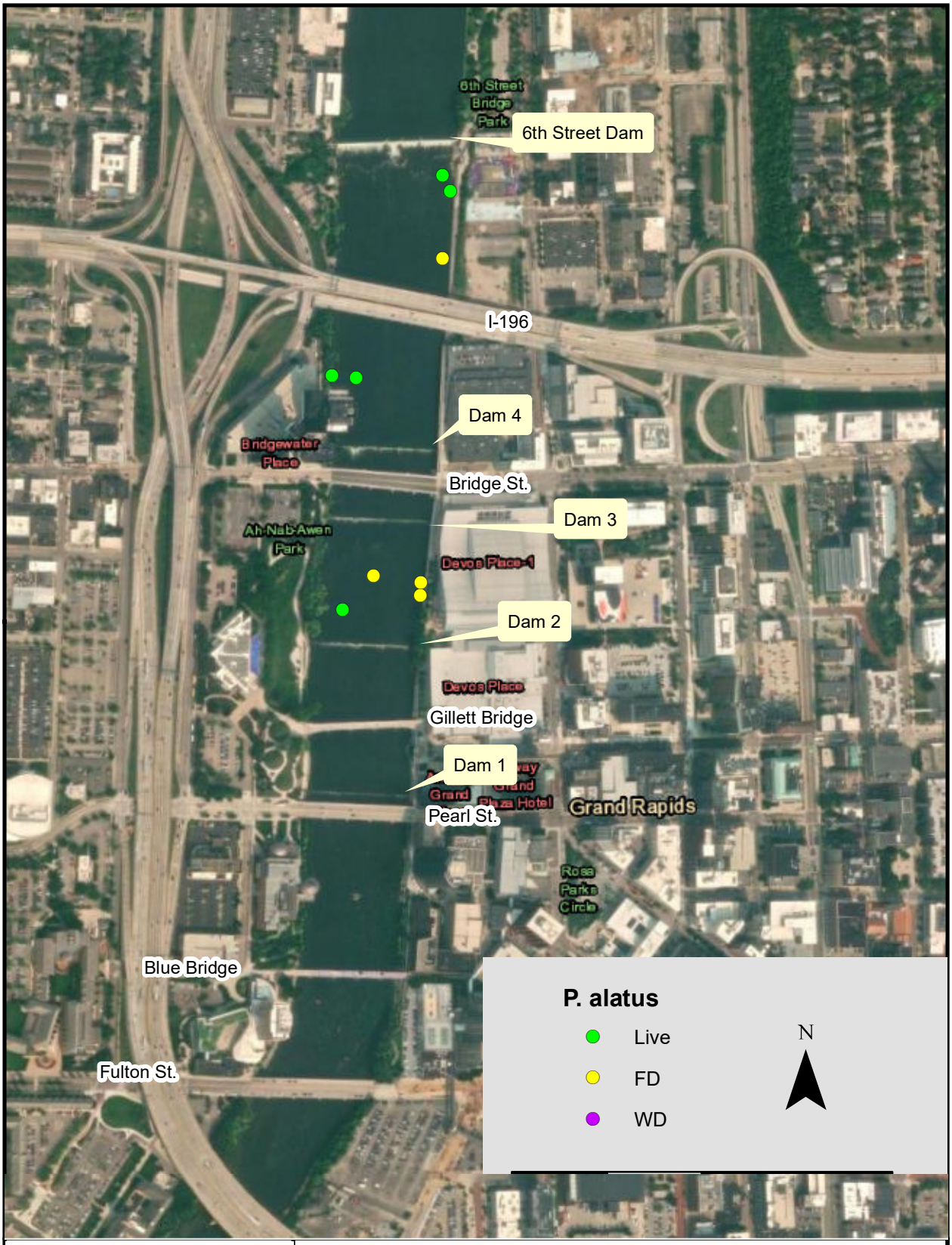

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Figure 4-14. *Potamilus alatus* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

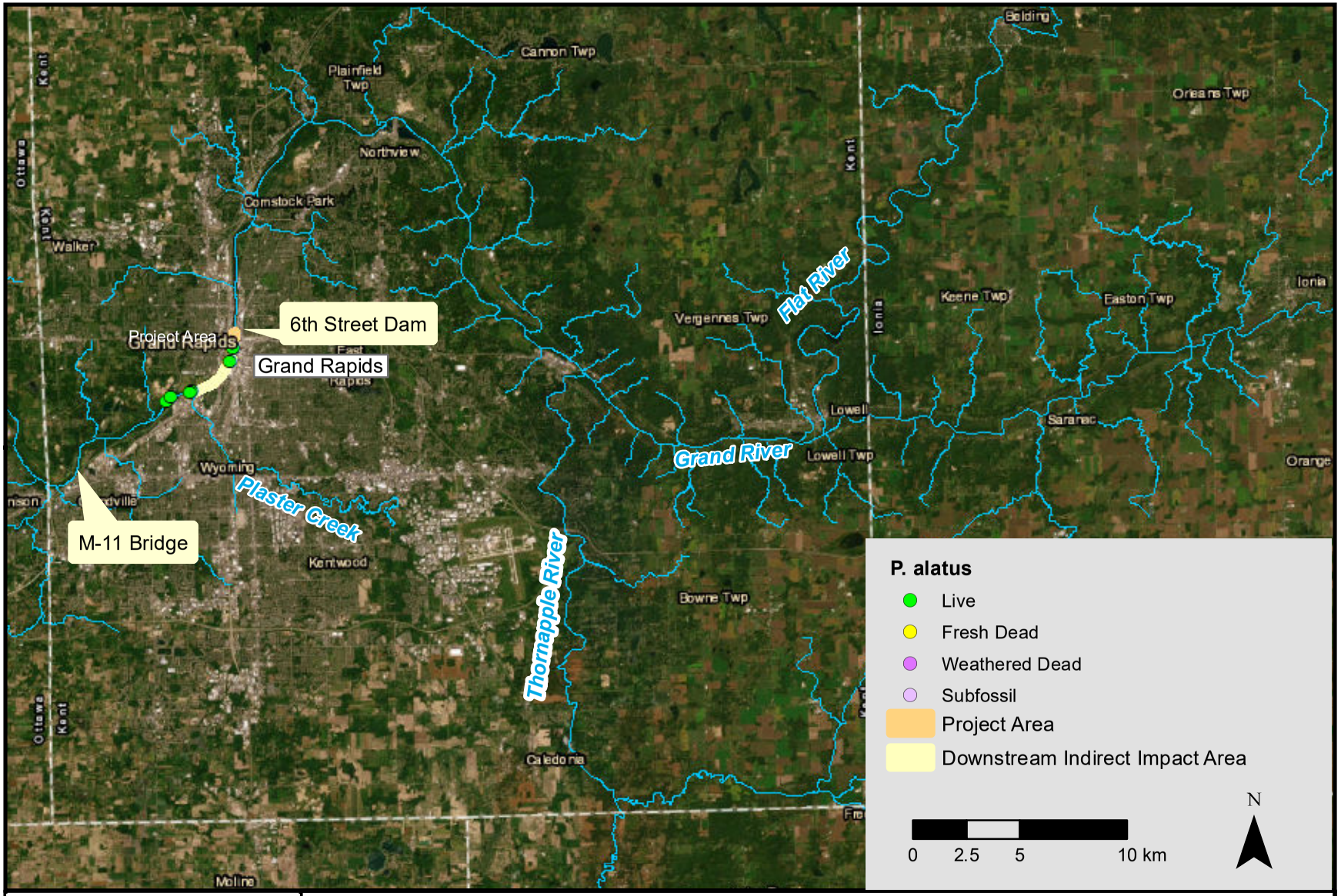

Figure 4-15. Distribution of *Potamilus alatus* in recent surveys, 2013-2022.

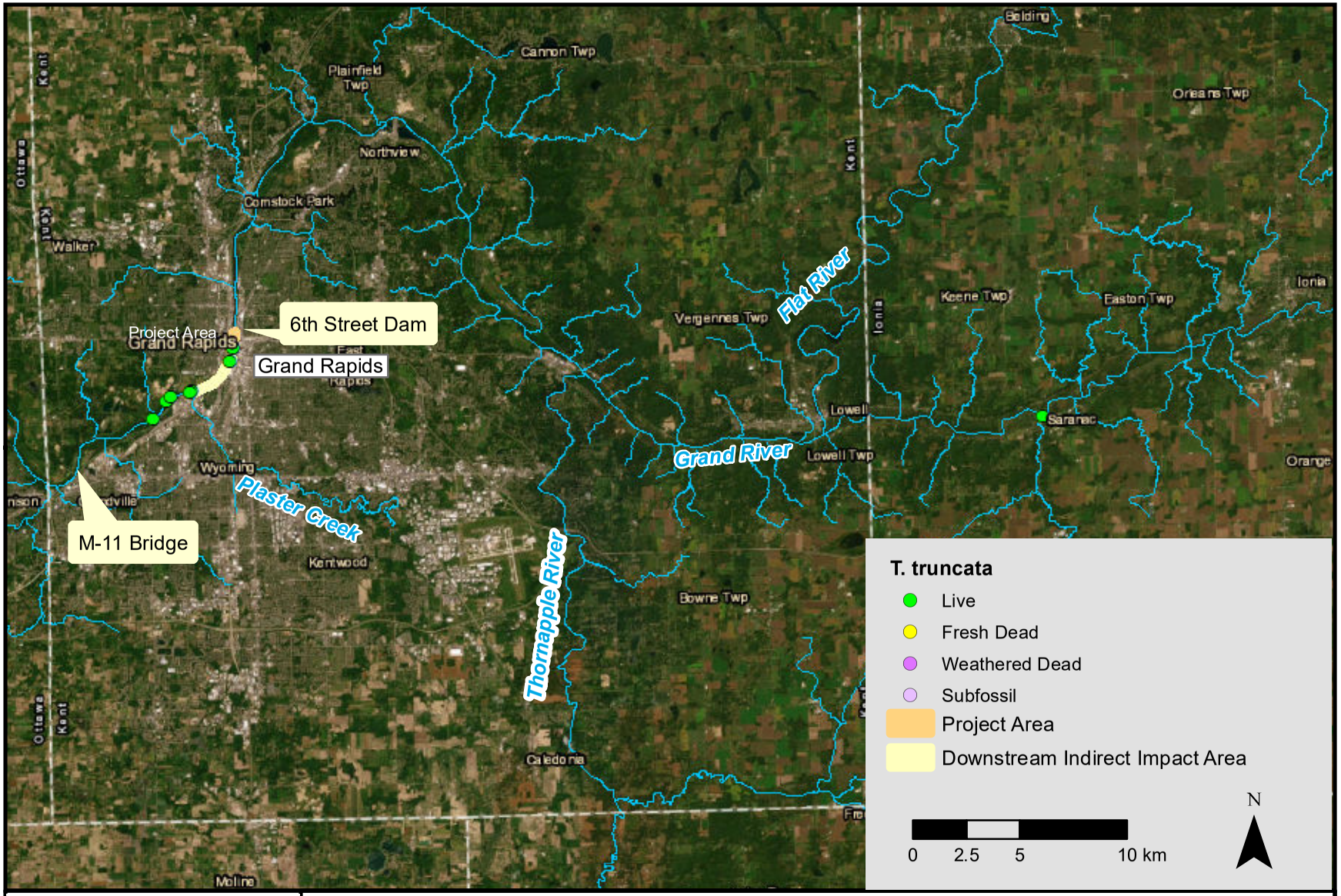

Figure 4-16. Distribution of *Truncilla truncata* in recent surveys, 2013-2022.

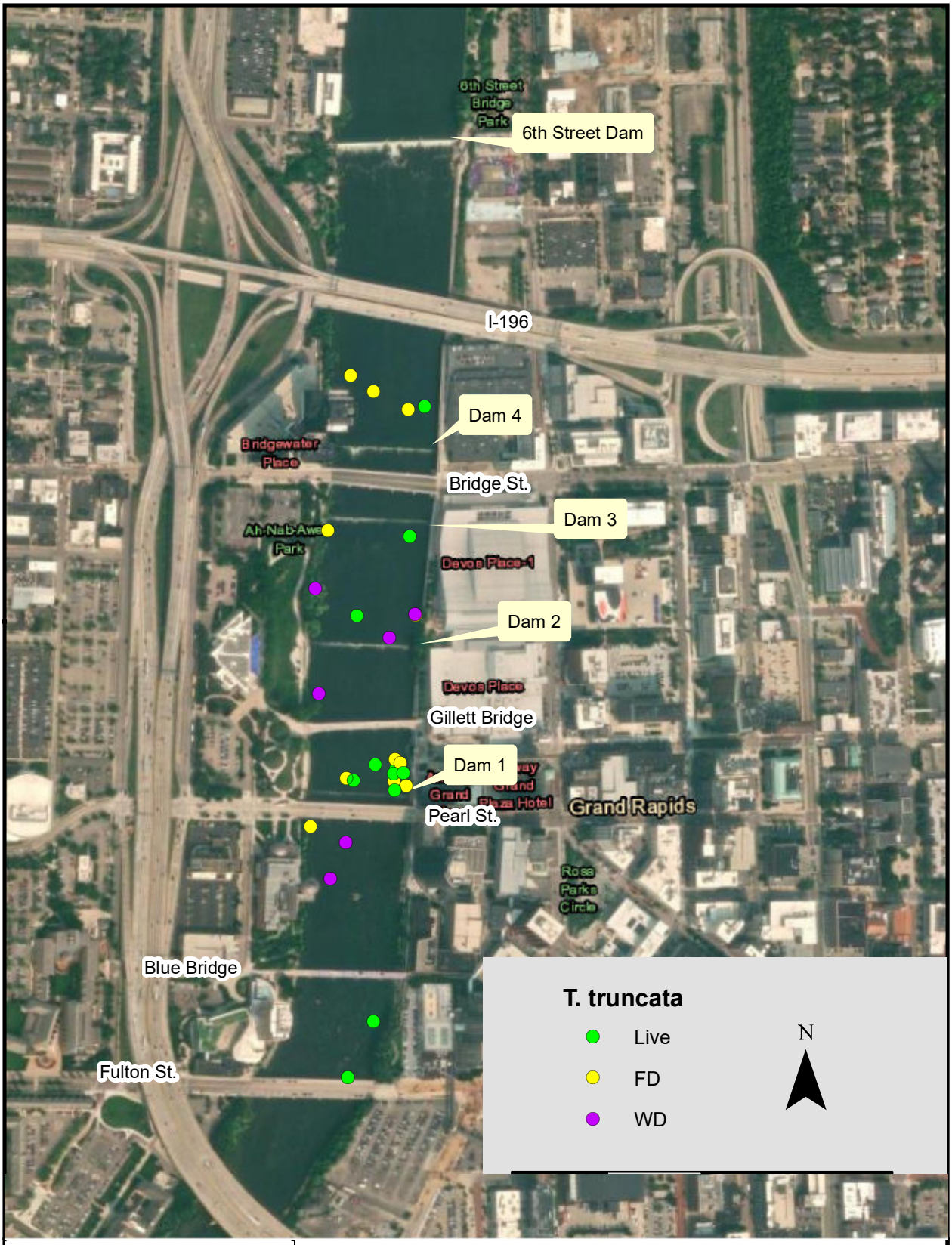

Figure 4-17. *Truncilla truncata* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

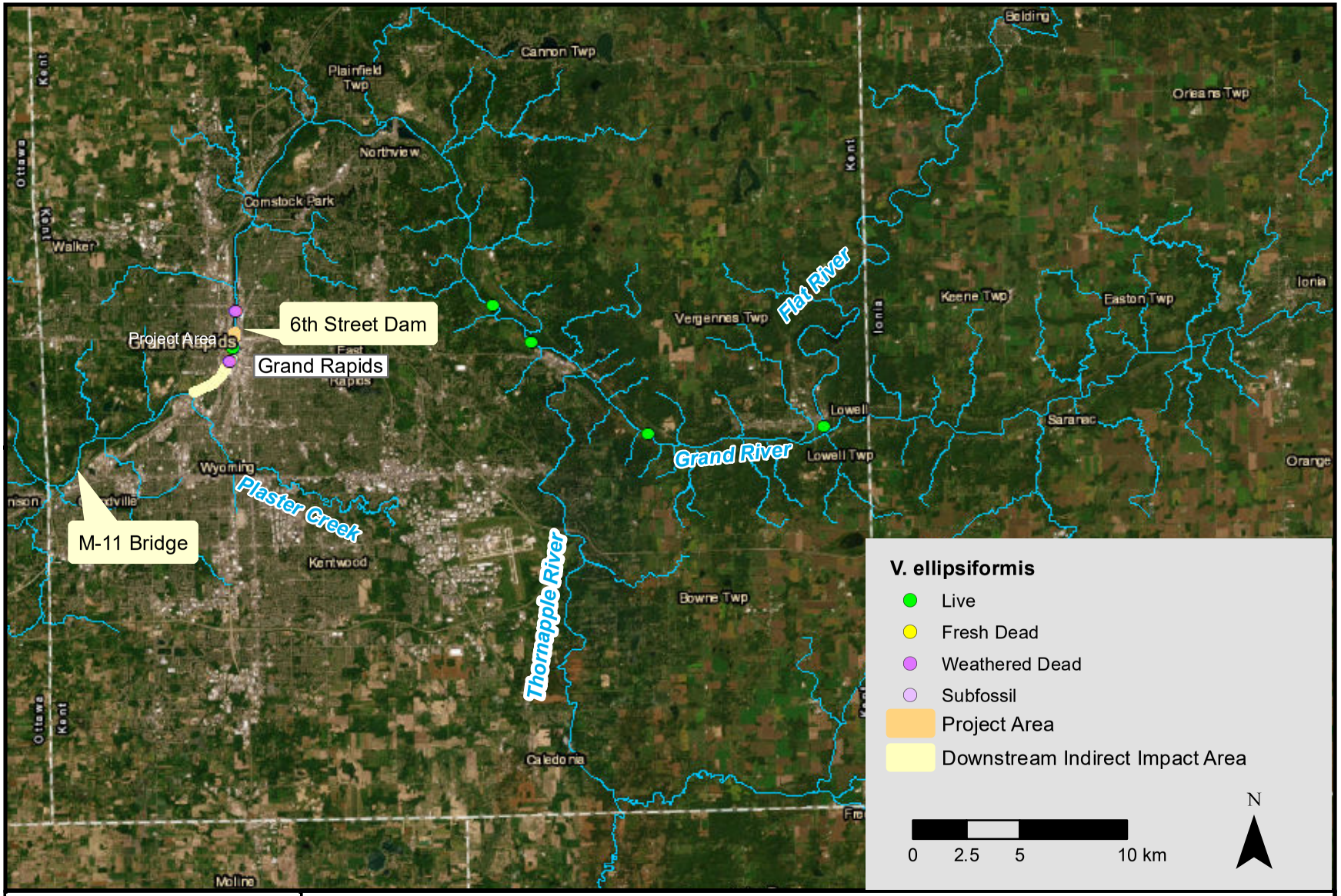

Figure 4-18. Distribution of *Venustaconcha ellipsiformis* in recent surveys, 2013-2022.



Figure 4-19. *Venustaconcha ellipsiformis* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

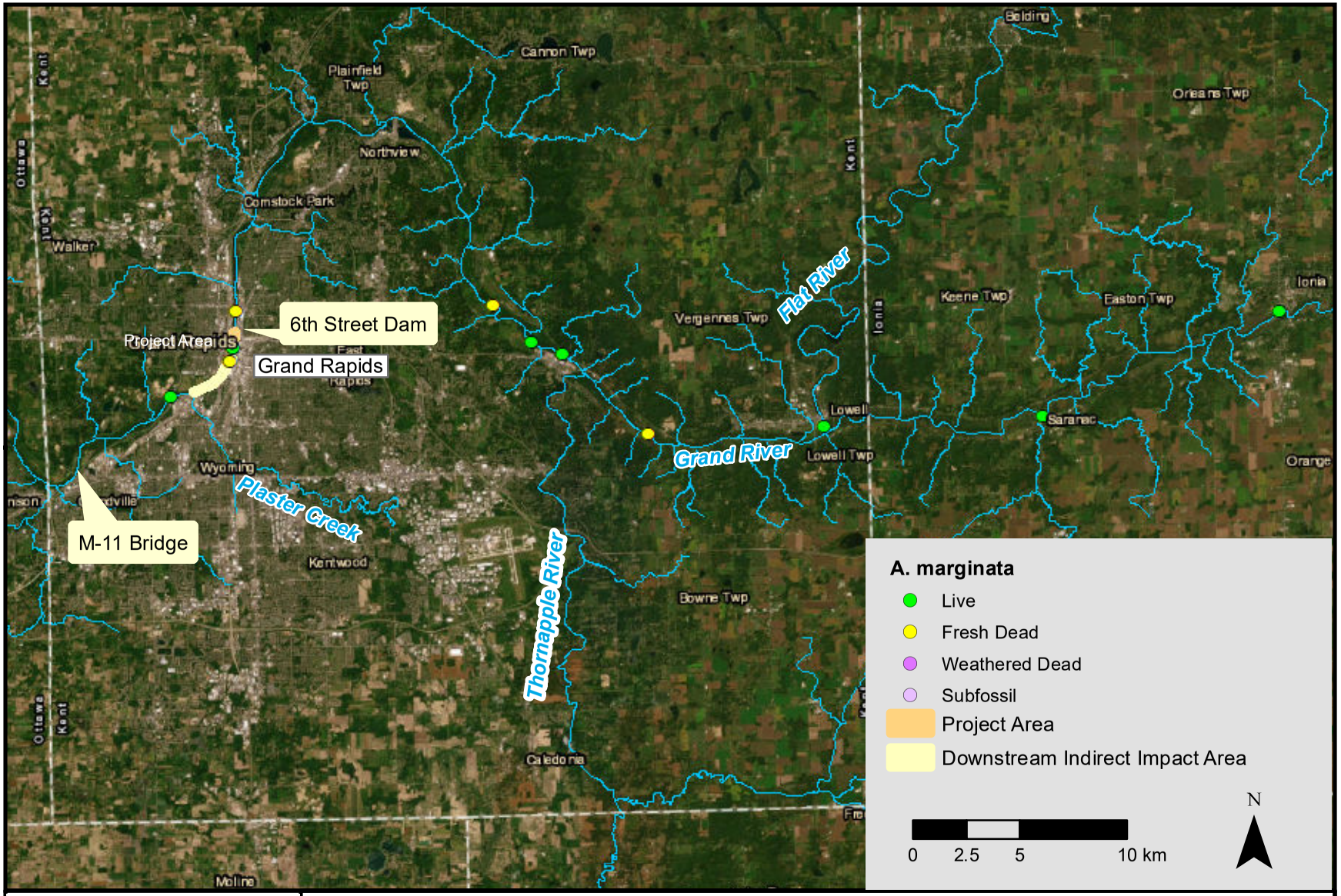

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Figure 4-20. Distribution of *Alasmidonta marginata* in recent surveys, 2013-2022.

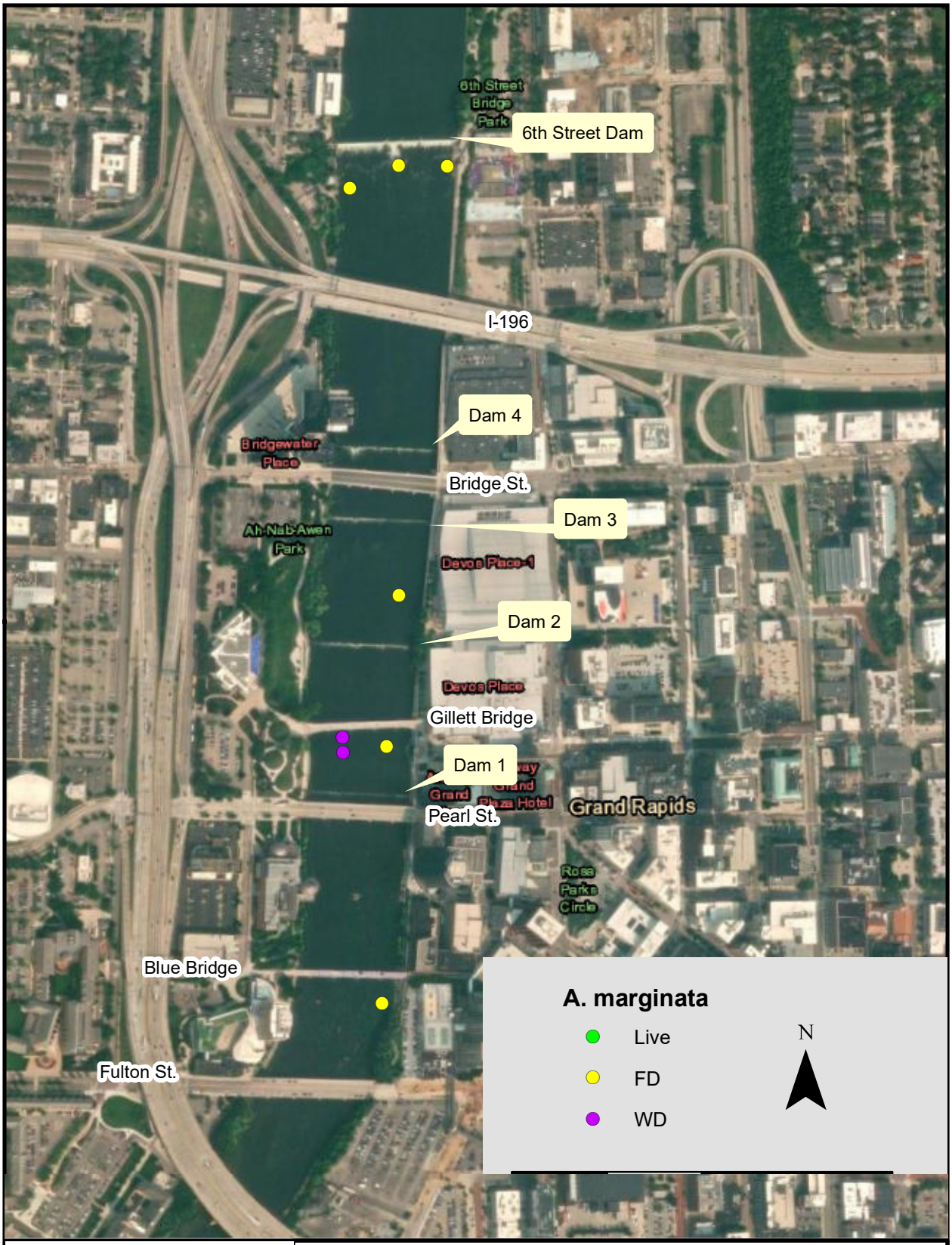

Figure 4-21. *Alasmidonta marginata* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

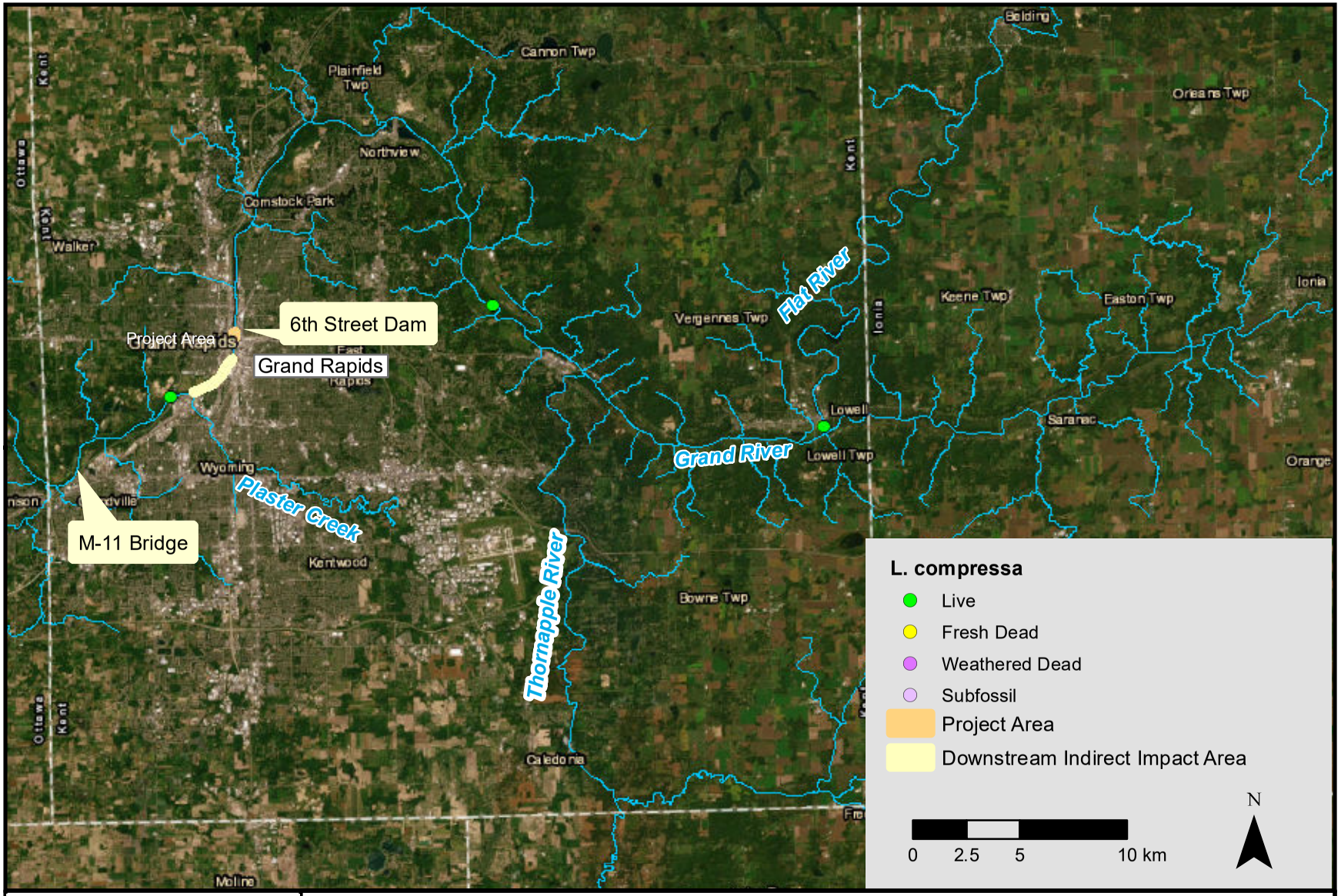

Figure 4-22. Distribution of *Lasmigona compressa* in recent surveys, 2013-2022.

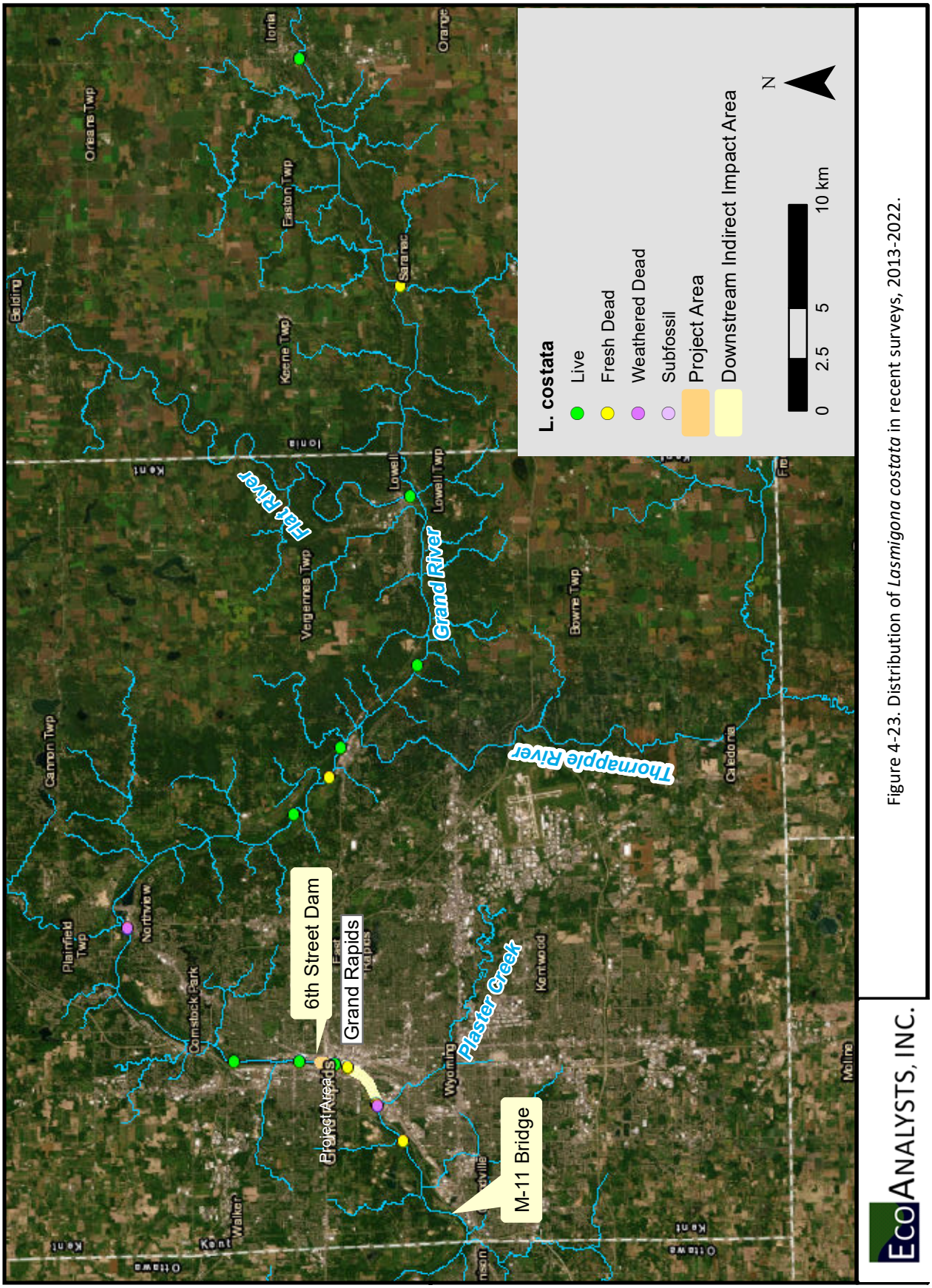

Figure 4-23. Distribution of *Lasmigona costata* in recent surveys, 2013-2022.

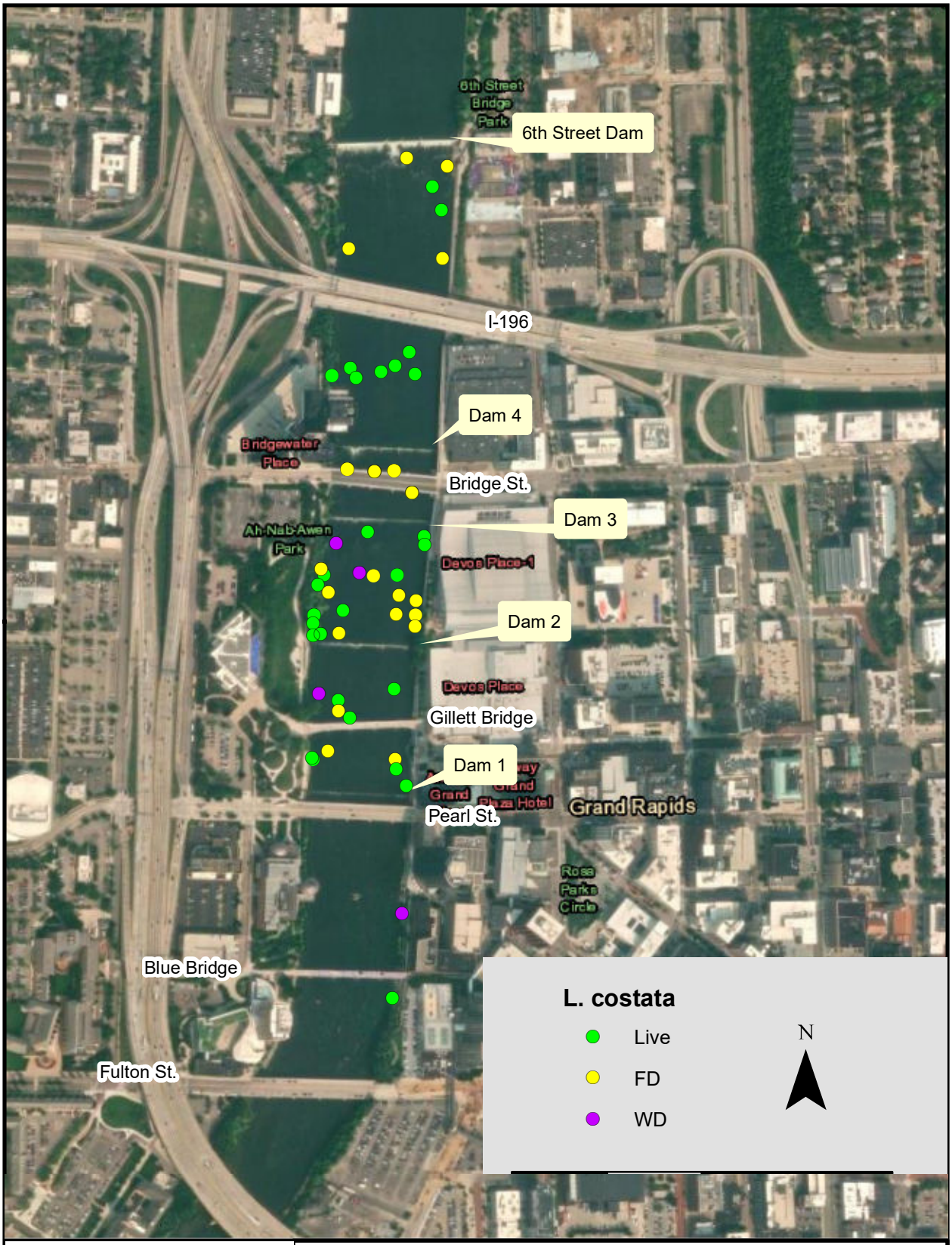

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Figure 4-24. *Lasmigona costata* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

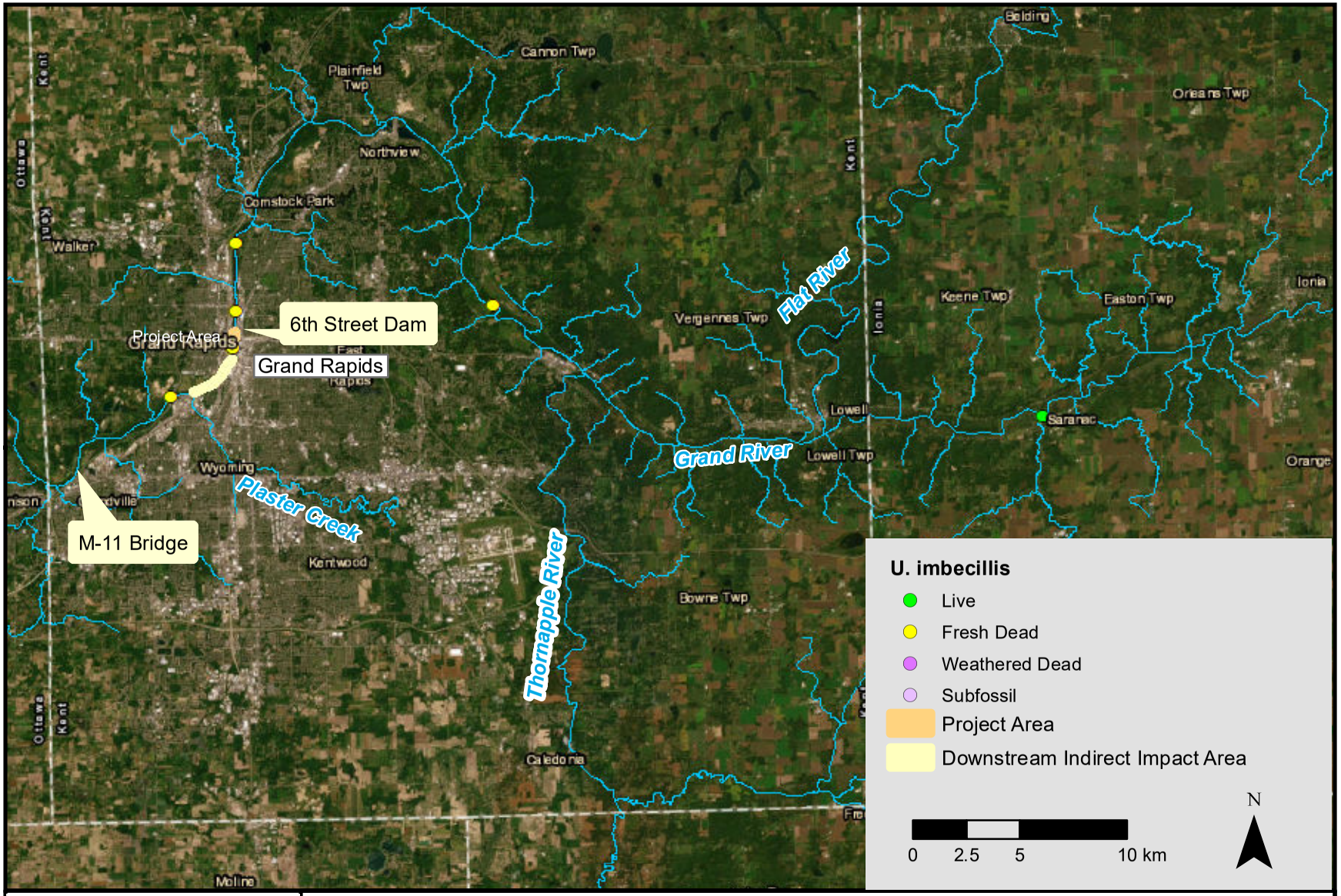

Figure 4-25. Distribution of *Utterbackia imbecilis* in recent surveys, 2013-2022.



Figure 4-26. *Utterbackia imbecillis* recently collected between the 6th Street Dam and Fulton Street Bridge, 2013-2020.

Table 1-1. Informal consultation meetings for Grand Rapids Revitalization Project.

Date	Participants[1]	Discussion
10/27/2023	USFWS, DNR, EGLE, NRCS, RRO, GRWW, City, Eco	Initiate informal consultation, project overview
11/9/2023	USFWS, DNR, EGLE, NRCS, RRO, GRWW, City, Eco	Mussel relocation, mitigation
11/16/2023	USFWS, DNR, EGLE, NRCS, RRO, GRWW, City, Eco	Construction/mussel relocation sequencing
12/14/2023	USFWS, DNR, EGLE, NRCS, RRO, GRWW, City, Eco	Alternatives, impacts, changes from previous project
12/20/2023	USFWS, DNR, EGLE, NRCS, RRO, GRWW, City, Eco	Species, relocation, construction/relocation sequencing
1/11/2024	USFWS, DNR, EGLE, NRCS, RRO, GRWW, City, Eco	Species, Ipac, MNFI, relocation scenario, project schedule
1/17/2024	USFWS, NRCS, GRWW, City, Eco	Relocation schedule (small federal handle), mitigation strategy Small federal handle/Urban Waters, species, mitigation

[1]USFWS=U.S. Fish and Wildlife Service, DNR=Michigan Department of Natural Resources, EGLE=Environment, Great Lakes, and Energy
NRCS=Natural Resource Conservation Service, RRO=River Restoration Organization, GRWW=Grand Rapids Whitewater
City=City of Grand Rapids, Eco=EcoAnalysts, Inc.

Table 1-2. Unionid species composition and abundance between 6th Street Dam and Fulton Street, 2013 to 2020[1].

Species by Tribe	2013 (total)[2]	2016 (Quan)[3]	2017 (Quan)[3]	16/17 (Relo)	2020 (Quan)[3]	Ave.
Amblemini						
Amblema plicata[4]	21.8	33.3	6.3	28.7	40.0	28.4
Pleurobemini						
Eurynia dilatata	**-**	**WD**	**WD**	**-**	**WD**	**WD**
Fusconaia flava[4]	4.1	WD	WD	5.1	FD	4.9
Pleurobema sintoxia	**FD**	**-**	**WD**	**0.5**	**WD**	**0.4**
Quadrulini						
Cyclonaias pustulosa[5]	7.6	WD	WD	3.8	5.0	3.9
Cyclonaias tuberculata	**4.1**	**WD**	**6.3**	**2.8**	**5.0**	**2.9**
Quadrula quadrula	2.4	WD	WD	3.3	WD	3.2
Lampsilini						
Actinonaias ligamentina[5]	5.9	WD	WD	3.0	WD	3.0
Cambarunio iris	**WD**	**-**	**WD**	**-**	**-**	**WD**
Epioblasma triquetra	**1.2**	**WD**	**WD**	**0.9**	**WD**	**0.9**
Lampsilis cardium[5]	19.4	44.4	18.8	35.0	22.5	34.0
Lampsilis siliquoidea	FD	-	-		5.0	0.1
Ligumia recta	**3.5**	**11.1**	**6.3**	**2.9**	**WD**	**2.9**
Potamilus alatus	**1.8**	**11.1**	**-**	**0.5**	**-**	**0.5**
Potamilus fragilis	4.7	FD	6.3	1.3	7.5	1.6
Toxolasma parvum	**-**	**-**	**-**	**-**	**-**	**0.0**
Truncilla truncata[5]	**5.3**	**-**	**6.3**	**1.4**	**7.5**	**1.7**
Venustaconcha ellipsiformis	**WD**	**-**	**-**	**0.0**	**-**	**0.1**
Anodontini						
Alasmidonta marginata	**FD**	**WD**	**WD**	**0.8**	**WD**	**0.7**
Alasmidonta viridis	**-**	**-**	**6.3**	**-**	**-**	**0.0**
Lasmigona complanata	1.2	WD	-	0.1	-	0.1
Lasmigona costata	**14.7**	**WD**	**25.0**	**3.3**	**2.5**	**4.0**
Pyganodon grandis	-	-	WD	0.0	WD	0.0
Strophitus undulatus	2.4	-	12.5	6.9	5.0	6.7
Utterbackia imbecillis	**FD**	**-**	**-**	**-**	**-**	**FD**
Total Live	170	9	16	3084	40	3319
Mean Density (95% Confidence interval)[6]		0.3 (0.1-0.5)	0.3 (0.2-0.5)	0.2	0.3 (0.2-0.5)	0.3
Total Construction Area (m^2)		119,260	119,260	119,260	119,260	119,260
Estimated no. of unionids		35,778	35,778	24,520	34,585	35,778
Lower 95% confidence interval		11,926	23,852		22659.4	
Upper 95% confidence interval		59,630	59,630		58437.4	
Live species	15	4	10	19	9	20
Total species	21	15	20	19	19	24
Live or FD TES species	8	2	6	9	3	11
% T&E species	30.6	22.2	#VALUE!	12.9	15.0	14.1
% ≤5 years old		55.6	43.8		62.5	
% ≤25 mm		0.0	25.0		7.5	

Nomenclature follows FMCS (2023)

TES (threatened, endangered, special concern) species are bolded

FD=freshly dead shell; WD=weathered dead shell, SF=subfossil shell

[1]Data from ESI (2014, 2017a), EcoAnalysts (2018, 2021); Total = qualitative and quantitative, Quan=quantitative only; Cardno (2017) relo = 2016/2017 relocation under I-196 bridge

[2]Relative abundance (% of total) based on all sampling methods combined

[3]Relative abundance (% of total) based on quantitative samples only

[4]Thermally tolerant species (Spooner and Vaughn, 2008)

[5]Thermally sensitive species (Spooner and Vaughn, 2008)

[6]95% confidence interval based on a simple random sample design

Table 1-3. Fish species records from the Action Area within the Grand River.[1]

Family	Scientific name	Common name	Federal and Michigan Status[2]	Present in Action Area: Lower[3]	Present in Action Area: Up of 6th street dam	Present in Action Area: Dn of 6th street dam	Host for unionids in the Project Area[4]	Host for TES unionids[4]
Lampreys	*Ichthyomyzon castaneus*	Chestnut lamprey		x	x	P		
	Ichthyomyzon unicuspis	Silver lamprey				P		
	Ichthyomyzon fossor	N. brook lamprey		x				
	Lampetra appendix	A. brook lamprey		x				
	Petromyzon marinus	Sea lamprey	I	x		x		
Sturgeons	*Acipenser fulvescens*	Lake sturgeon	MT	x		x		
Gars	*Lepisosteus oculatus*	Spotted gar		x				
	Lepisosteus osseus	Longnose gar		x	x	P	x	*L. costata*
Bowfins	*Amia calva*	Bowfin		x	x	P	x	*L. compressa, L costata*
Herrings	*Dorosoma cepedianum*	Gizzard shad		x	x	P		*L. compressa*
Minnows	*Carassius auratus*	Goldfish	I	x	x	x	x	*L. costata, U. imbecillis*
	Cyprinella spiloptera	Spotfin shiner		x	x	P	x	*L. compressa, L. costata, P. sintoxia*
	Cyprinus carpio	Common carp	I	x	x	P	x	*L. costata*
	Hybognathus hankinsoni	Brassy minnow				P		
	Luxilus chrysocephalus	Striped shiner		x	x	P	x	*L. costata*
	Luxilus cornutus	Common shiner		x	x	P	x	*L. compressa, L costata*
	Nocomis biguttatus	Hornyhead chub		x		P	x	*L. compressa, L costata*
	Nocomis micropogon	River chub		x	x	P		
	Notemigonus chrysoleucas	Golden shiner		x	x	P	x	*L. costata, U. imbecillis*
	Notropis atherinoides	Emerald shiner		x		P		*L. compressa*
	Notropis heterolepis	Blacknose shiner				P	x	
	Notropis hudsonius	Spottail shiner		x	x	P	x	*L. compressa, L costata*
	Notropis rubellus	Rosyface shiner		x	x	P	x	*L. recta*
	Notropis stramineus	Sand shiner		x	x	P	x	
	Notropis volucellus	Mimic shiner		x	x	P	x	*L. compressa, L costata*
	Pimephales notatus	Bluntnose minnow		x	x	P	x	*L. compressa, L. costata, P. sintoxia*
	Semotilus atromaculatus	Creek chub		x			x	*L. compressa, L costata*
Suckers	*Carpiodes cyprinus*	Quillback		x	x	P	x	*L. costata*
	Catostomus catostomus	Longnose sucker		x		x		
	Catostomus commersoni	White sucker		x	x	P	x	*A. marginata, L. compressa, L costata*
	Hypentelium nigricans	Northern hogsucker		x	x	P	x	*A. marginata, L. costata*
	Ictiobus cyprinellus	Bigmouth buffalo	I	x		P		
	Minytrema melanops	Spotted sucker		x	x	P		
	Moxostoma anisurum	Silver redhorse		x	x	P	x	*L. costata*
	Moxostoma carinatum	River redhorse	MT	x	x	P		
	Moxostoma duquesnei	Black redhorse		x	x	P		
	Moxostoma erythrurum	Golden redhorse		x	x	x		
	Moxostoma macrolepidotum	Shorthead redhorse		x	x	P	x	*A. marginata, L. costata*
	Moxostoma valenciennesi	Greater redhorse		x	x	P		
Catfish	*Ameiurus natalis*	Yellow bullhead		x	x	P	x	*C. tuberculata, L. compressa, L costata*
	Ictalurus punctatus	Channel catfish		x	x	P	x	*C. tuberculata, L. compressa, L costata, U. imbecillis*
	Pylodictis olivaris	Flathead catfish		x	x	P	x	*C. tuberculata, L. compressa, L costata*
Pikes	*Esox lucius*	Northern pike		x	x	P	x	*L. compressa, L costata*
	Esox masquinongy	Muskellunge		x				
Mudminnows	*Umbra limi*	Central mudminnow		x	x	x	x	*L. compressa, L costata*
Trouts	*Coregonus clupeaformis*	Lake whitefish		x				
	Oncorynchus kisutch	Coho salmon	I	x	x	x		
	Oncorynchus mykiss	Rainbow trout	I	x	x	x		
	Oncorynchus tshawytscha	Chinook salmon	I	x	x	x		
	Prosopium cylindraceum	Round whitefish		x		x		
	Salmo trutta	Brown trout	I	x	x	x		
	Salvelinus fontinalis	Lake trout		x		x		

Table 1-3 (cont.). Fish species records from the Project Area within the Grand River.[1]

Family	Scientific name	Common name	Federal and Michigan Status[2]	Present in Action Area: Lower[3]	Present in Action Area: Up of 6th street dam	Present in Action Area: Dn of 6th street dam	Host for unionids in the Project Area[4]	Host for TES mussel species[4]
Pirate perches	*Aphredoderus sayanus*	Pirate perch		x	x		x	*L. costata*
Cods	*Lota lota*	Burbot		x	x	P	x	*L. costata*
Killifishes	*Fundulus diaphanus*	Banded killifish				P		
Silversides	*Labidesthes sicculus*	Brook silverside		x	x	x	x	
Striped basses	*Morone chrysops*	White bass		x		P	x	
Sunfish	*Ambloplites rupestris*	Rock bass		x	x	P	x	*A. marginata, L. compressa, L. costata, L. recta, U. imbecillis*
	Lepomis cyanellus	Green sunfish		x	x	P	x	*L. compressa, L. costata, L. recta, T. parvum, U. imbecillis*
	Lepomis gulosus	Warmouth				P	x	*T. parvum, U. imbecillis*
	Lepomis gibbosus	Pumpkinseed		x	x	P	x	*L. compressa, L. costata, L. recta, U. imbecillis*
	Lepomis macrochirus	Bluegill		x	x	P	x	*P. sintoxia, L. recta, T. parvum, U. imbecillis*
	Lepomis peltastes	Northern longear sunfish		x	x	P	x	*L. recta, U. imbecillis*
	Micropterus dolomieu	Smallmouth bass		x	x	P	x	*L. compressa, L. costata*
	Micropterus salmoides	Largemouth bass		x	x	P	x	*L. recta, L. compressa, L. costata, U. imbecillis*
	Pomoxis annularis	White crappie		x	x	x	x	*L. recta, T. parvum*
	Pomoxis nigromaculatus	Black crappie		x	x	P	x	*L. recta, L. compressa, L. costata, U. imbecillis*
Perches	*Etheostoma blennioides*	Greenside darter		x		P	x	
	Etheostoma caeruleum	Rainbow darter		x	x	P	x	*L. costata, V. ellipsiformis*
	Etheostoma nigrum	Johnny darter		x	x	P	x	*A. viridis, L. compressa, L. costata, T. parvum, V. ellipsiformis*
	Perca flavescens	Yellow perch		x	x	P	x	*L. compressa, L. costata, L. recta, U. imbecillis*
	Percina caprodes semifasciata	Northern logperch		x	x	P	x	*E. triquetra, L. costata, V. ellipsiformis*
	Percina maculata	Blackside darter		x	x	P	x	*E. triquetra, L. compressa, L. costata, V. ellipsiformis*
	Sander vitreus	Walleye		x	x	P	x	*L. costata*
Drums	*Aplodinotus grunniens*	Freshwater drum		x		P	x	*L. costata, L. recta, P. alatus, T. truncata*
Gobies	*Neogobius melanostomus*	Round goby[5]	I	x	P	P	x	
No. species				75	59	73	53	

[1] Modified from Hanshue and Harrington (2017); P=Present, recent (2017 to 2022) collected between Dam 4 and Plaster Creek (M. Holtgren, 2024, pers. comm)

[2] I=Introduced, MT=Michigan threatened species (Hanshue and Harrington, 2017)

[3] Based on distribution maps in Hanshue and Harrington (2017)

[4] Either natural (NT) or laboratory (LT) transformation observed for at least one of the species in the Project Area (Freshwater Mussel Host Database https:https://mollusk.inhs.illinois.edu/57-2/, 2024)

[5] USGS (https://nas.er.usgs.gov/viewer/omap.aspx; 2024); N. Badgett (pers. comm, EcoAnalysts)

Table 2-1. Existing and Currnt Project areas and impacts to unionid mussels.

	Existing	2024 Project
Total wetted area at 890 CFS (m2)	167,353	166,020
Permanent impact area	643	4,638
Area available for mussel colonization[1]	166,710	161,382
Estimated no. of mussels in available area	50,013	48,415
Modeled Hydrophysical Habitat[2]	6,080	7,565
Construction Area		127,600
Direct Impact Area	0	45,445
Epioblasma triquetra	-	123
Michigan TES	-	1,800
Other unionid species	-	11,711
Indirect Impact Area		82,155
Epioblasma triquetra	-	222
Michigan TES	-	3,253
Other unionid species	-	21,171
OMRRR mussel area[3]		10,000
Epioblasma triquetra	-	27
Michigan TES	-	396
Other unionid species	-	2,577
Upstream Indirect Impact Area4		38,420
Epioblasma triquetra	-	104
Michigan TES	-	1,521
Other unionid species	-	9,901
Downstream Indirect Impact Area[5]		282,600
Epioblasma triquetra	-	0
Michigan TES	-	8,325
Other unionid species	-	28,250

[1]890 wetted area minus dams, boulders, transient sand, and rock or structures that mussels cannot occupy

[2] Areas with current velocity under 1,200 CFS conditions between 0.12 and 0.50 ft/sec; this defines areas with some flow under low flow, but not scouring flow.

Shear stress at 3,900 CFS >0.01 lb/sf to prevent sand deposition

[3] OMRRR (operation, maintenance, repair, rehabilitation, and replacement)

[4] 6th Street Dam to Construction Area

[5] Fulton St. to Plaster Creek - No live *E. triquetra* have been found downstream of Fulton, insufficient data on Michigan TES species to evaluate

Table 2-2. Coordinates[1] for sites within the Action Area.

Site	Easting	Northing
Upstream Indirect Impact Area		
Upstream west	608009	4758821
Upstream east	608158	4758823
Downstream west	608003	4758480
Downstream east	608140	4758473
Construction Area		
Upstream west	608003	4758480
Upstream east	608140	4758473
Downstream west	607905	4757597
Downstream east	608053	4757599
Downstream Indirect Impact Area		
Upstream west	607905	4757597
Upstream east	608053	4757599
Downstream north	606128	4756066
Downstream south	606147	4755979
Recipient sites		
Ada	622007	4869419
Riverside Park	608194	4763006
Plaster Creek	606105	4756021

[1] NAD 1983, UTM Zone 16 North

Table 2-3. 6th Street Dam tailwater elevations under construction and post-construction conditions, and change from existing conditions.[1]

Flowrate (CFS)	Hydraulic condition	Existing WSE[2]	Temporary conditions Model 1[4] WSE[2]	Temporary conditions Model 1[4] Change[3]	Temporary conditions Model 2[5] WSE[2]	Temporary conditions Model 2[5] Change[3]	Temporary conditions Model 3[6] WSE[2]	Temporary conditions Model 3[6] Change[3]	Post-construction Conditions WSE[2]	Post-construction Conditions Change[3]	Modeling results
1,200		595.92	596.25	0.33	596.23	0.31	595.59	-0.33	595.62	-0.30	
2,500	75% exceedance	596.64	596.96	0.32	596.94	0.30	596.30	-0.34	596.33	-0.31	
3,900		597.26	597.58	0.32	597.55	0.29	596.91	-0.35	596.93	-0.33	
5,000		597.67	598.00	0.33	597.97	0.30	597.33	-0.34	597.35	-0.32	SRH-2D
7,500		598.50	598.83	0.33	598.80	0.30	598.18	-0.32	598.19	-0.31	
10,000	1 yr flood	599.20	599.57	0.37	599.53	0.33	598.99	-0.21	598.96	-0.24	
13,000	Bankfull	599.90	600.13	0.23	600.07	0.17	599.94	0.04	599.88	-0.02	
18,000	2 yr flood	601.84	602.04	0.20	602.05	0.21	601.92	0.08	601.86	0.02	
26,000	5 yr flood	604.34	604.52	0.18	604.54	0.20	604.39	0.05	604.32	-0.02	
31,000	10 yr flood	605.98	606.14	0.16	606.15	0.17	605.99	0.01	605.93	-0.05	HEC-RAS
38,000	25 yr flood	608.17	608.29	0.12	608.30	0.13	608.09	-0.08	608.04	-0.13	
44,000	50 yr flood	610.26	610.36	0.10	610.37	0.11	610.16	-0.10	610.11	-0.15	
50,000	100 yr flood	612.92	612.98	0.06	612.99	0.07	612.80	-0.12	612.72	-0.20	

Yellow shading indicates conditions when the distance from the crest to tailwater level is <18"

[1]See Appendix D for methods and data

[2]WSE = wetted surface elevation (mean sea level; ft)

[3]Change = Existing - Post-construction or Construction conditions

[4]Assumes casueways to Dams 1 and 2, and causeways downstream of Pearl Street have been installed and all dams remain in place

[5]Assumes that the coffers at Dam 2 have been installed in addition to all causeways as described in model 1 and all dams remain in place

[6]Assumes the cofferdam has been removed and all proposed improvements are completed, but all causeways are still present

Table 2-4. Water surface elevation (WSE) at the base of the fish ladder.[1]

							Difference to invert[3]				
			Construction					Construction			
Flowrate CFS	Fish Ladder Invert	Existing[2]	Temp. model condtions 1[4]	Temp. model condtions 2[5]	Temp. model condtions 3[6]	Post constr.	Existing[2]	Temp. model condtions 1	Temp. model condtions 2	Temp. model condtions 3	Post constr.
2,500	597.50	596.64	596.96	596.64	596.30	596.33	-0.86	-0.54	-0.86	-1.20	-1.17
5,000	597.50	597.67	598.00	597.97	597.33	597.35	0.17	0.50	0.47	-0.17	-0.15
7,500	597.50	598.50	598.83	598.80	598.18	598.19	1.00	1.33	1.30	0.68	0.69
10,000	597.50	599.20	599.57	599.53	598.99	598.96	1.70	2.07	2.03	1.49	1.46

[1]See Appendix D for details; WSE = wetted surface elevation in feet

[2] Conditions prior to I-196 construction based on HEC RAS model and 1979 base conditions

[3] Construction and Project elevation minus fish ladder invert (jumping distance to the invert)

[4]Assumes casueways to Dams 1 and 2, and causeways downstream of Pearl Street have been installed and all dams remain in place

[5]Assumes that the coffers at Dam 2 have been installed in addition to all causeways as described in model 1 and all dams remain in place

[6]Assumes the cofferdam has been removed and all proposed improvements are completed, but all causeways are still present

Table 2-5. Host fish habitat comparison, existing versus current project.

	Existing	2024 Project
Gradual sloping margins[1]		
Dam to Bridge St	Right bank	Right bank
Bridge St. to Gillett	Right bank	Right bank
Gillette to Pearl St.	Right minimal	Right bank
Pearl St. to Blue Bridge	Minimal	Minimal
Blue Bridge to Fulton	No	No
Moderate depth with cover, slow velocity[2]		
Dam to Bridge St	Left bank	Left bank
Bridge St. to Gillett	Left bank up of beautification dam	Within dam 3 boulders
Gillette to Pearl St.	Dn of beautification dam, Bridge piers	Within and down of Dam 1 riffle
Pearl St. to Blue Bridge	Minimal	Within boulder fields
Blue Bridge to Fulton	Riprap along banks	Within boulder fields
Deeper pools [3]		
Dam to Bridge St	Left bank	Left bank
Bridge St. to Gillett	Bridge piers	Up of dam 2 riffle
Gillette to Pearl St.	No	Minimal
Pearl St. to Blue Bridge	No	No
Blue Bridge to Fulton	No	No
Riffles with large boulders[4]		
Dam to Bridge St	No	No
Bridge St. to Gillett	No	Dam 1 and 2 riffles
Gillette to Pearl St.	No	Dam 1 and 2 riffles
Pearl St. to Blue Bridge	No	No
Blue Bridge to Fulton	No	No
Raceways[5]		
Dam to Bridge St	Throughout	Throughout
Bridge St. to Gillett	Throughout	Throughout
Gillette to Pearl St.	Throughout	Between riffles
Pearl St. to Blue Bridge	Throughout	Throughout
Blue Bridge to Fulton	Throughout	Throughout
Open water[6]		
Dam to Bridge St	Mid channel	Mid channel
Bridge St. to Gillett	Mid channel	Mid channel
Gillette to Pearl St.	Mid channel	Between riffles
Pearl St. to Blue Bridge	Mid channel	Mid channel
Blue Bridge to Fulton	Throughout	Throughout

[1] Habitat for Cyprinidae (Minnows, Shiners)

[2] Habitat for *Lepomis* sp. (Sunfish), juvenile fish, *Catostoma commersoni* (White Sucker)

[3] Habitat for Ictaluridae (Catfish), *Micropterus* sp. (Bass); slow flowing, at least 1 m (3 ft) at 2500 CFS

[4] Habitat for *Percina caprodes* (Logperch), juvenile Ictaluridae (Catfish), juvenile Catostomidae (Suckers)

[5] Habitat for *Moxostoma* sp. (Redhorse), *Hypentelium nigricans* (N. Hogsuckers)

[6] Habitat for *Aplodinotis grunniens* (Freshwater Drum)

Table 2-6. Estimated fish passage success for three length groups of walleye at challenging swim

Location	CFS	Swim path #	50% of Population Would Pass 15" TL	17" TL	20" TL
Upper Ah-Nab-Awen Park (W-Weir/Riffle)	5,000	1	Y	Y	Y
		2	N	N	N
		3	Y	Y	Y
Lower Ah-Nab-Awen (Riffle Structure)	5,000	4	Y	Y	Y
		5	N	N	Y
		6	Y	Y	Y
Museum/JW Marriott	3,900	7	Y	Y	Y
		8	N	N	Y
		9	Y	Y	Y
		10	Y	Y	Y
Downstream of Blue Bridge	2,500	11	N	N	Y
		12	N	N	N
		13	Y	Y	Y
		14	Y	Y	Y
		15	Y	Y	Y

Modified from Holtgren (2024), see Appendix E for fish swimpaths

Y indicates at least 50% of the population would pass, N indicates they would not pass

Table 2-7. Unionid species collected within the lower Grand River, 2013 to 2020.

Species by Tribe	Federal/ State Status[1]	Ionia[2]	Saranac[2]	Flat River[2]	Peace Park[3]	Chief Hazy Cloud[2]	Ada[2]	Roselle Park[3]	Site 7[4]	Riverside Park[4]	Upstream[5]	6th Street Dam to Fulton Street[5]	Dnstream Indirect Impact Area[5]	Plaster Creek Recipient Site[6]	Plaster Creek to M-11 bridge[5,6,7]	Total
Amblemini																
Amblema plicata		27	19	36	7	3	7	45	2	238	523	40	3	L	L	947
Pleurobemini																
Eurynia dilatata		9	2	2	WD	-	-	WD	-	-	FD	WD	WD	WD	-	13
Fusconaia flava		9	11	16	23	3	2	23	WD	35	82	7	FD		L	211
Pleurobema sintoxia	MSC	5	15	2	3	4	4	8	-	1	10	L	WD		-	52
Quadrulini																
Cyclonaias pustulosa		7	5	5	7	1	8	6	WD	6	81	13	2	L	L	139
Cyclonaias tuberculata	MT	6	2	-	6	-	FD	5	-	-	29	7	L	L	-	55
Quadrula quadrula		4	7	2	7	2	1	5	WD	8	137	4	L	L	L	177
Lampsilini																
Actinonaias ligamentina		5	4	4	7	-	2	2	-	-	14	10	L	L	L	48
Epioblasma triquetra	FE, ME	3	2	6	3	4	3	2	WD	FD	3	2	SF	SF	L	28
Lampsilis cardium		22	15	62	8	1	2	10	1	2	40	37	3	3	L	200
Lampsilis siliquoidea		3	2	-	-	-	-	-	-	-	-	L	-		L	5
Ligumia recta	MT	-	10	14	-	-	3	L	-	-	10	7	1	1	L	44
Potamilus alatus	MSC	-	-	-	-	-	-	-	-	-	-	4	2	L	L	4
Potamilus fragilis		-	-		1	-	-	-	-	-	2	8	1	L	L	11
Toxolasma parvum	ME	1	-	1	WD	-	-	-	-	1	-	-	-		-	3
Truncilla donaciformis	ME	-	-	-	-	-	-	-	-	-	-	-	WD		WD	WD
Truncilla truncata	MSC	-	1	-	-	-	-	-	-	-	-	9	L	5	L	10
Venustaconcha ellipsiformis	MSC	-	-	94	1	-	2	1	-	-	WD	L	WD		-	98
Cambarunio iris	MSC	-	-	-	-	-	-	-	-	-	WD	WD	-		-	WD
Anodontini																
Alasmidonta marginata	MSC	1	1	7	FD	1	2	FD	-	-	FD	L	FD		L	12
Alasmidonta viridis	MT	-	-	-	-	-	-	-	-	-	WD	L	WD		-	L
Lasmigona complanata		-	-	-	-	-	-	-	-	-	2	2	L	L	L	4
Lasmigona compressa	MSC	-	-	5	-	-	-	L	-	-	-	-	-		L	L
Lasmigona costata	MSC	2	FD	25	1	1	FD	L	WD	1	47	25	FD	FD	FD	102
Pyganodon grandis		2	4	-	1	-	-	-	-	4	8	L	FD	FD	WD	19
Strophitus undulatus		4	4	6	2	FD	1	1	1	1	24	4	L	L	L	48
Utterbackia imbecillis	MSC	-	2	-	-	-	-	FD	-	FD	FD	FD	WD		FD	2
Total no. live		110	106	287	77	20	37	108	4	297	1012	179	12	9	-	1191
Live species		16	17	16	14	9	12	14	3	10	15	20	12	12	16	25
Total species		16	18	16	17	10	14	17	8	12	21	24	23	16	18	27
CPUE (no. live/hour)		39.8	31.5	169.7	-	-	-	-	-	133	83.7	2.2	-	-	-	-
No./m^2 (±95% conf. int.)		2.4 (±1.0)	3.4 (±1.1)	6.6 (±2.1)	4.5 (±1.3)	4.0 (±1.7)	2.8 (±0.9)	-	0.7 (±0.7)	1.6 (±1.2)	2.2 (±0.7)	0.6 (±0.4)[9]	0.1 (±0.3)	-	-	-
% ≤5 years old[8]		44.4	50.0	42.7	55.8	30.0	59.0	-	50.0	50.0	58.5	83.3	100.0	-	-	-
No./m^2 (±95% conf. int.) 2016		-	-	-	-	-	-	3.6 (±1.0)	-	-	2.2 (±0.7)	0.3 (±0.2)	-	-	-	-
% ≤5 years old[8]		-	-	-	-	-	-	59.3	-	-	61.2	55.6	-	-	-	-
No./m^2 (±95% conf. int.) 2017		-	-	-	-	-	-	3.4 (±0.8)	-	-	1.8 (±0.5)	0.3 (±0.2)	-	-	-	-
% ≤5 years old[8]		-	-	-	-	-	-	64.5	-	-	63.6	43.8	-	-	-	-
No./m^2 (±95% conf. int.) 2017		-	-	-	-	-	-	-	-	-	-	0.3 (±0.1)	-	-	-	-
% ≤5 years old[8]		-	-	-	-	-	-	-	-	-	-	62.5	-	-	-	-

Nomenclature follows FMCS (2023)

FD = Freshly dead shell, WD = Weathered dead shell, SF = Subfossil

[1]FE = federally endangered (USFWS, 2024); ME = Michigan endangered, MT = Michigan threatened, MSC = Michigan species of special concern (https://mnfi.anr.msu.edu/species/animals; accessed February 2024)

[2]ESI (2016); [3]ESI (2017a); EcoAnalysts (2018); [4] ESI (2014) quantitative samples only

[5]Number collected based on combination of quantitative and qualitative samples in 2013 (ESI, 2014);
species found in other studies (JFNew, 2013a, b, c, d; Cardno, 2017) or years (ESI, 2017a; ESI, 2018; EcoAnalysts, 2018, 2019, 2020) are indicate with an L (live)

[6]EcoAnalysts (2021); Species collected by EcoAnalysts (2019) are indicted with an L (live)

[7]Includes Sites 13 and 14 (ESI, 2016; ESI, 2018) and Site I196S (JFNew, 2013b; GEI, 2023); see Figure 3-1

[8]Based on quantitative samples only; [9]Samples were not distributed throughout the Project Area, samples were biased toward higher density areas

Table 2-8. Recipient site areas available for placing TES.[1]

	Ionia	Saranac	Peace Park	Chief Hazy Cloud	Ada	Site 7	Riverside Park[2]	Plaster Creek[2]	Total
Area (m^2)	9,421	5,650	6,749	1,991	23,480	6,675	8,650	286	62,902
Density	2.4	3.4	4.5	4.0	2.8	0.7	1.6	-	
Mussel estimate	22,610	19,210	30,371	7,964	65,744	4,673	13,840	-	164,411
TES Grid Area	-	-	-	-	3,400	-	8,650	286	12,050
No. of TES unionids[1]	-	-	-	-	4,760	-	6,920	-	11,680
Non-TES Area	9,421	5,650	6,749	1,991	15,000	6,675	-	-	45,486
No. mussels[2]	11,305	9,605	15,185	3,982	21,000	2,336	-	-	63,414

[1] No. of mussels that could be placed in the area, assuming density increase will be no more than 50% of resident density

[2] Very few *T. parvum, U. imbecillis, T. truncata* , or *P. alatus* are expected to be placed at these sites

Table 2-9. Estimated number of mussels, including TES within Direct Impact Areas that could translocatec

	Total[1]	≤2ft/sec[2]	Isolated Area[3]
Area (m^2)	45,445	8,225	3,285
No. unionids (0.3/m^2)	13,633	2,468	986
No. *E. triquetra* (0.90%)	123	22	9
No. Michigan TES (13.20%)	1,799	326	130
No. common species (85.90%)	11,710	2,120	847

Relative abundance of species based on Table 1-2

[1]Total direct impact area and estimated number of unionid mussels within direct impact areas

[2]Area within direct impact areas with current velocity ≤2ft/sec under 2500 CFS conditions and considered safe for collecting

[3]Isolated area that would be dewatered and safe for collecting unionid mussels

Table 2-10. Construction and mussel translocation flow rate exceedance probability chart.

Week of	Percent Chance of Exceedance (10 year record)					
	1,500 cfs	2,500 cfs	3,000 cfs	3,500 cfs	5,000 cfs	7,500 cfs
1-Jan	100%	97%	91%	79%	66%	24%
8-Jan	100%	98%	94%	78%	57%	24%
15-Jan	100%	100%	94%	79%	59%	28%
22-Jan	100%	98%	83%	76%	64%	47%
29-Jan	100%	93%	79%	77%	70%	55%
5-Feb	100%	92%	79%	78%	75%	43%
12-Feb	100%	89%	79%	78%	72%	19%
19-Feb	100%	92%	88%	84%	71%	32%
26-Feb	100%	95%	93%	91%	77%	63%
5-Mar	100%	96%	93%	89%	79%	67%
12-Mar	100%	100%	100%	100%	96%	71%
19-Mar	100%	100%	100%	100%	88%	61%
26-Mar	100%	100%	100%	100%	81%	75%
2-Apr	100%	100%	100%	100%	79%	75%
9-Apr	100%	100%	100%	100%	88%	76%
16-Apr	100%	100%	100%	100%	92%	73%
23-Apr	100%	100%	98%	94%	81%	62%
30-Apr	100%	100%	95%	92%	78%	67%
7-May	100%	99%	94%	93%	79%	51%
14-May	100%	95%	93%	91%	77%	60%
21-May	100%	93%	86%	80%	75%	59%
28-May	100%	88%	80%	78%	72%	38%
4-Jun	100%	85%	79%	75%	48%	12%
11-Jun	100%	79%	77%	75%	59%	29%
18-Jun	98%	79%	77%	75%	63%	37%
25-Jun	95%	79%	78%	76%	68%	46%
2-Jul	93%	78%	75%	71%	54%	16%
9-Jul	93%	77%	74%	66%	29%	20%
16-Jul	91%	75%	67%	51%	13%	1%
23-Jul	94%	69%	42%	21%	0%	0%
30-Jul	90%	53%	15%	0%	0%	0%
6-Aug	86%	37%	4%	3%	0%	0%
13-Aug	96%	68%	49%	42%	19%	0%
20-Aug	93%	61%	40%	28%	12%	0%
27-Aug	91%	72%	53%	37%	9%	0%
3-Sep	91%	57%	24%	23%	11%	0%
10-Sep	89%	63%	30%	15%	0%	0%
17-Sep	87%	39%	18%	9%	0%	0%
24-Sep	84%	46%	25%	18%	4%	0%
1-Oct	81%	72%	67%	60%	46%	21%
8-Oct	90%	76%	72%	68%	54%	13%
15-Oct	99%	78%	76%	72%	42%	0%
22-Oct	100%	79%	76%	72%	31%	17%
29-Oct	100%	80%	77%	74%	64%	35%

Table 2-10 (cont). Construction and mussel translocation flow rate exceedance probability chart.

Week of	Percent Chance of Exceedance (10 year record)					
	1,500 cfs	2,500 cfs	3,000 cfs	3,500 cfs	5,000 cfs	7,500 cfs
5-Nov	100%	80%	78%	77%	59%	20%
12-Nov	100%	80%	77%	72%	28%	0%
19-Nov	100%	79%	77%	75%	55%	19%
26-Nov	100%	90%	82%	77%	60%	23%
3-Dec	100%	89%	79%	77%	54%	21%
10-Dec	100%	79%	77%	75%	40%	3%
17-Dec	100%	87%	81%	75%	27%	0%
24-Dec	100%	96%	88%	79%	32%	10%

Table 2-11. Estimated collection effort in Direct Impact areas ≤2 ft/sec under 2,500 CFS conditions.

Construction Area	Total Area (m^2)	Estimated person days[1]	Area (m^2) ≤2 ft/sec[2]	Estimated person days[1]
Dam 2 [3]	6,925	58	810	7
Dam 1	9,045	75	2,470	10
Dam 3 and 4	14,950	125	5,815	48
Down of Pearl	11,240	94	295	2
Isolated area	3,285	27	3,285	27
Total	45,445	379	12,675	94

[1] Assumes 3 min/m^2, with 1 diver/snorkeler, 6 hours of active collecting/day (see methods in text)

[2] Excludes areas within 10 m of the lowhead dams (see Figure 2-8)

[3] Excluding isolated area

Table 2-12. Potential mussel mortality.

	Isolated area only collected (Maximum mortality)					Area ≤2 ft/sec^2 and isolated area (most likely)					All Direct Impact Areas collected (Minimum mortality)			
	Mortality of mussels outside the isolated area	Mussels within the isolated area	15% not collected	5% mortality	Total Mortality	Mortality of mussels outside the collection area	Est. no. of unionids	15% not collected	5% mortality	Total	Est. no. of unionids	15% not collected	5% mortality	Total
Area (m^2)	42,160	3,285				32,770	8,225				45,445			
No. unionids (0.3/m^2)	12,648	986	148	7	12,803	9,831	2,468	370	18	10,219	13,632	2,045	102	2,147
No. *E. triquetra* (0.90%)	114	9	1	0	115	88	22	3	0	92	123	18	1	19
No. Michigan TES (13.20%)	1,670	130	20	1	1,690	1,298	326	49	2	1,349	1,798	270	13	283
No. common species (85.80%)	10,865	847	127	6	10,998	8,445	2,120	318	16	8,779	11,711	1,757	88	1,845

Table 2-13. Potential unionid mortality and resulting mitigation fund.

	Potential Unionid Mortality[1]			Mitigation Fund[2]		
	All Direct Impact Areas translocated	Isolated and ≤2ft/sec areas translocated	Only isolated area translocated	All Direct Impact Areas translocated	Isolated area and ≤2ft/sec areas translocated	Only isolated area translocated
Area (m^2)	45,445	8,225	42,160			
No. unionids (0.3/m^2)	2,147	10,220	12,803	$73,214.06	$348,502.00	$436,589.67
No. *E. triquetra* (0.90%)	19	92	115			
No. Michigan TES (13.20%)	283	1,349	1,690			
No. common species (85.80%)	1,844	8,779	10,998			

[1] 15% not relocated within collected area and 5% not surviving relocation

[2]Mitigation fund based on mortality x $34.10; $28.50 used in the 2020 BA adjusted for inflation between 2020 and 2024.

Table 2-14. Anticipated permitting and construction schedule.

Task/Milestone	Schedule[1]
Final Biological Assessment Submitted to NRCS	February 2024
NRCS Submittal of Biological Assessment (BA) to USFWS	February 2024
USFWS Formal Consultation of BA	February to May 2024
Biological Opinion	June/July 2024
Endangered species permits issued by MDNR	April 2024
MDNR scientific collecting permit	May-24
Mussel translocation[2]	August to October 2024
Publish Draft EA for Public Review	April 2024
Prepare Draft Final EA	May 2024
EGLE Permit Submission	March 2024
Final EA	June 2024
EGLE Review	90 days
EGLE permit receipt	June 2024
Construction Mobilization	April to May 2025
Construction	June 2025 to October 2026

[1] Dates are tentative

[2] Some translocation may occur in 2025

Table 3-1. Unionid mussel records from the Grand River.[1]

Species by Tribe	Common name	Federal and Michigan Status[2]	Headwaters	Upper	Middle[3]	Lower[4]
Amblemini						
Amblema plicata	Threeridge		H	H	R	R
Pleurobemini						
Eurynia dilatata	Spike		H	H	R	R
Elliptio crassidens	Elephantear					H
Fusconaia flava	Wabash Pigtoe		H	H	R	R
Pleurobema sintoxia	Round Pigtoe	MSC	H	H	R	R
Quadrulini						
Cyclonaias tuberculata	Purple Wartyback	MT	-	-	R	R
Cyclonaias pustulosa	Pimpleback		-	-	R	R
Quadrula quadrula	Mapleleaf		-	-	R	R
Lampsilini						
Actinonaias ligamentina	Mucket		-	H	R	R
Cambarunio iris	Rainbow	MSC	H	H	R	H
Epioblasma triquetra	Snuffbox	FE, ME	-	-	R	R
Lampsilis cardium	Pocketbook		H	H	R	R
Lampsilis siliquoidea	Fat Mucket		H	H	R	R
Ligumia recta	Black Sandshell	MT	-	-	R	R
Obliquaria reflexa	Threehorn Wartyback	ME	-	-	-	H
Obovaria olivaria	Hickorynut	ME	-	-	-	H
Potamilus alatus	Pink Heelsplitter	MSC	-	-	-	R
Potamilus fragilis	Fragile Papershell		-	-	-	R
Potamilus ohiensis	Pink Papershell	MT				H
Toxolasma parvum	Lilliput	ME	-	-	R	R
Truncilla donaciformis	Fawnsfoot	MT	-	-	-	H
Truncilla truncata	Deertoe	MSC	-	-	R	R
Venustaconcha ellipsiformis	Ellipse	MSC	H	H	R	R
Anodontini						
Alasmidonta marginata	Elktoe	MSC	-	H	R	R
Alasmidonta viridis	Slippershell	MT	H	H	H	R
Anodontoides ferussacianus	Cylindrical Papershell		H	H	-	R
Lasmigona complanata	White Heelsplitter		-	-	-	R
Lasmigona compressa	Creek Heelsplitter	MSC	H	H	H	R
Lasmigona costata	Flutedshell	MSC	H	H	R	R
Pyganodon grandis	Floater		H	H	R	R
Strophitus undulatus	Creeper		H	H	R	R
Utterbackia imbecillis	Paper Pondshell	MSC	-	-	R	R
No. recently collected species			0	0	21	26
Total no. species			14	16	23	32

[1]Modified from Hanshue and Harrington (2017); H=pre 1950 or recently as only shell material, R=1999 to present

[2] FE=Federally endangered (USFWS, 2024); ME=Michigan endangered, MT=Michigan threatened, MSC=Michigan species of special concern (https://mnfi.anr.msu.edu/species/animals; accessed February 2024)

[3]Added recent records from Woolnough and Barnett (2013), Woolnough (2015)

[4]Added recent records from ESI (2014, 2016, 2017a, 2018); EcoAnalysts (2018, 2019, 2021); JFNew (2013a, b, c, d), Cardno (2017), ES (2013) and records from Badra (2010)

Table 3-2. Unionid records from the middle and lower Grand River.

Species by Tribe	Federal and Michigan Status[1]	Middle: Portland, MI to Maple River [2,5,6,7]	Lower: Maple River to Flat River [2,3,4,5,6,8,11]	Lower: Flat River to Thornapple River [3,4,6,11]	Lower: Thornapple River to Rogue River [3,4,11]	Lower: Rogue River thru Grand Rapids [2,3,4,6,9,11,12]	Lower: Downstrm of Fulton St. [6,10,12]	Total
Amblemini								
Amblema plicata		H,R,C	H,R,C	H,R,C	H,R,C	H,R,C	H,C	H,R,C
Pleurobemini								
Eurynia dilatata		H,C	H,C	H,R	H	H,C	H	H,R,C
Fusconaia flava		R,C	H,R,C	H,R,C	H,R,C	H,R,C	H,C	H,R,C
Pleurobema sintoxia	MSC	H,C	H,R,C	H,C	H,C	H,R,C	H	H,R,C
Quadrulini								
Cyclonaias tuberculata	MT	H,C	H,R,C	H,R,C	H,C	H,R,C	H,C	H,R,C
Cyclonaias pustulosa		H,C	H,R,C	H,R,C	H,R,C	H,R,C	R,C	H,R,C
Quadrula quadrula		H,C	H,R,C	H,R,C	H,R,C	H,R,C	R,C	H,R,C
Lampsilini								
Actinonaias ligamentina		H,R,C	H,R,C	H,C	H,C	H,R,C	H,C	H,R,C
Cambarunio iris	MSC	H,C	H	H	-	H	-	H,C
Epioblasma triquetra	FE, ME	H,C	R,C	R,C	C	R,C	H,C	H,R,C
Lampsilis cardium		H,R,C	H,R,C	H,R,C	H,R,C	H,R,C	R,C	H,R,C
Lampsilis siliquoidea		H,C	H,C	-	-	H,C	H,C	H,C
Ligumia recta	MT	H,C	H,R,C	H	H,C	H,R,C	C	H,R,C
Obliquaria reflexa	ME	-	-	-	-	H	-	H
Obovaria olivaria	ME	-	-	-	-	H	-	H
Potamilus alatus	MSC	-	H	-	-	H,C	C	H,C
Potamilus fragilis		-	-	C	-	H,C	R,C	H,R,C
Toxolasma parvum	ME	C	C	H	-	C	-	H,C
Truncilla donaciformis	MT	-	-	-	-	-	H	H
Truncilla truncata	MSC	C	R,C	R	R	H,R,C	R,C	H,R,C
Venustaconcha ellipsiformis	MSC	H,C	H	R,C	H,C	C	H	H,R,C
Anodontini								
Alasmidonta marginata	MSC	H,C	H,R,C	H,R,C	H,C	H,R,C	H,C	H,R,C
Alasmidonta viridis	MT	H	-	-	-	C	H	H,C
Anodontoides ferussacianus		-	H	R	-	H	-	H,R
Lasmigona complanata		-	-	-	-	H,C	C	H,C
Lasmigona compressa	MSC	H,C	-	R	C	-	C	H,R,C
Lasmigona costata	MSC	H,C	H,R,C	R,C	H,C	H,R,C	R,C	H,R,C
Pyganodon grandis		H,R,C	H,C	R,C	-	H,R,C	C	H,R,C
Strophitus undulatus		H,C	H,R,C	H,R,C	H,C	H,R,C	H,C	H,R,C
Utterbackia imbecillis	MSC	C	C	-	C	C	C	C
No. recent/current species		22	19	19	17	24	16	27
Total no. species		23	23	22	18	28	24	30

[1] FE=Federally endangered (USFWS, 2024); ME=Michigan endangered, MT=Michigan threatened, MSC=Michigan species of special concern (https://mnfi.anr.msu.edu/species/animals; accessed February 2024)

H=Collected before 1950 or post 1950 as a shell only; R=Recently collected live (1999-2003); C=Current, collected live or freshly dead (FD) 2013 to 2022

[2] H (Coker et al., 1919)

[3] H (van der Schalie, 1948)

[4] R (Goforth et al., 2000)

[5] H-shells, R-live (Badra and Goforth, 2002)

[6] H-shells, R-live; (Badra and Goforth, 2003)

[7] H-shell, C-live (Woolnough and Barnett, 2013; Woolnough, 2015)

[8] H-Shell, C-live (ES, 2013)

[9] H-Shell, C-live (JFNew, 2013a, 2013b; Cardno, 2017)

[10] H-shell, C-live (JFNew, 2013c, 2013d)

[11] H-shell, C-live or FD (ESI, 2016, 2017a; EcoAnalysts, 2018)

[12] H-Shell, C-live or FD (ESI, 2014, 2017a, 2018; EcoAnalysts, 2018, 2019, 2021; GEI, 2023)

Table 3-3. TES recruitment evidence within the Action Area, 2013 to 2020[1].

	Ionia 2015	Saranac 2015	Flat River 2015	Peace Park 2016	Chief Hazy Cloud 2015	Ada 2015	Roselle Park 2016-2017	Site 7 2015	Riverside Park 2013	Upstream 2013-2017	6th St. Dam to Fulton 2013-2020
Pleurobema sintoxia	X	X	-	X	-	X	X	-	-	X	-
Cyclonaias tuberculata	X	-	-	X	-	-	X	-	-	-	X
Epioblasma triquetra	X	X	X	-	-	X	X	-	-	-	X
Ligumia recta	-	-	-	-	-	X	X	-	-	-	X
Potamilus alatus	-	-	-	-	-	-	-	-	-	-	-
Toxolasma parvum	-	-	-	-	-	-	-	-	X	-	-
Truncilla truncata	-	X	-	-	-	-	-	-	-	-	X
Venustaconcha ellipsiformis	-	-	X	-	-	X	-	-	-	-	-
Alasmidonta marginata	X	X	X	-	X	X	-	-	-	-	-
Alasmidonta viridis	-	-	-	-	-	-	-	-	-	-	-
Lasmigona compressa	-	-	X	-	-	-	X	-	-	-	-
Lasmigona costata	X	-	X	-	X	-	-	-	X	X	X
Utterbackia imbecillis	-	-	-	-	-	-	-	-	-	-	-

X=at least one individual ≤5 years old collected

[1] ESI (2014, 2016, 2017a); EcoAnalysts (2018, 2021)

Table 3-4. Physical characteristics of sites sampled in the lower Grand River upstream of the Project Area, 2015-2016.

	Ionia	Saranac	Flat River	Peace Park	Chief Hazy Cloud	Ada	Roselle Park	Site 7	Riverside
Area (m^2)	9,400	5,650	12,100	6,750	1,990	23,480	44,300	6,675	8,650
Substrate (%)									
Bedrock	2	0	0	0	0	0	0	0	0
Boulder	4	6	3	3	0	0	3	0	0
Cobble	28	36	25	16	58	11	14	38	0
Gravel	46	35	55	33	24	43	45	25	0
Sand	20	23	17	40	18	43	25	32	88
Silt	0	0	0	6	0	0	12	5	11
Clay	0	0	0	0	0	0	1	0	1
Shell	0	0	0	0	0	3	0	0	0
Detritus	0	0	0	0	0	0	0	0	0
Woody Debris	0	0	0	0	0	0	0	0	0
Vegetation	0	0	0	1	0	0	0	0	0
Water depth range (m)	0.3 - 1.5	0.2 - 1.5	0.2 - 0.9	0.6 - 2.8	0.3 - 0.8	0.3 - 1.2	0.3 - 3.4	0.2 - 0.6	0.2 - 0.6
Relative current velocity	Fast up and down, moderate in middle	Fast upstream, mod to slow elsewhere	Moderate	Fast upstream, moderate to slow downstream	Mod to slow	Moderate	Fast upstream, moderate elsewhere	Mod to slow	Mod to slow

Table 3-5. Potential area (m^2) of larval *P. marinus* habitat upstream of the 6th Street Dam.

Site	Type I	Type II	Total
Bear Creek	13,161	12,745	25,906
Bellamy Creek	8,297	18,967	27,264
Crooked Creek	2,080	4,874	6,954
Fish Creek	173,950	349,147	523,097
Grand River to Webber Dam	594,962	4,571,422	5,166,384
Grand River Webber Dam to North Lansing Dam	240,933	219,310	460,243
Honey Creek	7,612	9,371	16,983
Libhart	21,728	35,428	57,156
Lowell Creek	7,904	16,926	24,830
Maple River (below Elsie Dam)	1,785,662	924,491	2,710,153
Mill Creek	5,801	12,109	17,910
Prairie Creek	30,266	42,005	72,271
Rogue River (below Rockford Dam)	15,402	37,066	52,468
Segwun, Section 9, Tolles, Timberlin Creeks	6,045	12,725	18,770
Bradford, Carl, Egypt, Three Mile, Webber Creeks	9,537	18,786	28,323
Bewell, Kissing Rock, Pump Creeks	4,827	20,896	25,723
Stony Creek	29,534	90,378	119,912
Total	2,957,701	6,396,646	9,354,347

Modified from GLFC (2015)

Table 5-1. Estimated number of unionid mussels in the Direct Impact areas.

		Direct Impact Area (m^2)			
	Relative Abundance (%)[1]	Isolated Area[2] 3,285	≤2ft/sec[3] 8,225	Other Direct Impact Areas[4] 33,935	Total 89,195
Federal TES					
Epioblasma triquetra	0.90	9	22	92	123
Michigan TES					
Pleurobema sintoxia	0.43	4	11	44	59
Cyclonaias tuberculata	2.86	28	71	291	390
Ligumia recta	2.89	28	71	294	394
Potamilus alatus	0.54	5	13	55	74
Toxolasma parvum	0.00	0	0	0	0
Truncilla truncata	1.69	17	42	172	230
Venustaconcha ellipsiformis	0.06	1	1	6	8
Alasmidonta marginata	0.72	7	18	73	98
Alasmidonta viridis	0.03	0	1	3	4
Lasmigona compressa	0.00	0	0	0	0
Lasmigona costata	3.98	39	98	405	543
Utterbackia imbecillis	0.00	0	0	0	0
Total Michigan TES	13.20	130	326	1,344	1,800
Common species					
Amblema plicata	28.38	280	700	2,889	3,869
Fusconaia flava	4.91	48	121	500	669
Cyclonaias pustulosa	3.95	39	97	402	539
Quadrula quadrula	3.19	31	79	325	435
Actinonaias ligamentina	3.04	30	75	309	414
Lampsilis cardium	33.99	335	839	3,460	4,634
Lampsilis siliquoidea	0.06	1	1	6	8
Potamilus fragilis	1.57	15	39	160	214
Lasmigona complanata	0.12	1	3	12	16
Pyganodon grandis	0.03	0	1	3	4
Strophitus undulatus	6.66	66	164	678	908
Total common species	85.90	847	2,120	8,745	11,711
Total mussels	100.00	986	2,468	10,181	13,634

[1]See Table 1-2 for species relative abundance

[2]Area within isolation measures where no construction or tracking will occur until mussels and fish are salvaged

[3]Areas with ≤2ft/sec current velocity under 2,500 CFS conditions and should be safe to collect mussels

[4] Area outside isolated area, and areas >2 ft/sec under 2,500 CFS

Table 5-2. Estimated minimum and maximum mussel mortality due to translocation.

	Relative Abundance (%)[1]	No. mussels in Direct Impact Areas	No. Unsuccessfully Translocated[2]		
			Isolated area only collected	Area ≤2 ft/sec[2] and isolated area (most likely)	All Direct Impact Areas collected
Federal TES					
Epioblasma triquetra	0.90	123	1	3	19
Michigan TES					
Pleurobema sintoxia	0.43	59	1	2	9
Cyclonaias tuberculata	2.86	390	4	11	61
Ligumia recta	2.89	394	4	11	62
Potamilus alatus	0.54	74	1	2	12
Toxolasma parvum	0.00	0	0	0	0
Truncilla truncata	1.69	230	3	7	36
Venustaconcha ellipsiformis	0.06	8	0	0	1
Alasmidonta marginata	0.72	98	1	3	15
Alasmidonta viridis	0.03	4	0	0	1
Lasmigona compressa	0.00	0	0	0	0
Lasmigona costata	3.98	543	6	15	85
Utterbackia imbecillis	0.00	0	0	0	0
Total Michigan TES	13.20	1,800	21	51	283
Common species					
Amblema plicata	28.38	3,869	44	110	609
Fusconaia flava	4.91	669	8	19	105
Cyclonaias pustulosa	3.95	539	6	15	85
Quadrula quadrula	3.19	435	5	12	68
Actinonaias ligamentina	3.04	414	5	12	65
Lampsilis cardium	33.99	4,634	53	132	730
Lampsilis siliquoidea	0.06	8	0	0	1
Lasmigona complanata	0.12	16	0	0	3
Pyganodon grandis	0.03	4	0	0	1
Strophitus undulatus	6.66	908	10	26	143
Total Common Species	84.33	11,497	133	334	1,845
Total mussels	98.43	13,419	155	388	2,147

[1] See Table 1-2

[2] 15% not collected, and 5% mortality due to handling

Table 5-3. Estimated minimum and maximum number of mussels (mortality) in areas not translocated.

	Relative Abundance (%)[1]	No. mussels in Direct Impact Areas	No. in uncollected areas[2]	
			Isolated area only collected (Maximum mortality)	Area ≤2 ft/sec[2] and isolated area (most likely)
Federal TES				
Epioblasma triquetra	0.90	123	114	88
Michigan TES				
Pleurobema sintoxia	0.43	59	54	42
Cyclonaias tuberculata	2.86	390	362	281
Ligumia recta	2.89	394	366	284
Potamilus alatus	0.54	74	68	53
Toxolasma parvum	0.00	0	0	0
Truncilla truncata	1.69	230	214	166
Venustaconcha ellipsiformis	0.06	8	8	6
Alasmidonta marginata	0.72	98	91	71
Alasmidonta viridis	0.03	4	4	3
Lasmigona compressa	0.00	0	0	0
Lasmigona costata	3.98	543	503	391
Utterbackia imbecillis	0.00	0	0	0
Total Michigan TES	13.20	1,800	1,670	1,298
Common species				
Amblema plicata	28.38	3,869	3590	2790
Fusconaia flava	4.91	669	621	483
Cyclonaias pustulosa	3.95	539	500	388
Quadrula quadrula	3.19	435	404	314
Actinonaias ligamentina	3.04	414	385	299
Lampsilis cardium	33.99	4,634	4299	3342
Lampsilis siliquoidea	0.06	8	8	6
Potamilus fragilis	1.57	214	199	154
Lasmigona complanata	0.12	16	15	12
Pyganodon grandis	0.03	4	4	3
Strophitus undulatus	6.66	908	842	655
Total Common Species	85.90	11,711	10,865	8,445
Total mussels	100.00	13,634	12,649	9,831

[1]See Table 1-2

Table 5-4. Estimated minimum and maximum number of mussels unsuccessfully translocated (mortality).

			No. Unsuccessfully Translocated[2]		
	Relative Abundance (%)[1]	No. mussels in Direct Impact Areas	Isolated area only collected (Maximum mortality)	Area ≤2 ft/sec[2] and isolated area (most likely)	All Direct Impact Areas collected (Minimum mortality
Federal TES					
Epioblasma triquetra	0.90	123	115	92	19
Michigan TES					
Pleurobema sintoxia	0.43	59	55	44	9
Cyclonaias tuberculata	2.86	390	366	292	61
Ligumia recta	2.89	394	370	295	62
Potamilus alatus	0.54	74	69	55	12
Toxolasma parvum	0.00	0	0	0	0
Truncilla truncata	1.69	230	216	173	36
Venustaconcha ellipsiformis	0.06	8	8	6	1
Alasmidonta marginata	0.72	98	92	74	15
Alasmidonta viridis	0.03	4	4	3	1
Lasmigona compressa	0.00	0	0	0	0
Lasmigona costata	3.98	543	510	407	85
Utterbackia imbecillis	0.00	0	0	0	0
Total Michigan TES	13.20	1,800	1,690	1,349	283
Common species					
Amblema plicata	28.38	3,869	3633	2900	609
Fusconaia flava	4.91	669	629	502	105
Cyclonaias pustulosa	3.95	539	506	404	85
Quadrula quadrula	3.19	435	408	326	68
Actinonaias ligamentina	3.04	414	389	311	65
Lampsilis cardium	33.99	4,634	4352	3474	730
Lampsilis siliquoidea	0.06	8	8	6	1
Potamilus fragilis	1.57	214	201	160	34
Lasmigona complanata	0.12	16	15	12	3
Pyganodon grandis	0.03	4	4	3	1
Strophitus undulatus	6.66	908	853	681	143
Total Common Species	85.90	11,711	10,998	8,779	1,845
Total mussels	100.00	13,634	12,803	10,220	2,147

[1] See Table 1-2

[2] Mortality from NRCS (Table 5-3) and USFWS project (Table 5-2) combined

Table 5-5. Estimated number of unionid mussels in Indirect Impact areas.

Area (m^2)	Project Area Relative Abund. (%)[1]	Upstream Indirect 38,420	Construction Indirect 82,155	Project Area Total 120,575	Downstream Relative Abund (%)[4]	Downstream Indirect Area 282,600
Federal TES						
Epioblasma triquetra	0.90	104	222	326	0.20	55
Michigan TES species						
Pleurobema sintoxia	0.43	50	106	156	0.00	0
Cyclonaias tuberculata	2.86	330	705	1,035	0.02	5
Ligumia recta	2.89	333	712	1,045	0.91	255
Potamilus alatus	0.54	62	133	195	2.50	705
Toxolasma parvum	0.00	0	0	0	0.00	0
Truncilla truncata	1.69	195	417	611	30.19	8,530
Venustaconcha ellipsiformis	0.06	7	15	22	0.00	0
Alasmidonta marginata	0.72	83	177	260	0.05	15
Alasmidonta viridis	0.03	3	7	11	0.00	0
Lasmigona compressa	0.00	0	0	0	0.00	0
Lasmigona costata	3.98	459	981	1,440	0.00	0
Utterbackia imbecillis	0.00	0	0	0	0.00	0
Total Michigan TES	13.20	1,521	3,253	4,775	29.47	9,510
Common species						
Amblema plicata	28.38	3,271	6,995	10,266	17.95	5,075
Fusconaia flava	4.91	566	1,210	1,776	0.96	270
Cyclonaias pustulosa	3.95	455	974	1,429	6.28	1,775
Quadrula quadrula	3.19	368	786	1,154	1.32	375
Actinonaias ligamentina	3.04	350	749	1,100	1.13	320
Lampsilis cardium	33.99	3,918	8,377	12,295	13.20	3,730
Lampsilis siliquoidea	0.06	7	15	22	6.70	1,895
Potamilus fragilis	1.57	181	387	568	10.99	3,105
Lasmigona complanata	0.12	14	30	43	0.64	180
Pyganodon grandis	0.03	3	7	11	0.00	0
Strophitus undulatus	6.66	768	1,641	2,409	6.97	1,970
Total common species	85.90	9,901	21,171	31,072	70.53	18,695
Total mussels	100.00	11,526	24,647	36,173	100.00	28,260

[1] See Table 1-2

[2] Area within the Project Area not directly affected by construction, but may be affected by local changes in hydraulics

[3] Areas between direct impact areas that may also be affected by construction related turbidity

[4] Downstream relative abundance and density ($0.1/m^2$) based on average of mussels collected between Fulton St. and I-196 by ESI/EcoAnalysts in 2013, 2017, and 2018 (ESI, 2014 and 2018; EcoAnalysts, 2019) and GEI (2023)

Table 5-6. Maximum estimated number of unionid mussels in areas that could be affected by OMRRR[1].

	Relative Abundance (%)[1]	OMRRR area[3] 10,000 m^2
Federal TES		
Epioblasma triquetra	0.90	27
Michigan TES		
Pleurobema sintoxia	0.43	13
Cyclonaias tuberculata	2.86	86
Ligumia recta	2.89	87
Potamilus alatus	0.54	16
Toxolasma parvum	0.00	0
Truncilla truncata	1.69	51
Venustaconcha ellipsiformis	0.06	2
Alasmidonta marginata	0.72	22
Alasmidonta viridis	0.03	1
Lasmigona compressa	0.00	0
Lasmigona costata	3.98	119
Utterbackia imbecillis	0.00	0
Total Michigan TES	13.20	396
Common species		
Amblema plicata	28.38	851
Fusconaia flava	4.91	147
Cyclonaias pustulosa	3.95	119
Quadrula quadrula	3.19	96
Actinonaias ligamentina	3.04	91
Lampsilis cardium	33.99	1,020
Lampsilis siliquoidea	0.06	2
Potamilus fragilis	1.57	47
Lasmigona complanata	0.12	4
Pyganodon grandis	0.03	1
Strophitus undulatus	6.66	200
Total common species	85.90	2,577
Total mussels	100.00	3,000

[1]OMRRR=Operation, maintainence, repair, rehabilitation, and replacement

[2] See Table 1-2

[3] Maximum area estimated to be affected by OMRRR activities

Appendix A. Summary of Project Changes: 2023 B3 Conceptual Design

Summary of Project Changes: 2023 B3 Conceptual Design

Since the 2022 permit submittal of Alternative 3a, the following changes have been made to the proposed project improvements. The list below only summarizes changes to proposed post-project conditions and does not include detail on changes to temporary construction conditions at this time. Coordination with the new construction manager has been initiated and updates to construction sequencing and means and methods will be determined through that process. A complete new set of drawings will be developed to reflect the new design.

Summary of changes to proposed improvements:

1. Between Blue Bridge and Fulton Street
    - The boulder wave structure on the west side of the channel has been replaced with an augmented boulder vane structure with a reduced footprint and surrounding scattered boulders.
    - The previous design included a recovery pool downstream of the wave; this pool has been removed from the design. There may be a small scour pool directly downstream of the vane structure, similar to other Michigan projects that have implemented W-weir or Aadland rock arch designs.
    - The previous design also contained some excavation beneath blue bridge for construction access and increased flood conveyance; changes to this will be determined through coordination with the construction manager and ongoing flood impact modeling.
    - The east side of the channel is largely the same as previously proposed, with scattered boulders in the same general location.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from **1.0 acres to 0.2 acres**.
2. Between Pearl and Blue Bridge
    - The hydraulic feature here, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with scattered boulder and a series of vane structures to provide slack water near designated access points on the banks. The layout of scattered boulder and vane structures is still being designed and evaluated from a flood modeling impact standpoint.
    - The recovery pool of the previous design has been removed.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from **1.2 acres to 0.1 acres.**
3. Between Gillett and Pearl Street (Location of Dam 1)
    - The hydraulic feature here, which included a boulder wave structure on the west side connected to a constructed riffle structure on the east, has been replaced with a single constructed riffle and moved downstream to have more overlap with the dam 1 removal footprint.
    - The recovery pool of the previous design has been removed.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from **1.9 acres to 1.4 acres.**

4. Location of Dam 2
    - The hydraulic feature here, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with a hydraulic feature that combines constructed riffles on either side of the river with a series of boulder drop structures in the center of the channel. The new hydraulic feature has a reduced footprint.
    - The recovery pool of the previous design has been removed. Small scour pools are included directly downstream of the boulder drop structures, similar to other Michigan projects that have implemented W-weir or Aadland rock arch designs.
    - Total estimated permanent direct impact area in this section of the reach has been reduced from **3.0 acres to 1.5 acres.**
5. Location of Dam 3
    - The dam removal limits have been expanded to include re-grading of the channel upstream of Dam 3.
    - Per coordination with EGLE in Fall 2021 for creation of alternative 2b, the grading limits around Dams 3 and 4 were expanded to provide a more gradual sloping riverbed when the dams were removed. EGLE requested the expanded grading limits be the baseline for the 2023 design concept.
    - Scattered boulder is proposed to be placed within the dam removal footprint.
    - Total estimated permanent direct impact area in this section of the reach has been changed from **0.2 acres to 1.2 acres.**
6. Location of Dam 4
    - The dam removal limits have been expanded to include re-grading of the channel upstream of Dam 4.
    - Per coordination with EGLE in Fall 2021 for creation of alternative 2b, the grading limits around Dams 3 and 4 were expanded to provide a more gradual sloping riverbed when the dams were removed. EGLE requested the expanded grading limits be the baseline for the 2023 design concept.
    - Total estimated permanent direct impact area in this section of the reach has been changed from **0.3 acres to 1.6 acres.**

Total estimated total permanent direct impact area for the project has been reduced **from 7.6 acres to 6.1 acres**. A figure comparing the areas of permanent direct impact between Alternative 3a and the current Re-design concept is attached.

Summary of changes to modeled tailwater elevations at 6th Street Dam

The previous project design (Alternative 3a) proposed lowering the upstream hydraulic control elevation from a uniform elevation of 595' (Dam 4 crest) to a variable crest elevation of approximately 593'. This lowering of two feet resulted in decreases in modeled tailwater elevations at 6th Street Dam of up to 0.5' at low flow and similar tailwater elevations (or very small decreases) during flood flows, when Dam 4 (and all proposed grade control) is submerged by several feet.

The elevation to which the upstream hydraulic control of the reach was proposed to be lowered in the previous design was driven by project goal to avoid modeled increased tailwater at 6th Street Dam as a means to demonstrate that the effectiveness of the dam as a barrier to sea lamprey would not be

adversely impacted. This goal was balanced with the goal of avoiding increased velocities and scour potential upstream of the project area to 6th Street Dam. Over the last 100 years, Dam 4 has been providing a level of protection to bed mobility and infrastructure, as well as decreased velocities that the angling community has become accustomed to. Therefore, the proposed upstream crest elevation was set to maintain these conditions to the highest degree possible, while also meeting the lamprey barrier effectiveness goal. None of this has changed as part of the re-design effort.

For these reasons, modeled tailwater elevations for the re-designed concept remain very similar to those of Alternative 3a. These modeled tailwater elevations are compared in the table below. All water surface elevations are based on SRH-2D modeling results.

Table 1: Changes to proposed modeled tailwater elevations at 6th Street Dam.

Flowrate (cfs)	Existing Conditions (ft)	Alternative 3a		Re-design Concept	
		Tailwater Elev. (ft)	Change in Tailwater (ft)	Tailwater Elev. (ft)	Change in Tailwater (ft)
1,200	595.9	595.6	-0.3	595.6	-0.3
2,500	596.7	596.4	-0.3	596.4	-0.3
3,900	597.4	597.1	-0.3	597.0	-0.4
5,000	597.8	597.5	-0.3	597.4	-0.4
7,500	598.7	598.4	-0.3	598.3	-0.4
10,000	599.5	599.2	-0.3	599.1	-0.4
13,000	600.2	600.1	-0.1	600.0	-0.2
18,000	601.7	601.7	0.0	601.6	-0.1
27,000	604.4	604.4	0.0	604.4	0.0
33,000	606.4	606.4	0.0	606.4	0.0

Please let me know if you have any questions or if any additional information would be helpful.

Sincerely,



Scott Prins P.E.
River Engineer
scott.prins@riverrestoration.org
(970) 947-9568

Attachment: *Permanent Direct Impact Comparison Map*



LEGEND

LIMITS OF PERMANENT DIRECT IMPACTS - ALTERNATIVE 3A: 7.6 ACRES

LIMITS OF PERMANENT DIRECT IMPACTS - REDESIGN CONCEPT: 6.1 ACRES

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. **5315**

Sheet No. 1 of ___

Appendix B. IPac and MNFI species coordination

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Michigan Ecological Services Field Office
2651 Coolidge Road Suite 101
East Lansing, MI 48823-6360
Phone: (517) 351-2555 Fax: (517) 351-1443

In Reply Refer To: January 15, 2024
Project Code: 2024-0036384
Project Name: Grand rapids whitewater lower reach

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

Official Species List
The attached species list identifies any Federally threatened, endangered, proposed and candidate species that may occur within the boundary of your proposed project or may be affected by your proposed project. The list also includes designated critical habitat if present within your proposed project area or affected by your project. This list is provided to you as the initial step of the consultation process required under section 7(c) of the Endangered Species Act, also referred to as Section 7 Consultation.

Under 50 CFR 402.12(e) (the regulations that implement section 7 of the Endangered Species Act), the accuracy of this species list should be verified after 90 days. You may verify the list by visiting the IPaC website (https://ipac.ecosphere.fws.gov/) at regular intervals during project planning and implementation. To update an Official Species List in IPaC: from the My Projects page, find the project, expand the row, and click Project Home. In the What's Next box on the Project Home page, there is a Request Updated List button to update your species list. Be sure to select an "official" species list for all projects.

Consultation requirements and next steps
Section 7 of the Endangered Species Act of 1973 requires that actions authorized, funded, or carried out by Federal agencies not jeopardize Federally threatened or endangered species or adversely modify designated critical habitat. To fulfill this mandate, Federal agencies (or their designated non-Federal representative) must consult with the Fish and Wildlife Service if they determine their project may affect listed species or critical habitat.

There are two approaches to evaluating the effects of a project on listed species.

Approach 1. Use the All-species Michigan determination key in IPaC. This tool can assist you in making determinations for listed species for some projects. In many cases, the determination key

will provide an automated concurrence that completes all or significant parts of the consultation process. Therefore, we strongly recommend screening your project with the **All-Species Michigan Determination Key (Dkey)**. For additional information on using IPaC and available Determination Keys, visit https://www.fws.gov/media/mifo-ipac-instructions (and click on the attachment). Please carefully review your Dkey output letter to determine whether additional steps are needed to complete the consultation process.

Approach 2. Evaluate the effects to listed species on your own without utilizing a determination key. Once you obtain your official species list, you are not required to continue in IPaC, although in most cases using a determination key should expedite your review. If the project is a Federal action, you should review our section 7 step-by-step instructions before making your determinations: https://www.fws.gov/office/midwest-region-headquarters/midwest-section-7-technical-assistance. If you evaluate the details of your project and conclude "no effect," document your findings, and your listed species review is complete; you do not need our concurrence on "no effect" determinations. If you cannot conclude "no effect," you should coordinate/consult with the Michigan Ecological Services Field Office. The preferred method for submitting your project description and effects determination (if concurrence is needed) is electronically to EastLansing@fws.gov. Please include a copy of this official species list with your request.

For all **wind energy projects** and **projects that include installing communications towers >450 feet that use guy wires**, please contact this field office directly for assistance, even if no Federally listed plants, animals or critical habitat are present within your proposed project area or may be affected by your proposed project.

Migratory Birds
Please see the "Migratory Birds" section below for important information regarding incorporating migratory birds into your project planning. Our Migratory Bird Program has developed recommendations, best practices, and other tools to help project proponents voluntarily reduce impacts to birds and their habitats. The Bald and Golden Eagle Protection Act prohibits the take and disturbance of eagles without a permit. If your project is near an eagle nest or winter roost area, see our Eagle Permits website at https://www.fws.gov/program/eagle-management/eagle-permits to help you avoid impacting eagles or determine if a permit may be necessary.

Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your consideration of threatened and endangered species during your project

planning. Please include a copy of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- USFWS National Wildlife Refuges and Fish Hatcheries
- Bald & Golden Eagles
- Migratory Birds
- Wetlands

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Michigan Ecological Services Field Office
2651 Coolidge Road Suite 101
East Lansing, MI 48823-6360
(517) 351-2555

PROJECT SUMMARY

Project Code: 2024-0036384
Project Name: Grand rapids whitewater lower reach
Project Type: Restoration / Enhancement of Waterbody
Project Description: Direct impact areas extend from 300 ft above Dam 4 to Fulton Street bridge. Causeways will be constructed for equipment to remove existing low head dams and create riffles and drop structures. Indirect impact areas extend upstream to the 6th street dam and downstream to the mouth of Plaster Creek. Construction would like to begin in September 2024 and will likely extend thru 2025. Construction equipment will be staged at Ah-nab-awen park.

Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@42.9618622,-85.67743905554654,14z



Counties: Kent County, Michigan

ENDANGERED SPECIES ACT SPECIES

There is a total of 8 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 1 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Indiana Bat *Myotis sodalis* There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/5949 General project design guidelines: https://ipac.ecosphere.fws.gov/project/OCKXVTBBYBEV5P5UBNVETDRRT4/documents/generated/6982.pdf	Endangered
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Endangered
Tricolored Bat *Perimyotis subflavus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10515	Proposed Endangered

BIRDS

NAME	STATUS
Whooping Crane *Grus americana* Population: U.S.A. (AL, AR, CO, FL, GA, ID, IL, IN, IA, KY, LA, MI, MN, MS, MO, NC, NM, OH, SC, TN, UT, VA, WI, WV, western half of WY) No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/758	Experimental Population, Non-Essential

REPTILES

NAME	STATUS
Eastern Massasauga (=rattlesnake) *Sistrurus catenatus*	Threatened

No critical habitat has been designated for this species.
This species only needs to be considered under the following conditions:
- For all Projects: Project is within EMR Range

Species profile: https://ecos.fws.gov/ecp/species/2202
General project design guidelines:
https://ipac.ecosphere.fws.gov/project/OCKXVTBBYBEV5P5UBNVETDRRT4/documents/generated/5280.pdf

CLAMS

NAME	STATUS
Snuffbox Mussel *Epioblasma triquetra*	Endangered

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/4135

INSECTS

NAME	STATUS
Karner Blue Butterfly *Lycaeides melissa samuelis*	Endangered

There is **proposed** critical habitat for this species.
Species profile: https://ecos.fws.gov/ecp/species/6656

Monarch Butterfly *Danaus plexippus*	Candidate

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/9743

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

USFWS NATIONAL WILDLIFE REFUGE LANDS AND FISH HATCHERIES

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS OR FISH HATCHERIES WITHIN YOUR PROJECT AREA.

BALD & GOLDEN EAGLES

Bald and golden eagles are protected under the Bald and Golden Eagle Protection Act[1] and the Migratory Bird Treaty Act[2].

Any person or organization who plans or conducts activities that may result in impacts to bald or golden eagles, or their habitats[3], should follow appropriate regulations and consider implementing appropriate conservation measures, as described in the links below. Specifically, please review the "Supplemental Information on Migratory Birds and Eagles".

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1. The Bald and Golden Eagle Protection Act of 1940.
2. The Migratory Birds Treaty Act of 1918.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

There are bald and/or golden eagles in your project area.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the PROBABILITY OF PRESENCE SUMMARY below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Dec 1 to Aug 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (▪)

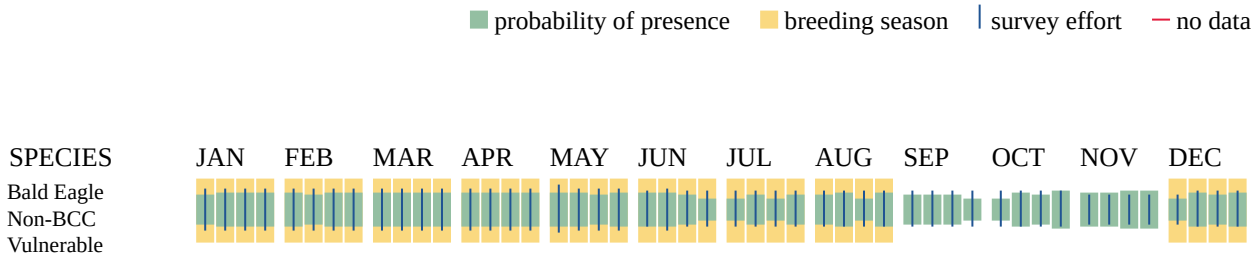
Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (▪)
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)

Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

MIGRATORY BIRDS

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats[3] should follow appropriate regulations and consider implementing appropriate conservation measures, as described in the links below. Specifically, please review the "Supplemental Information on Migratory Birds and Eagles".

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1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the PROBABILITY OF PRESENCE

SUMMARY below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Dec 1 to Aug 31
Black-billed Cuckoo *Coccyzus erythropthalmus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9399	Breeds May 15 to Oct 10
Canada Warbler *Cardellina canadensis* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9643	Breeds May 20 to Aug 10
Cerulean Warbler *Dendroica cerulea* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/2974	Breeds Apr 22 to Jul 20
Chimney Swift *Chaetura pelagica* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9406	Breeds Mar 15 to Aug 25
Golden-winged Warbler *Vermivora chrysoptera* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8745	Breeds May 1 to Jul 20
Lesser Yellowlegs *Tringa flavipes* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9679	Breeds elsewhere
Long-eared Owl *asio otus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/3631	Breeds Mar 1 to Jul 15
Pectoral Sandpiper *Calidris melanotos* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9561	Breeds elsewhere

NAME	BREEDING SEASON
Red-headed Woodpecker *Melanerpes erythrocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9398	Breeds May 10 to Sep 10
Rusty Blackbird *Euphagus carolinus* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/9478	Breeds elsewhere
Short-billed Dowitcher *Limnodromus griseus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9480	Breeds elsewhere
Wood Thrush *Hylocichla mustelina* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9431	Breeds May 10 to Aug 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (■)
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

■ probability of presence ■ breeding season | survey effort – no data



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management

- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

WETLANDS

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

RIVERINE

- R2UBH

FRESHWATER FORESTED/SHRUB WETLAND

- PFO1A

IPAC USER CONTACT INFORMATION

Agency: Natural Resources Conservation Service
Name: Heidi Dunn
Address: 1417 Hoff Industrial Dr.
City: O'Fallon
State: MO
Zip: 63366
Email hdunn@ecoanalysts.com
Phone: 3142778773

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Natural Resources Conservation Service

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Michigan Ecological Services Field Office
2651 Coolidge Road Suite 101
East Lansing, MI 48823-6360
Phone: (517) 351-2555 Fax: (517) 351-1443

In Reply Refer To: January 15, 2024
Project code: 2024-0036384
Project Name: Grand rapids whitewater lower reach

Subject: Consistency letter for 'Grand rapids whitewater lower reach' for specified federally threatened and endangered species and designated critical habitat that may occur in your proposed project area consistent with the Michigan Determination Key for project review and guidance for federally listed species (Michigan Dkey).

Dear Heidi Dunn:

The U.S. Fish and Wildlife Service (Service) received on **January 15, 2024** your effect determination(s) for the 'Grand rapids whitewater lower reach' (the Action) using the Michigan DKey within the Information for Planning and Consultation (IPaC) system. The Service developed this system in accordance with the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

Based on your answers and the assistance of the Service's Michigan DKey, you made the following effect determination(s) for the proposed Action:

Species	**Listing Status**	**Determination**
Eastern Massasauga (=rattlesnake) (*Sistrurus catenatus*)	Threatened	May affect
Indiana Bat (*Myotis sodalis*)	Endangered	No effect
Karner Blue Butterfly (*Lycaeides melissa samuelis*)	Endangered	No effect
Monarch Butterfly (*Danaus plexippus*)	Candidate	No effect
Northern Long-eared Bat (*Myotis septentrionalis*)	Endangered	No effect
Snuffbox Mussel (*Epioblasma triquetra*)	Endangered	May affect
Tricolored Bat (*Perimyotis subflavus*)	Proposed Endangered	No effect
Whooping Crane (*Grus americana*)	Experimental Population, Non-Essential	No effect

Please carefully review this letter. Your Endangered Species Act requirements are not complete.

Eastern Massasauga (EMR):
EMR may be present in the Action area. The following projects are not within the scope of the Michigan DKey: prescribed fire; new roads or trails that create a permanent barrier to EMR movement; projects that alter hydrology permanently, or temporarily if during the inactive season; projects that are large in scale; and projects that do not apply recommended conservation measures. Project-specific review is needed for these types of projects. **Please coordinate with the Michigan Ecological Services Field Office to further evaluate effects of the Action on EMR.**

Freshwater Mussels:
Federally listed mussels may be present in the Action area. Projects may affect listed mussels if they may permanently affect local hydrology, directly impact a Group 3 stream[1] (e.g., stream/road crossings, new stormwater outfall discharge, dams, other in-stream work, etc.), and/or indirectly impact a Group 3 stream or riparian zone (e.g., cut and fill, horizontal directional drilling, construction, vegetation removal, discharge, etc.). **Please coordinate with the Michigan Ecological Services Field Office to further evaluate effects of the Action on Federally listed mussels.**

Freshwater mussels are one of the most critically imperiled groups of organisms in the world. In North America, 65% of the remaining 300 species are vulnerable to extinction (Haag and Williams 2014). Implementing measures to conserve and restore freshwater mussel populations directly improves water quality in lakes, rivers, and streams throughout Michigan. An adult freshwater mussel filters anywhere from 1 to 38 gallons of water per day (Baker and Levinton 2003, Barnhart pers. comm. 2019). A 2015 survey found that in some areas mussels can reduce the bacterial populations by more than 85% (Othman et al. 2015 in Vaughn 2017). Mussels are also considered to be ecosystem engineers, stabilizing substrate and providing habitat for other aquatic organisms (Vaughn 2017). In addition to ecosystem services, mussels play an important role in the food web, contributing critical nutrients to both terrestrial and aquatic habitats, including those that support sport fish (Vaughn 2017). Taking proactive measures to conserve and restore freshwater mussels will improve water quality, which has the potential to positively impact human health and recreation in the State of Michigan.

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[1]The Group 3 is a specific list of stream segments within known counties that contain habitat likely to be occupied by listed mussels (see Michigan Freshwater Mussel Survey Protocol and Relocation Procedures for additional information).

Bald and Golden Eagles:
Bald eagles, golden eagles, and their nests are protected under the Bald and Golden Eagle Protection Act (54 Stat. 250, as amended, 16 U.S.C. 668a-d) (Eagle Act). The Eagle Act prohibits, except when authorized by an Eagle Act permit, the “taking” of bald and golden eagles and defines “take” as “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb.” The Eagle Act’s implementing regulations define disturb as “…to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially

interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

If the Action may impact bald or golden eagles, additional coordination with the Service under the Eagle Act may be required. For more information on eagles and conducting activities in the vicinity of an eagle nest, please visit https://www.fws.gov/library/collections/all-about-eagles. In addition, the Service developed the National Bald Eagle Management Guidelines (May 2007) in order to assist landowners in avoiding the disturbance of bald eagles. The full Guidelines are available at https://www.fws.gov/media/national-bald-eagle-management-guidelines-0.

If you have further questions regarding potential impacts to eagles, please contact Chris Mensing, Chris_Mensing@fws.gov or 517-351-2555.

Monarch butterfly and other pollinators
In December 2020, after an extensive status assessment of the monarch butterfly, we determined that listing the monarch under the Endangered Species Act is warranted but precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants. Therefore, the Service added the monarch butterfly to the candidate list. The Service will review its status each year until we are able to begin developing a proposal to list the monarch.

The Endangered Species Act does not establish protections or consultation requirements for candidate species. Some Federal and State agencies may have policy requirements to consider candidate species in planning. We encourage implementing measures that will remove or reduce threats to these species and possibly make listing unnecessary.

For all projects, we recommend the following best management practices (BMPs) to benefit monarch and other pollinators.

Monarch and Pollinator BMP Recommendations

Consider monarch and other pollinators in your project planning when possible. Many pollinators are declining, including species that pollinate key agricultural crops and help maintain natural plant communities. Planting a diverse group of native plant species will help support the nutritional needs of Michigan's pollinators. We recommend a mix of flowering trees, shrubs, and herbaceous plants so that something is always blooming and pollen is available during the active periods of the pollinators, roughly early spring through fall (mid-March to mid-October). To benefit a wide variety of pollinators, choose a wide range of flowers with diverse colors, heights, structure, and flower shape. It is important to provide host plants for any known butterfly species at your site, including native milkweed for Monarch butterfly. Incorporating a water source (e.g., ephemeral pool or low area) and basking areas (rocks or bare ground) will provide additional resources for pollinators.

Many pollinators need a safe place to build their nests and overwinter. During spring and summer, leave some areas unmowed or minimize the impacts from mowing (e.g., decrease frequency, increase vegetation height). In fall, leave areas unraked and leave plant stems standing. Leave patches of bare soil for ground nesting pollinators.

Avoid or limit pesticide use. Pesticides can kill more than the target pest. Some pesticide residues can kill pollinators for several days after the pesticide is applied. Pesticides can also kill natural predators, which can lead to even worse pest problems.

Planting native wildflowers can also reduce the need to mow and water, improve bank stabilization by reducing erosion, and improve groundwater recharge and water quality.

Resources:

https://www.fws.gov/initiative/monarchs
https://www.fws.gov/library/collections/pollinators

Coordination with the Service is not complete if additional coordination is advised above for any species. Please email our office at MIFO_DKey@fws.gov and attach a copy of this letter, so we can discuss methods to avoid or minimize potential adverse effects to those species.

Summary of conservation measures for your project You agreed to the following conservation measures to avoid adverse effects to listed species and our concurrence is only valid if the measures are fully implemented. These must be included as permit conditions if a permit is required and/or included in any contract language.

Hydrologic changes
Any effects to hydrology will not result in a significant change in the elevation of surface water upstream or downstream or in the local groundwater (i.e., will not result in changes to elevations of more than 6 inches or result in inundation).

Karner blue butterfly
Avoid ground disturbance and use of chemicals in oak savannah habitat and wild lupine, if present.

The action will not include temporary or permanent lighting of roadway(s), facility(ies), and/or parking lot(s).

Action Description
You provided to IPaC the following name and description for the subject Action.

1. Name

Grand rapids whitewater lower reach

2. Description

The following description was provided for the project 'Grand rapids whitewater lower reach':

> Direct impact areas extend from 300 ft above Dam 4 to Fulton Street bridge. Causeways will be constructed for equipment to remove existing low head dams and create riffles and drop structures. Indirect impact areas extend upstream to the 6th street dam and downstream to the mouth of Plaster Creek. Construction would like to begin in September 2024 and will likely extend thru 2025. Construction equipment will be staged at Ah-nab-awen park.

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@42.9618622,-85.67743905554654,14z



QUALIFICATION INTERVIEW

1. Are there any possible effects to any listed species or to designated critical habitat from your project or effects from any other actions or projects subsequently made possible by your project?

   Select "Yes" even if the expected effects to the species or critical habitat are expected to be 1) extremely unlikely (discountable), 2) can't meaningfully be measured, detected, or evaluated (insignificant), or 3) wholly beneficial.

   Select "No" to confirm that the project details and supporting information allow you to conclude that listed species and their habitats will not be exposed to any effects (including discountable, insignificant, or beneficial effects) and therefore, you have made a "no effect" determination for all species. If you are unsure, select YES to answer additional questions about your project.

   Yes

2. This determination key is intended to assist the user in the evaluating the effects of their actions on Federally listed species in Michigan. It does not cover other prohibited activities under the Endangered Species Act (e.g., for wildlife: import/export, Interstate or foreign commerce, possession of illegally taken wildlife, purposeful take for scientific purposes or to enhance the survival of a species, etc.; for plants: import/export, reduce to possession, malicious destruction on Federal lands, commercial sale, etc.) or other statutes. Click yes to acknowledge that you must consider other prohibitions of the ESA or other statutes outside of this determination key.

   Yes

3. Is the action the approval of a long-term (i.e., in effect greater than 10 years) permit, plan, or other action? (e.g., a new or re-issued hydropower license, a land management plan, or other kinds of documents that provide direction for projects or actions that may be conducted over a long term (>10 years) without the need for additional section 7 consultation).

   No

4. Is the action being funded, authorized, or carried out by a Federal agency?

   Yes

5. Does the action involve the installation or operation of wind turbines?

   No

6. Are there at least 30 days prior to your action occurring? Endangered species consultation must be completed before taking any action that may have effects to listed species. The Service also needs 30 days to review projects before we can verify conclusions in some dkey output letters. For example, if you have already started some components of the project on the ground (e.g., removed vegetation) before completing this key, answer “no” to this question. The only exception is if you have a Michigan Field Office pre-approved emergence survey (i.e., if you have conducted pre-approved emergence surveys for listed bats before tree removal, you can still answer yes to this question).

   Yes

7. Does the action involve constructing a new communication tower or modifying an existing communications tower?

   No

8. Does the activity involve aerial or other large-scale application of any chemical (including insecticide, herbicide, etc.)?

   No

9. Does your project include water withdrawal (ground or surface water) greater than 10,000 gallons/day?

   No

10. Will your action permanently affect hydrology?

    Yes

11. Will your project have any direct impacts to a stream or river (e.g., Horizontal Directional Drilling (HDD), hydrostatic testing, stream/road crossings, new storm-water outfall discharge, dams, other in-stream work, etc.)?

    Yes

12. Does your project have the potential to indirectly impact the stream/river or the riparian zone (e.g., cut and fill, horizontal directional drilling, hydrostatic testing, construction, vegetation removal, discharge, etc.)?

    Yes

13. Are you applying for one of the following Michigan EGLE/Army Corps of Engineers joint permit application Minor Permit (MP) Categories:
MP 3 - Boat Hoist; MP 5 - Boal Wells; MP 7 - Completed Enforcement Actions; MP 12 - Dock;
MP 21 - Fish and Wildlife Habitat Structures;
MP 22 - Ford Stream Crossings for Commercial Forestry Operations;
MP 28 - Maintenance and Repair of Serviceable Structures;
MP 45 - Temporary Recreational Structures;
MP 48 - Wetland Habitat Restoration and Enhancement?

    Verify the MP category number and associated description matches your project/ application (https://www.michigan.gov/documents/egle/WRD-Minor-Project-Categories_733320_7.pdf). If you don't know what category applies for your project, answer no to this question.

    No

14. Are you applying for one of the following Michigan EGLE/Army Corps of Engineers joint permit application General Permit (GP) Categories:
GP A - Aids to Navigation;
GP C - Clear Span Bridge;
GP E - Culverts - Small;
GP J - Dry Fire Hydrant;
GP O - Minor Permit Revisions and Transfers;
GP Q - Mooring Buoy;
GP W - Scientific Measuring Devices;
GP X - Snow Road Stream Crossings for Forestry Operations;
GP Z - Spring Piles and Piling Clusters;
GP DD - Wetland Habitat Restoration and Enhancement?

    Verify the GP category number and associated description matches your project/ application (https://www.michigan.gov/documents/deq/wrd-general-permit-categories_555828_7.pdf). If you don't know what category applies for your project, answer no to this question.

    No

15. Will your action disturb the ground or existing vegetation? This includes any off road vehicle access, soil compaction, digging, seismic survey, directional drilling, heavy equipment, grading, trenching, placement of fill, pesticide application, vegetation management (including removal or maintenance using equipment or chemicals), cultivation, development, etc.

    No

16. Is the action a utility-scale solar development project?

    No

17. [Hidden semantic] Does the action intersect the MOBU AOI?

    Automatically answered
    Yes

18. Under the ESA, monarchs remain warranted but precluded by listing actions of higher priority. The monarch is a candidate for listing at this time. The Endangered Species Act does not establish protections or consultation requirements for candidate species. Some Federal and State agencies may have policy requirements to consider candidate species in planning. We encourage implementing measures that will remove or reduce threats to these species and possibly make listing unnecessary. If your project will have no effect on monarch butterflies (for example, if your project won't affect their habitat or individuals), then you can make a "no effect" determination for this project. Are you making a "no effect" determination for monarch?

    Yes

19. [Hidden Semantic] Does the action intersect the Eastern massasauga rattlesnake area of influence?

    Automatically answered
    Yes

20. In a previous answer in this key, you indicated your project will have permanent effects to hydrology. Will the hydrological impacts result in a significant change in the elevation of surface water upstream or downstream, or in the local groundwater elevations?

    A significant change is one where the elevations are expected to change more than 6 inches or result in inundation.

    Yes

21. [Semantic] Does the action area intersect the snuffbox area of influence?

    Automatically answered
    Yes

22. [Hidden Semantic] Does the action intersect the Karner blue butterfly area of influence?

    Automatically answered
    Yes

23. Will the action occur in oak savanna, oak or pine barrens, openings within oak forest, old fields in association with oak forest, or openings or rights-of-way with abundant native grasses and wildflowers?

    Yes

24. Is the larval host plant, wild lupine, present on site? If unsure, select YES.

    No

25. [Hidden Semantic] Does the action area intersect the whooping crane (ex. Pop) area of influence?

    Automatically answered
    Yes

26. Have you determined that the action will have no effect on individuals within the whooping crane nonessential experimental population (NEP)?

    Yes

27. The project has the potential to affect federally listed bats. Does the action area contain any known or potential bat hibernacula (natural caves, abandoned mines, or underground quarries)?

    No

28. Has a presence/absence bat survey or field-based habitat assessment following the Service's Range-wide Indiana Bat and Northern Long-eared Bat Summer Survey Guidelines been conducted within the action area?

    No

29. Does the action involve removal/modification of a human structure (barn, house or other building) known to contain roosting bats?

    No

30. Does the action include removal/modification of an existing bridge or culvert?

    No

31. Does the action include temporary or permanent lighting of roadway(s), facility(ies), and/or parking lot(s)?

    No

32. Does the action include one or more of the following: (1) tree cutting/trimming, (2) prescribed fire, (3) pesticide (including insecticide and/or rodenticide), and/or (4) herbicide/fungicide application?

    No

33. [Hidden Semantic] Does the action area intersect the Indiana bat AOI?

    Automatically answered
    Yes

34. [Hidden Semantic] Does this project intersect the northern long-eared bat area of influence?

    Automatically answered
    Yes

35. [Hidden semantic] Does the action intersect the Tricolored bat AOI/SLA/range?

    Automatically answered
    Yes

36. The tricolored bat was proposed for listing as endangered on September 13, 2022. In Michigan, the tricolored bat was rare pre-white nose syndrome (WNS) and is exceedingly rare post-WNS. The species has been observed in 12 Michigan counties to date, largely during the fall or winter. With very few exceptions, the species has not been observed in Michigan in the summer months, and no maternity colonies have been found. During winter, tricolored bats hibernate in caves, abandoned mines, and abandoned tunnels ranging from small to large in size. During spring, summer and fall months, they roost primarily among leaf clusters of live or recently dead deciduous/hardwood trees.

    Are you making a no effect determination on this project for the tricolored bat?

    Yes

IPAC USER CONTACT INFORMATION

Agency: Natural Resources Conservation Service
Name: Heidi Dunn
Address: 1417 Hoff Industrial Dr.
City: O'Fallon
State: MO
Zip: 63366
Email hdunn@ecoanalysts.com
Phone: 3142778773

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Natural Resources Conservation Service

MICHIGAN STATE UNIVERSITY | Extension

Cheryl Pitchford
Fishbeck
1515 Arboretum Drive SE
Grand Rapids, MI 495546

June 6, 2023

Re: Rare Species Review #3507 – Canal Park and Ah-Nab-Awen Park Improvements

Hello:

The location for the proposed project was checked against known localities for rare species and unique natural features, which are recorded in the Michigan Natural Features Inventory (MNFI) natural heritage database. This continuously updated database is a comprehensive source of existing data on Michigan's endangered, threatened, or otherwise significant plant and animal species, natural plant communities, and other natural features. Records in the database indicate that a qualified observer has documented the presence of special natural features. The absence of records in the database for a particular site may mean that the site has not been surveyed. The only way to obtain a definitive statement on the status of natural features is to have a competent biologist perform a complete field survey.

Under Act 451 of 1994, the Natural Resources and Environmental Protection Act, Part 365, Endangered Species Protection, "a person shall not take, possess, transport, …fish, plants, and wildlife indigenous to the state and determined to be endangered or threatened," unless first receiving an Endangered Species Permit from the Michigan Department of Natural Resources (MDNR), Wildlife Division. Responsibility to protect endangered and threatened species is not limited to the lists below. Other species may be present that have not been recorded in the database.

Several at-risk species and/or natural communities have been documented within 1 mile of the project location and it is possible that adverse impacts will occur. This response reflects a desktop review of the database and MNFI cannot fully evaluate this project without visiting the area. MNFI offers several levels of Rare Species Reviews, including field surveys which I would be happy to discuss with you.

Sincerely,

Michael Sanders

Michael Sanders
Environmental Review Specialist/Zoologist
Michigan Natural Features Inventory

MSU EXTENSION

Michigan Natural Features Inventory

PO Box 13036
Lansing MI 48901

(517) 284-6200
Fax (517) 373-9566

mnfi.anr.msu.edu

MSU is an affirmative-action, equal-opportunity employer.

Comments for Rare Species Review #3507:
It is important to note that it is the applicant's responsibility to comply with both state and federal threatened and endangered species legislation. Therefore, if a state listed species occurs at a project site, and you think you need an endangered species permit please contact: Casey Reitz, DNR-Wildlife Division, 517-284-6210, or ReitzC@michigan.gov. If a federally listed species is involved and, you think a permit is needed, please contact Jessica Pruden, U.S. Fish and Wildlife Service, East Lansing office, 517-351-8316, or Jessica_Pruden@fws.gov.

NOTE: special concern species and natural communities are not protected under endangered species legislation, but efforts should be taken to minimize any or all impacts. Please consult MNFI's Rare Species Explorer for additional information on Michigan's rare plants and animals.

NOTE: Michigan rivers and streams have been grouped according to existing information of mussel distribution and individual species conservation status. The Mussel Protocol Stream Groups are designed to document the **potential** presence or absence of state or federally listed mussel species. The layer was created by modeling the habitat suitability for each mussel species and may not correspond directly with a documented location for a listed mussel. A segment may be predicted as suitable for a number of mussel species, so the stream group number was assigned to the most restrictive of the potential mussel species present.

This stretch of the **Grand River** is designated a Group 3 mussel stream which means that federally threatened and endangered mussel species may occur here and that certain surveys and possibly relocation procedures apply. I encourage you to read the ***Michigan Freshwater Mussel Survey Protocols and Relocation Procedures*** publication if in-stream work and/or land clearing activities occur that result in streambed disturbance and erosion and sedimentation into the river. A copy of the publication is being provided to you in this mailing.

Table 1: Occurrences of Threatened & Endangered Species within 1 mile of Project Site

Element Category	Scientific Name	Common Name	Federal Status	State Status	G Rank	S Rank	EO Rank	First Observed Date	Last Observed Date
Animal	*Epioblasma triquetra*	Snuffbox	LE	E	G3	S1S2	E	1969-pre	2018-09-16
Plant	*Galearis spectabilis*	Showy orchis		T	G5	S2	H	1892	1893-05-15
Plant	*Mertensia virginica*	Virginia bluebells		E	G5	S1S2	E	1973	1973-05-12
Plant	*Linum virginianum*	Virginia flax		T	G4G5	S2	H	1899	1899-09-16
Animal	*Falco peregrinus*	Peregrine falcon		E	G4	S3	AC	2004	2020
Animal	*Moxostoma carinatum*	River redhorse		T	G4	S2	E	2007-06-18	2018-09-12
Animal	*Cyclonaias tuberculata*	Purple wartyback		T	G5	S2	E	1945	2017-08-31
Animal	*Alasmidonta viridis*	Slippershell		T	G4G5	S2S3	E		2017-08-31
Animal	*Leptodea leptodon*	Scaleshell	LE	E	G1G2	SX	H	1930-pre	1930-pre
Animal	*Ligumia recta*	Black sandshell		E	G4G5	S1?	E	1969-Pre	2018-09-16
Animal	*Cyclonaias*	Purple		T	G5	S2	E	2013-09-19	2013-09-21

	tuberculata	wartyback							

Comments for Table 1:

River redhorse (*Moxostoma carinatum*)

Habitat

Known to occur in the Grand River, river redhorse prefer medium to large rocky rivers with moderate to strong currents. They are most often associated with long, deep run habitats between 0.3 and 3 m deep. This species requires clear, unpolluted waters and is intolerant of silt and turbidity.

Management Recommendations

Maintaining or establishing vegetated riparian buffers will help protect this species habitat. These are wide-ranging species, hence maintaining or establishing river connectivity is also important to this species, especially for spawning migrations.

For more information, see the *Moxostoma carinatum* species page on the MNFI website.

Black sandshell (*Ligumia recta*)

Habitat

Known to occur in the Grand River, the black sandshell most commonly occupies rivers with strong currents and lakes with a firm substrate of gravel or sand (Watters et al. 2009).

Management Recommendations

Maintaining healthy populations of black sandshell's host fish species and open water conditions to facilitate their movement, will benefit this species. As all unionid species are vulnerable to pollutants and heavy metals, reducing point and non-point source water pollution is a priority. Black sandshell in particular has shown extreme sensitivity to copper and cadmium (Pip 1995), which is commonly introduced to aquatic systems through pesticide/herbicide applications, industrial waste, urban runoff, and mine drainage (Grabarkiewicz and Davis 2008). Alteration of habitat through river impoundment, dredging, bridge construction, and dam removal pose a threat to all native mussels, and monitoring and mitigation measures should be planned for prior to such activities taking place. Efforts to control the spread of zebra mussels, such as cleaning boat hulls, trailers, and scuba and fishing gear before traveling between bodies of water, are necessary for the conservation of this species.

For more information, see the *Ligumia recta* species page on the MNFI website.

Scaleshell (*Leptodea leptodon*)

Habitat

Known to occur in the Grand River, the scaleshell occurs in riffle areas of clean, clear medium to large rivers. They are associated with strong currents and substrates of mud and sand, or mixtures of gravel, cobble, and boulder.

Management Recommendations

The species is severely impacted by alteration and inundation of channels, siltation from agriculture and clear-cutting, chemical and organic pollution. Habitat loss caused by degradation from construction activities and intensive land use also threatens the scaleshell mussel. Also impacted by exotic zebra mussels. Maintenance or establishment of vegetated riparian buffers can help protect mussel habitats from many of their threats. Control of zebra mussels is critical to preserving native mussels. And as with all mussels, protection of their hosts habitat is also crucial.

For more information, see the *Leptodea leptodon* species page on the MNFI website.

Snuffbox (*Epioblasma triquetra*)

Habitat

Known to occur in the Grand River, the snuffbox inhabits sand, gravel, or cobble substrates in swift small and medium-sized rivers. Individuals are often buried deep in the sediment.

Management Recommendations

The Snuffbox mussel is sensitive to river impoundment, siltation and disturbance, due to its requirement for clean, swift current and relative immobility as an adult. In order to maintain the current populations in Michigan, rivers need to be protected to reduce silt loading and run-off. Maintaining or establishing vegetated riparian buffers can aid in controlling many of the threats to mussels. Control of zebra mussels is critical to preserving native mussels. And as with all mussels, protection of their hosts habitat is also crucial. Because the life cycle of the snuffbox is inherently linked with that of the logperch in Michigan, conservation and management of this fish species is needed to insure that of the Snuffbox.

For more information, see the *Epioblasma triquetra* species page on the MNFI website.

Purple wartyback (*Cyclonaias tuberculata*)

Habitat

Known to occur in the Grand River, the Purple wartyback is found in medium to large rivers with gravel or mixed sand and gravel substrates.

Management Recommendations

Like other mussels, threats are varied and include: habitat degradation, poor water quality, flow alterations, water temperature changes, heavy metals, organic pollution, sedimentation, and siltation. Maintenance or establishment of vegetated riparian buffers can help protect mussel habitats from many of these threats. Control of zebra mussels is critical to preserving native mussels. As with all mussels, fish host requirements also need to be considered.

For more information, see the *Cyclonaias tuberculata* species page on the MNFI website.

Slippershell (*Alasmidonta viridis*)

Habitat

Known to occur in the Grand River, the slippershell typically occurs in creeks and headwaters of rivers in sand or gravel substrates. Occasionally, they occur in larger rivers and lakes and in mud substrates.

Management Recommendations

The slippershell requires clear, clean water and substrates for survival. Like other mussels, threats include: siltation, poor water quality, point and non-point source pollution, and alteration of natural flow regimes. Maintenance or establishment of vegetated riparian buffers can help protect mussel habitats from these threats. Additionally, zebra mussels and other exotic species are a major threat to all mussels. Hence, control and management of exotic species also help protect native mussel species. And as with all mussels, protection of their hosts habitat is also crucial.

For more information, see the *Alasmidonta viridis* species page on the MNFI website.

Table 2: Occurrences of Special Concern Species within 1 mile of Project Site

Element Category	Scientific Name	Common Name	Federal Status	State Status	G Rank	S Rank	EO Rank	First Observed Date	Last Observed Date
Animal	*Pomatiopsis cincinnatiensis*	Brown walker		SC	G4	SH	H		

Plant	*Boechera missouriensis*	Missouri rock-cress		SC	G5	S2	H	1893	1893-06-18
Animal	*Terrapene carolina carolina*	Eastern box turtle		SC	G5T5	S2S3	E		2021-06-30
Plant	*Echinacea purpurea*	Purple coneflower		X	G4	SX	X	1891	1891-08-15
Animal	*Fontigens nickliniana*	Watercress snail		SC	G5	S2S3	H		
Animal	*Truncilla truncata*	Deertoe		SC	G5	S2S3	E	2013-09-19	2018-09-18
Animal	*Venustaconcha ellipsiformis*	Ellipse		SC	G4	S3	E	1898-10-10	2017-08-31
Animal	*Alasmidonta marginata*	Elktoe		SC	G4	S3?	E		2017-08-31
Animal	*Pleurobema sintoxia*	Round pigtoe		SC	G4G5	S3	E	1890	2017-08-31
Animal	*Oxyloma peoriense*	Depressed ambersnail		SC	G4G5	SNR	H	1885	1885
Animal	*Ventridens intertextus*	Pyramid dome		SC	G5	SNR	H	1948-09-13	1948-09-13
Animal	*Valvata perdepressa*	Purplecap valvata		SC	G2G3	SNR	H	1914-09-26	1914-09-26
Animal	*Villosa iris*	Rainbow		SC	G5	S3	H?		2017-08-31
Animal	*Cincinnatia cincinnatiensis*	Campeloma spire snail		SC	G5	S3	H		
Animal	*Lasmigona compressa*	Creek heelsplitter		SC	G5	S3	H	1899	1899
Animal	*Lasmigona costata*	Flutedshell		SC	G5	SNR	E	1945	2018-09-18
Animal	*Potamilus alatus*	Pink heelsplitter		SC	G5	SNR	E	2013-09-19	2018-09-16
Animal	*Myotis septentrionalis*	Northern long-eared bat	LT	SC	G2G3	S1	H	1975-06-24	1975-06-24
Animal	*Bombus pensylvanicus*	American bumble bee		SC	G3G4	S1	H	1937-09-06	1946-09-10
Animal	*Bombus auricomus*	Black and gold		SC	G5	S2	H	1933-09-12	1933-09-12

		bumble bee							
Plant	*Collinsia verna*	Blue-eyed Mary		SC	G5	SNR	H	1891-05-02	1897-05-10
Plant	*Graphephorum melicoides*	Purple false oats		SC	G4G5	SNR	H	1893-08-12	1894-08-12
Animal	*Moxostoma duquesnei*	Black Redhorse		SC	G5	S2	E	2007-06	2018-07-10

Comments for Table 2:

Black redhorse (*Moxostoma duquesnei*)

Habitat

Known to occur in the Grand River, the black redhorse inhabits swift flowing areas in medium- to large-sized rivers with clear water and sand, gravel, and rock substrates. Black redhorse is less tolerant of turbid water, low gradient rivers, and siltation than golden redhorse. Young black redhorse feed in schools near emergent aquatic vegetation by the edge of pools. Adults typically feed in schools just upstream or downstream of riffles. This fish eats microcrustaceans, aquatic insects, detritus, and algae. Eggs are buried in a substrate of fine rubble, sand, and gravel in water 15 to 60 cm deep, typically at the upstream or downstream end of a riffle. Black redhorse spawn when water temperatures reach 13 to 17°C (55-62°F).

Management Recommendations

Maintaining and creating riparian buffers along rivers is an important method of mitigating non-point source impacts such as excessive sedimentation and turbidity. Black redhorse are very sensitive to these impacts because many species of microcrustaceans and aquatic insects they rely on for food require clean water and substrates. Avoiding impacts to headwater streams and wetlands benefits all downstream habitats and species like black redhorse that rely on clear water and river substrates. Black redhorse populations are particularly vulnerable to the loss of habitat used by young-of-the-year fish, given current levels of habitat availability. The blockage of migratory routes by dams and reservoirs with degraded tailwater habitats have contributed to the decline of black redhorse populations in the U.S. Remove barriers to fish migration such as dams that are no longer functioning and/or are not economically viable, and restore natural river flow to impounded areas.

For more information, see the *Moxostoma duquesnei* species page on the MNFI website.

Elktoe (*Alasmidonta marginata*)

Habitat

Known to occur in the Grand River, the Elktoe is found in small to large sized streams and small to medium rivers. It is a riffle species, preferring swifter currents over packed sand and gravel substrates. The Elktoe is typically only found in clean, clear water (Cummings and Mayer 1992).

Management Recommendations

The elktoe needs clean, fast-flowing water to survive. Therefore, changes to its habitat, such as river impoundment, siltation and channel disturbances, including dredging, negatively affect this species. Pollution from point (industrial and residential discharge) and non-point (siltation, herbicide and surface run-off) sources is also a threat to mussels and should be limited and monitored to insure compliance with the Clean Water Act. Control of zebra mussels is critical to preserving native mussels. It is essential to

protect not only the habitat of the elktoe, but also the white sucker, northern hog sucker, shorthead redhorse, rockbass and warmouth, as they serve as hosts for the glochidia.

For more information, see the *Alasmidonta marginata* species page on the MNFI website.

Codes to accompany table

State Protection Status Code Definitions (SPROT)
E = Endangered
T = Threatened
SC = Special concern

Federal Protection Status Code Definitions (USESA)
LE = listed endangered
LT = listed threatened
LELT = partly listed endangered and partly listed threatened
PDL = proposed delist
E(S/A) = endangered based on similarities/appearance
PS = partial status (federally listed in only part of its range)
C = species being considered for federal status

Global Heritage Status Rank Definitions (GRANK)
The priority assigned by NatureServe's national office for data collection and protection based upon the element's status throughout its entire world-wide range. Criteria not based only on number of occurrences; other critical factors also apply. Note that ranks are frequently combined.
G1 = critically imperiled globally because of extreme rarity (5 or fewer occurrences range-wide or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single western state, a physiographic region in the East) or because of other factor(s) making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.
G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5 = Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
Q = Taxonomy uncertain

State Heritage Status Rank Definitions (SRANK)
The priority assigned by the Michigan Natural Features Inventory for data collection and protection based upon the element's status within the state. Criteria not based only on number of occurrences; other critical factors also apply. Note that ranks are frequently combined.
S1 = Critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state.
S2 = Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.
S3 = Rare or uncommon in state (on the order of 21 to 100 occurrences). S4 = apparently secure in state, with many occurrences.
S5 = demonstrably secure in state and essentially ineradicable under present conditions.
SX = apparently extirpated from state.

EO Rank Codes

Element Occurrence (EO) ranks refer to the viability or ecological integrity of the occurrence; they provide an assessment of the likelihood that if current conditions prevail the EO will persist for a defined period of time, typically 20-100 years.

A - Excellent estimated viability/ecological integrity
A? - Possibly excellent estimated viability/ecological integrity
AB - Excellent or good estimated viability/ecological integrity
AC - Excellent, good, or fair estimated viability/ecological integrity
B - Good estimated viability/ecological integrity
B? - Possibly good estimated viability/ecological integrity
BC - Good or fair estimated viability/ecological integrity
BD - Good, fair, or poor estimated viability/ecological integrity
C - Fair estimated viability/ecological integrity
C? - Possibly fair estimated viability/ecological integrity
CD - Fair or poor estimated viability/ecological integrity
D - Poor estimated viability/ecological integrity
D? - Possibly poor estimated viability/ecological integrity
E - Verified extant (viability/ecological integrity not assessed)
F - Failed to find
F? - Possibly failed to find
H - Historical
H? - Possibly historical
X - Extirpated
X? - Possibly extirpated
U - Unrankable
NR - Not ranked



MNFI INQUIRY SUBMITTED AT CANAL PARK & AH–NAB–AWEN PARK ON JUNE 6, 2023

NORTH

MNFI AREA MAP

SCALE: 1" = 1000'

0 500 1000 2000

fishbeck
Engineers | Architects | Scientists | Constructors

Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

City of Grand Rapids
Grand Rapids, MI

Grand River Restoration

PROJECT NO.
180419

FIGURE NO.
1

PLOT INFO: Z:\2018\180419\CAD\PRECD\MNFI FIGURE.DWG LAYOUT: LAYOUT1 DATE: 1/8/2024 TIME: 10:52:13 AM USER: THEATH

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Appendix C. 60% Construction and Design Plans

UTILITIES - CONTACT INFORMATION

PUBLIC

CITY OF GRAND RAPIDS TRAFFIC SIGNALS
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3847

CITY OF GRAND RAPIDS STREET LIGHTING
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49503
(616) 456-3281

CITY OF GRAND RAPIDS WATER SYSTEM
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49503
(616) 456-3141

CITY OF GRAND RAPIDS
SANITARY AND STORM SEWER MAINTENANCE
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49503
(616) 456-3141

KENT COUNTY ROAD COMMISSION
1500 SCRIBNER AVE. NW
GRAND RAPIDS, MI 49504
(616) 242-6910

KENT COUNTY DEPT. OF PUBLIC WORKS
(616) 336-2500

M.D.O.T.
1420 FRONT AVE. NW
GRAND RAPIDS, MI 49504
(616) 451-3091

GRAND RAPIDS TOWNSHIP
1836 EAST BELTLINE AVE. NE
GRAND RAPIDS, MI 49505
(616) 361-7391

PRIVATE

CONSUMERS ENERGY COMPANY (ELECTRIC)
4000 CLAY AVE. SW
GRAND RAPIDS, MI 49501-0201
(616) 530-4244 (AERIAL DIST)
(616) 530-4381 (METRO UG)

AT&T (TEL/FIBER OPTIC)
ROOM 5 (PROJECTS N. OF FRANKLIN ST.)
2ND FLOOR (PROJECTS S. OF FRANKLIN ST.)
955 36TH ST. SE
GRAND RAPIDS, MI 49508
(616) 246-7203 (N. OF FRANKLIN ST.)
(616) 246-7210 (S. OF FRANKLIN ST.)

DTE ENERGY/MICHCON (NATURAL GAS)
444 WEALTHY ST. SW
GRAND RAPIDS, MI 49501
(800) 947-5000

COMCAST (CABLE TV)
955 CENTURY AVE. SW
GRAND RAPIDS, MI 49503
(616) 245-5039

VERIZON BUSINESS (TEL/FIBER OPTIC)
2855 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 265-8553

CENTURY TEL (TEL/FIBER OPTIC)
320 N. WASHINGTON SQUARE
LANSING, MI 48933
(989) 239-8110

MCI WORLDCOM (TEL/FIBER OPTIC)
(616) 224-4343

CHOICEONE (TEL/FIBER OPTIC)
(616) 988-7100

SBC AMERITECH (TEL/FIBER OPTIC)
(616) 246-7240

VACINITY ENERGY
156 FULTON ST. W
GRAND RAPIDS, MI 49501
(616) 356-2535

LEVEL 3 COMMUNICATIONS (FIBER OPTIC)
1025 ELDORADO BLVD.
BROOMFIELD, CO 80021
(720) 888-0336

TDS METROCOM (TEL/FIBER OPTIC)
1575 GEZON PARKWAY SUITE B
WYOMING, MI 49509
(616) 301-3033

CALL 811 FOR MISS DIG

FOR PROTECTION OF UNDERGROUND UTILITIES AND IN CONFORMANCE WITH PUBLIC ACT 53, 1974, THE CONTRACTOR SHALL CALL 811 A MINIMUM OF THREE (3) FULL WORKING DAYS (EXCLUDING SATURDAYS, SUNDAYS AND HOLIDAYS) PRIOR TO EXCAVATING IN THE VICINITY OF UTILITY LINES. ALL "MISS DIG" PARTICIPATING MEMBERS WILL THUS BE ROUTINELY NOTIFIED. THIS DOES NOT RELIEVE THE CONTRACTOR OF THE RESPONSIBILITY OF NOTIFYING UTILITY OWNERS WHO MAY NOT BE A PART OF THE "MISS DIG" ALERT SYSTEM.

GENERAL NOTES

1. MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE 1993 EDITION OF THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, EXCEPT AS OTHERWISE INDICATED ON THESE PLANS OR IN THE SUPPLEMENTAL SPECIAL SPECIFICATIONS.
2. IF A WATER SERVICE (COPPER, LEAD OR OTHERWISE) IS DISTURBED, DAMAGED, RELOCATED OR REPLACED FROM THE WATER MAIN TO THE CURB STOP, WHETHER PLANNED OR UNINTENTIONAL, THE CONTRACTOR IS TO HAVE THE SERVICE MATERIAL VERIFIED FROM THE MAIN TO THE METER. IF ANY PORTION IS FOUND TO BE LEAD, THEN THE CONTRACTOR MUST HAVE THE LEAD REPLACED WITH A COPPER WATER SERVICE. ALL WATER SERVICE REPLACEMENTS MUST BE COMPLETED BY A REGISTERED UNDERGROUND CONTRACTOR. IF THE REPLACEMENT INVOLVES WORK ON PRIVATE PROPERTY, THE CONTRACTOR IS TO CONTACT THE ENGINEER IMMEDIATELY TO OBTAIN PERMISSIONS FOR THE SERVICE TO BE REPLACED BY CITY OF GRAND RAPIDS UNDERGROUND CONTRACTORS ON TERM CONTRACT FOR LEAD SERVICE REPLACEMENT. THE CONTRACTOR WILL REIMBURSE THE CITY FOR THIS COST.

CITY OF GRAND RAPIDS

GRAND RAPIDS, MICHIGAN

PUBLIC SERVICES

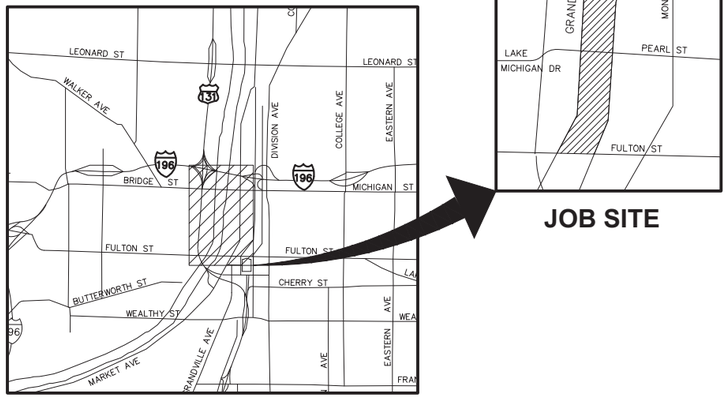
IMPROVEMENTS IN THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

DRAFT 60% PLANSET



PROJECT LOCATION

JOB SITE

BID SET			
BID SET NO.	DATE	BID SET NO.	DATE

REVISIONS			
REV NO.	DATE	SHEET NUMBER(S)	APPROVED BY

AS-BUILT RECORD	
CONTRACTOR	
FIELD ENGINEER	
INSPECTED BY	
AS-BUILT BY	
AS-BUILT DATE	
BORINGS BY	
WATER PIPE MANUFACTURER	
SANITARY PIPE MANUFACTURER	
STORM PIPE MANUFACTURER	

PERMITS		
M.D.E.Q. WATER SYSTEM PERMIT NO.:	OTHER:	NO.:
M.D.E.Q. WASTEWATER SYSTEM PERMIT NO.:	OTHER:	NO.:
M.D.O.T. RIGHT-OF-WAY PERMIT NO.:	OTHER:	NO.:

CITY COMMISSION PROC. NO. _____ DATE _____

MDOT AGREEMENT ☐ CONTRACT AWARDED ☐

FINANCIAL AGREEMENT ☐ SHPO AGREEMENT ☐

GRANT AGREEMENT ☐ COST SHARING AGREEMENT ☐

PUBLIC UTILITIES EASEMENT (SEE EASEMENT DESCRIPTION SHEET)

ADDITIONAL CITY COMMISSION PROCEEDINGS

PROCEEDING NO. DATE PURPOSE

INDEX OF SHEETS

SEE SHEET 2 FOR PLAN SHEET INDEX

DRAFT DRAWINGS NOT FOR CONSTRUCITON

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

ALL ELEVATIONS ARE IN NAVD 88 DATUM

CONSULTANT #2	CONSULTANT #1
PROFESSIONAL PERSON IN RESPONSIBLE CHARGE OF	PROFESSIONAL PERSON IN RESPONSIBLE CHARGE OF
SHEETS: 1-00	SHEETS: 1-00
NAME OF LICENSEE: NAME	NAME OF LICENSEE: NAME
NUMBER: NUMBER	NUMBER: NUMBER
SIGNATURE	SIGNATURE

City of Grand Rapids
PUBLIC SERVICES
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)

COVER SHEET

Drawn by _____ Notes in _____

Check: Field _____ Office _____

Approved _____ _____
Tim Burkman, PE. City Engineer Date

APPROVAL OF SHEET(S) 1 - 71 ONLY

Project No.	GPF No.	Sheet No.
17014	5315	1 of 32 G00

Construction Document - Sheet Index

Febrary 2024

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2	G01	SHEET LIST	17	R02	DAMS 3 AND 4 REMOVAL DETAIL
3	G02	PROPERTY TAX ID MAP (1 OF 3)	18	R03	DAM 2 REACH
4	G03	PROPERTY TAX ID MAP (2 OF 3)	19	R04	DAM 2 REACH CROSS SECTION
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			21	R06	DAM 2 REACH TIE-IN SECTIONS
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10	T05	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION PLAN LAYOUT	27	R12	BLUE BRIDGE TO FULTON ST. REACH
11	T06	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - PROFILE DETAILS	28	R13	BLUE BRIDGE TO FULTON ST. CROSS SECTIONS
12	T07	TEMP. CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION ENTRANCE AND TRACKING PAD DETAIL			
13	T08	TEMP. CONSTRUCTION ACCESS & CARE OF WATER - STORMWATER INLET PROTECTION DETAIL	**Design Details**		
14	T09	TEMPORARY CONSTRUCTION ACCESS & CARE OF WATER - DETAILS	29	D01	HABITAT BOULDER
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			31	D03	RIFFLE STRUCTURE AND EMERGENT BOULDERS
			32	D04	EROSION CONTROL BLANKET INSTALLATION DETAIL

SHEET LIST

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. **5315**

Sheet No. 2 of 32
G01

623 Monroe Ave NW
CONSUMERS ENERGY
COMPANY

555 Monroe Ave NW
CITY OF GRAND
RAPIDS

647 Monroe Ave NW
41-13-24-431-019
City of Grand Rapids

225 Michigan St NW
United States
Postal Service

GRAND RIVER

M.L.34 P. 101

M.L.34 P. 119

M.L.34 P. 125

M.L.34 P. 114

M.L.34 P. 116

M.L.34 P. 142

2160+00

2158+00

2156+00

2154+00

2152+00

2150+00

2148+00

2146+00

GRAND RIVER
CENTER LINE

LIMITS OF
EARTH CHANGE (TYP.)

100 YEAR FLOODPLAIN
LIMITS

W I-196

E I-196

PROJECT LIMIT

BRIDGE ST

624 FRONT AVE NW
CITY OF GRAND RAPIDS

624 FRONT AVE NW
CITY OF GRAND RAPIDS

271 BRIDGE ST NW
CITY OF GRAND RAPIDS

333 Bridge St NW
SH-2 LLC & BT-2
LLC

303 Pe
NA
STATES OF

335 Bridge
St NW

SCRIBNER AVE NW

NORTH

0 60' 120'

SCALE: 1" = 60'

CITY OWNED PROPERTY LIMITS

OTHER PROPERTY LIMITS

RIVER EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

DAM EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

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REVISIONS

NO.	DATE	DESCRIPTION

PROPERTY TAX ID MAP
(1 OF 3)

SURVEYED & DESIGNED BY:

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IMPROVEMENTS ALONG THE

GRAND RIVER

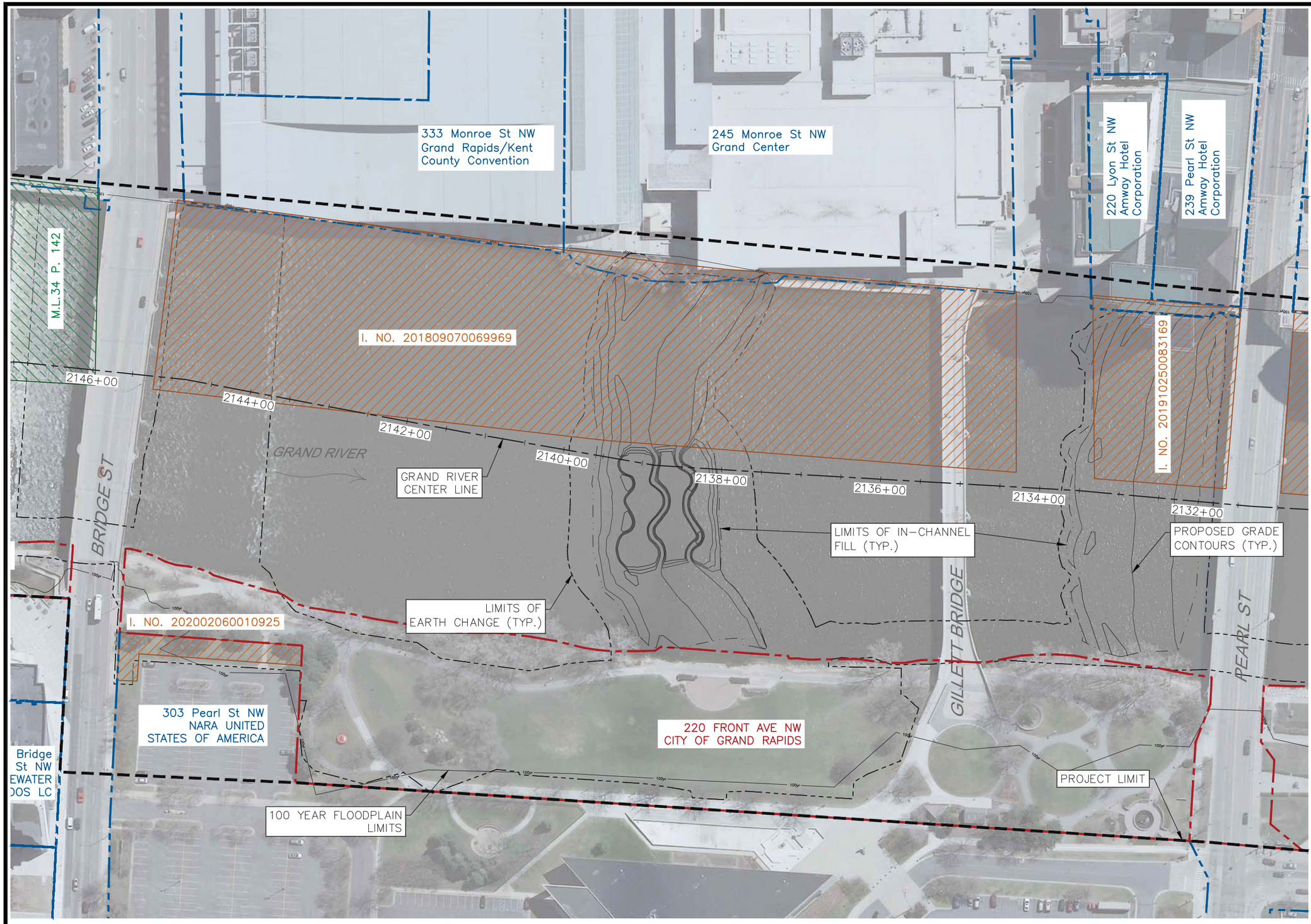
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 3 of 32 G02



CITY OWNED PROPERTY LIMITS

OTHER PROPERTY LIMITS

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DAM EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

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REVISIONS

NO.	DATE	DESCRIPTION

PROPERTY TAX ID MAP
(2 OF 3)

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IMPROVEMENTS ALONG THE

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(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

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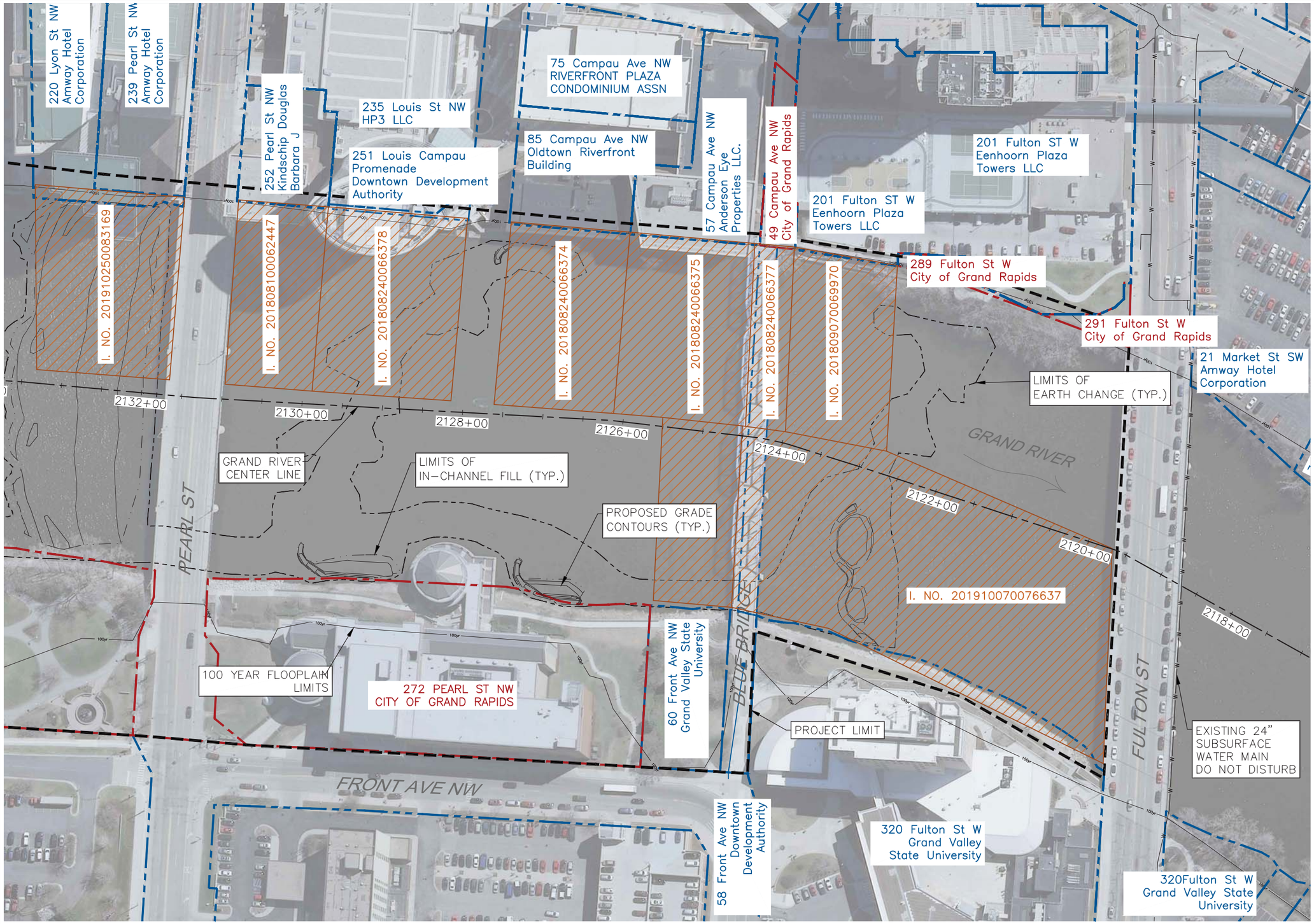
Check: Office _____

GPF No. 5315

Sheet No. 4 of 32 G03



NORTH

0 60' 120'

SCALE: 1" = 60'

CITY OWNED PROPERTY LIMITS

OTHER PROPERTY LIMITS

RIVER EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

DAM EASEMENTS TO CITY OF G.R. (APPROX. LIMITS)

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PROPERTY TAX ID MAP
(3 OF 3)

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GPF No. 5315

Sheet No. 5 of 32 G04

MICHIGAN UNIFIED KEYING SYSTEM SOIL EROSION & SEDIMENTATION CONTROL MEASURES

✳ INDICATES APPLICABILITY OF A SPECIFIC CONTROL MEASURE TO ONE OR MORE OF THE SEVEN PROBLEM AREAS

KEY	DETAIL	CHARACTERISTICS	SLOPES A	STREAMS AND WATERWAYS B	SURFACE DRAINAGEWAYS C	ENCLOSED DRAINAGE (Inlet & Outlet Control) D	LARGE FLAT SURFACE AREAS E	BORROW AND STOCKPILE AREAS F	ADJACENT PROPERTIES G
1	Dust Control – No Detail –	DUST CONTROL APPLICATIONS CAN INCLUDE WATERING, CHEMICAL DUST SUPPRESSION, GRAVEL OR ASPHALT SURFACING, TEMPORARY AGGREGATE COVER AND HAUL TRUCK COVERS	✳				✳	✳	
2	Selective Grading & Shaping	WATER CAN BE DIVERTED TO MINIMIZE EROSION FLATTER SLOPES EASE EROSION PROBLEMS	✳				✳	✳	✳
3	Grubbing Omitted	SAVES COST OF GRUBBING, PROVIDES NEW SPROUTS RETAINS EXISTING ROOT MAT SYSTEM, REDUCES WIND FALL AT NEW FOREST EDGE. DISCOURAGES EQUIPMENT ENTRANCE	✳				✳		✳
4	Vegetative Stabilization	MAY UTILIZE A VARIETY OF PLANT MATERIAL STABILIZES SOIL SLOWS RUNOFF VELOCITY FILTERS SEDIMENT FROM RUNOFF	✳	✳	✳		✳	✳	✳
5	AVAILABLE DETAIL								
6	Sodding with Mesh Blanket and/or Matting	FACILITATES ESTABLISHMENT OF VEGETATIVE COVER EFFECTIVE FOR DRAINAGEWAYS WITH LOW VELOCITY EASILY PLACED IN SMALL QUANTITIES BY INEXPERIENCED PERSONNEL SHOULD INCLUDE PREPARED TOPSOIL BED	✳		✳			✳	✳
7	AVAILABLE DETAIL								
8	Sodding	PROVIDES IMMEDIATE PROTECTION CAN BE USED ON STEEP SLOPES WHERE SEED MAY BE DIFFICULT TO ESTABLISH. EASY TO PLACE, MAY BE REPAIRED IF DAMAGED SHOULD INCLUDE PREPARED TOPSOIL BED	✳		✳		✳	✳	✳
9	Vegetative Buffer Strip	SLOWS RUNOFF VELOCITY FILTERS SEDIMENT FROM RUNOFF REDUCES VOLUME OF RUNOFF ON SLOPES	✳	✳					✳
10	Mulching	USED ALONE TO PROTECT EXPOSED AREAS FOR SHORT PERIODS PROTECTS SOIL FROM IMPACT OF FALLING RAIN PRESERVES SOIL MOISTURE AND PROTECTS GERMINATING SEED FROM TEMPERATURE EXTREMES	✳				✳	✳	
11	Roughened Surface	REDUCES VELOCITY AND INCREASES INFILTRATION RATES COLLECTS SEDIMENT HOLDS WATER, SAND AND MULCH BETTER THAN SMOOTH SURFACES	✳				✳		
12	AVAILABLE DETAIL								
13	Riprap, Rubble, Gabions	USED WHERE VEGETATION IS NOT EASILY ESTABLISHED EFFECTIVE FOR HIGH VELOCITIES OR IRON CONCENTRATIONS PERMITS RUNOFF TO INFILTRATE SOIL DISSIPATES ENERGY FLOW AT SYSTEM OUTLETS	✳	✳	✳				
14	AVAILABLE DETAIL								
15	AVAILABLE DETAIL								
16	AVAILABLE DETAIL								
17	Benches	REDUCES RUNOFF VELOCITY BY REDUCING EFFECTIVE SLOPE LENGTH COLLECTS SEDIMENT. PROVIDES ACCESS TO SLOPES FOR SEEDING, MULCHING AND MAINTENANCE	✳					✳	
18	Earth Diversion Berm	DIVERTS WATER FROM VULNERABLE AREAS COLLECTS AND DIRECTS WATER TO PREPARED DRAINAGEWAYS MAY BE PLACED AS PART OF NORMAL CONSTRUCTION OPERATION	✳					✳	✳
18A	Earth Diversion Berm With Stone Outlet at Inlet	DIVERTS WATER FROM VULNERABLE AREAS COLLECTS AND DIRECTS WATER TO PREPARED DRAINAGEWAYS MAY BE PLACED AS PART OF NORMAL CONSTRUCTION OPERATION	✳					✳	✳
19	Diversion Ditch	COLLECTS AND DIVERTS WATER TO REDUCE EROSION POTENTIAL MAY BE INCORPORATED IN PERMANENT PROJECT DRAINAGE SYSTEMS	✳					✳	✳
20	Diversion Berm & Ditch	DIVERTS WATER TO A PREPARED DRAINAGEWAY MAY BE USED AT INTERVALS ACROSS SLOPE FACE TO REDUCE EFFECTIVE SLOPE LENGTH	✳					✳	✳
21	Stone Filter Berm	CONSTRUCTED OF GRAVEL OR STONE INTERCEPTS AND DIVERTS RUNOFF TO STABILIZED AREAS OR PREPARED DRAINAGE SYSTEMS SLOWS RUNOFF AND COLLECTS SEDIMENT	✳	✳					✳
21A	Stone Filter Berm with Silt Fence	CONSTRUCTED OF GRAVEL OR STONE INTERCEPTS AND DIVERTS RUNOFF TO STABILIZED AREAS OR PREPARED DRAINAGE SYSTEMS SLOWS RUNOFF AND COLLECTS SEDIMENT – SILT FENCE PREVENTS EROSION AROUND SPILLWAY	✳	✳					✳
22	AVAILABLE DETAIL								
23	AVAILABLE DETAIL								
24	Grassed Waterway	MUCH MORE STABLE FORM OF DRAINAGEWAY THAN BARE CHANNEL GRASS TENDS TO SLOW RUNOFF AND FILTER OUT SEDIMENT USED WHERE BARE CHANNEL WOULD BE ERODED			✳				
25	Slope Drain (Surface Pipe)	PREVENTS EROSION ON SLOPES WHEN RUNOFF CANNOT BE DIVERTED TO EDGES OF SLOPE AREA. USUALLY TEMPORARY CAN BE CONSTRUCTED OR EXTENDED AS GRADING PROGRESSES	✳						✳
26	Slope Drain – Paved Chute/Flume	PREVENTS EROSION ON SLOPES WHEN RUNOFF CANNOT BE DIVERTED TO EDGE OF SLOPE AREA. USUALLY PERMANENT CAN BE CONSTRUCTED OR EXTENDED AS GRADING PROGRESSES	✳						✳
27	Slope Drain (Subsurface Pipe)	PREVENTS EROSION ON SLOPES WHEN RUNOFF CANNOT BE DIVERTED TO EDGE OF SLOPE AREA. USUALLY PERMANENT CAN BE CONSTRUCTED AS GRADING PROGRESSES	✳						✳
28	Drop Spillway	SLOWS VELOCITY OF FLOW, REDUCING EROSIVE CAPACITY		✳	✳				
29	Pipe Drop	REDUCES RUNOFF VELOCITY REMOVES SEDIMENT AND TURBIDITY CAN BE DESIGNED TO HANDLE LARGE VOLUMES OF FLOW			✳				
30	Pipe Spillway	REMOVES SEDIMENT AND TURBIDITY FROM RUNOFF MAY BE PART OF PERMANENT EROSION CONTROL PLAN			✳				
31	Energy Dissipator	SLOWS RUNOFF VELOCITY TO NON-EROSIVE LEVEL PERMITS SEDIMENT COLLECTION FROM RUNOFF	✳		✳	✳			
32	Level Spreader	CONVERTS COLLECTED CHANNEL OR PIPE FLOW BACK TO SHEET FLOW AVOIDS CHANNEL EASEMENTS AND CONSTRUCTION OFF PROJECT SITE SIMPLE TO CONSTRUCT			✳				
33	Sediment Trap	MAY BE CONSTRUCTED OF A VARIETY OF MATERIALS TRAPS SEDIMENT AND REDUCES VELOCITY OF FLOW CAN BE CLEANED AND EXPANDED AS NEEDED			✳				
34	Sediment Basin	TRAPS SEDIMENT RELEASES RUNOFF AT NON-EROSIVE RATES CONTROLS RUNOFF AT SYSTEM OUTLETS CAN BE VISUAL AMENITIES			✳	✳			
35	AVAILABLE DETAIL								
36	Catch Basin Inlet Protection	COLLECTS HIGH VELOCITY CONCENTRATED RUNOFF MAY USE FILTER CLOTH OVER INLET					✳		✳

✳ INDICATES APPLICABILITY OF A SPECIFIC CONTROL MEASURE TO ONE OR MORE OF THE SEVEN PROBLEM AREAS

KEY	DETAIL	CHARACTERISTICS	SLOPES A	STREAMS AND WATERWAYS B	SURFACE DRAINAGEWAYS C	ENCLOSED DRAINAGE (Inlet & Outlet Control) D	LARGE FLAT SURFACE AREAS E	BORROW AND STOCKPILE AREAS F	ADJACENT PROPERTIES G
37	Sod Filter	INEXPENSIVE AND EASY TO CONSTRUCT PROVIDES IMMEDIATE PROTECTION PROTECTS AREAS AROUND INLETS FROM EROSION				✳			
38	AVAILABLE DETAIL								
39	Fabric Filter Curb Inlet Protection	CAN UTILIZE MATERIAL FOUND ON SITE EASY TO CONSTRUCT FILTERS SEDIMENT FROM RUNOFF				✳			✳
40	Inlet Sediment Trap	EASY TO SHAPE COLLECTS SEDIMENT MAY BE CLEANED AND EXPANDED AS NEEDED				✳			
41	Stone and Rock Ford Crossing	MAY BE ROCK OR CLEAN RUBBLE MINIMIZES STREAM TURBIDITY INEXPENSIVE MAY ALSO SERVE AS DITCH CHECK OR SEDIMENT TRAP		✳					
42	Temporary Culvert	ELIMINATES STREAM TURBULENCE AND TURBIDITY PROVIDES UNOBSTRUCTED PASSAGE FOR FISH AND OTHER WATER LIFE CAPACITY FOR NORMAL FLOW CAN BE PROVIDED WITH STORM WATER FLOWING OVER ROADWAY		✳					
43	Culvert Sediment Trap	EASY TO INSTALL AT INLET KEEPS CULVERT CLEAN AND FREE FLOWING MAY BE CONSTRUCTED OF LUMBER OR LOGS		✳					✳
44	AVAILABLE DETAIL								
45	Temporary Stream Channel Change	NEW CHANNEL KEEPS NORMAL FLOWS AWAY FROM CONSTRUCTION REQUIRES STATE PERMIT		✳					
46	AVAILABLE DETAIL								
47	Cofferdam	WORK CAN BE CONTINUED DURING MOST ANTICIPATED STREAM CONDITIONS CLEAR WATER CAN BE PUMPED DIRECTLY BACK INTO STREAM		✳					
48	AVAILABLE DETAIL								
49	Check Dam	REDUCES FLOW VELOCITY CATCHES SEDIMENT CAN BE CONSTRUCTED OF LOGS, STRAW, HAY, ROCK, LUMBER, MASONRY, OR SAND BAGS		✳	✳				
50	AVAILABLE DETAIL								
51	Retaining Wall	REDUCES GRADIENT WHERE SLOPES ARE EXTREMELY STEEP PERMITS RETENTION OF EXISTING VEGETATION, KEEPING SOIL STABLE IN CRITICAL AREAS, MINIMIZES MAINTENANCE	✳						✳
52	AVAILABLE DETAIL								
53	Windbreak	MINIMIZES WIND EROSION MAY BE SNOW FENCE					✳		
54	Silt Fence	USES GEOTEXTILE FABRIC AND POSTS OR POLES EASY TO CONSTRUCT AND LOCATE AS NECESSARY	✳		✳		✳		✳
55	Stone Filter–Before Paving	STONE FILTER TO PROVIDE INEXPENSIVE AND EASILY CONSTRUCTED SEDIMENT CONTROL PRIOR TO PAVING SEE DETAIL AT LEFT			✳	✳			
55A	Stone Filter–After Paving	STONE FILTER TO PROVIDE INEXPENSIVE AND EASILY CONSTRUCTED SEDIMENT CONTROL AFTER PAVING SEE DETAIL AT LEFT			✳	✳			
55B	Catch Basin, Filter Bag	MANUFACTURED FILTER BAG INSERTED UNDER CASTING. COLLECTS SEDIMENT AT CATCH BASIN INLET SEE DETAIL AT LEFT			✳	✳			
56	Turbidity Curtain	A TURBIDITY CURTAIN IS USED WHEN SLACK WATER AREA IS NECESSARY TO ISOLATE CONSTRUCTION ACTIVITIES FROM THE WATERCOURSE. THE STILL WATER AREA CONTAINS THE SEDIMENT WITHIN THE CONSTRUCTION LIMITS		✳					
57	Stream – Liner	MAY BE 6A TYPE STONE, SMALL ROCKS OR SIMILAR–SIZED CLEAN CONCRETE–MASONRY RUBBLE, MINIMIZES STREAM TURBIDITY RELATIVELY INEXPENSIVE MAY BE USED AS DITCH CHECK OR SEDIMENT TRAP			✳				
58	Sediment Sump	CONTROLS SEDIMENTATION IN LARGE STREAMS, CONSIST OF OVER EXCAVATING THE DRAIN BY ONE TO TWO FEET, THE SUMP WILL BE AT LEAST 200 FEET LONG, SEDIMENTS ACCUMULATED DURING CONSTRUCTION WILL BE REMOVED UPON PROJECT COMPLETION			✳				
59	AVAILABLE DETAIL								
60	Temporary Construction Entrance	ASSISTS IN REMOVING SOIL FROM THE TIRES OF CONSTRUCTION VEHICLES AND VEHICLES WHEN EXITING THE CONSTRUCTION SITE. THIS REDUCES TRACKING EXCESSIVE SEDIMENT/SOIL ONTO THE ADJACENT ROAD							✳

SOIL EROSION & SEDIMENTATION CONTROL NOTES

1. CONTRACTOR SHALL PLACE ALL SOIL EROSION & SEDIMENTATION CONTROL MEASURES AS SHOWN IN THE PLANS, OR AS DIRECTED BY THE ENGINEER IN ACCORDANCE WITH THE MICHIGAN UNIFIED KEYING SYSTEM.
2. CONSTRUCTION OPERATIONS SHALL BE SCHEDULED AND PERFORMED SO THAT PREVENTATIVE EROSION CONTROL MEASURES ARE IN PLACE PRIOR TO EXCAVATION; TEMPORARY STABILIZATION MEASURES ARE IN PLACE IMMEDIATELY FOLLOWING BACK FILLING AND/OR GRADING OPERATIONS.
3. SPECIAL PRECAUTIONS WILL BE TAKEN IN THE USE OF CONSTRUCTION EQUIPMENT TO PREVENT SITUATIONS THAT PROMOTE EROSION.
4. CLEANUP WILL BE DONE IN A MANNER TO ENSURE THAT EROSION CONTROL MEASURES ARE NOT DISTURBED.
5. THE PROJECT WILL BE INSPECTED DAILY FOR SOIL EROSION AND SEDIMENTATION CONTROL COMPLIANCE BY CERTIFIED STORM WATER OPERATOR PROVIDED BY CONTRACTOR. DEFICIENCIES WILL BE CORRECTED BY THE CONTRACTOR WITHIN 24 HOURS.
6. TEMPORARY EROSION CONTROL MEASURES SHALL BE COMPLETELY REMOVED BY THE CONTRACTOR UPON ESTABLISHMENT OF PERMANENT CONTROL MEASURES, WITH PRIOR APPROVAL OF OWNER, ENGINEER, AND/OR AGENCY HAVING JURISDICTION.
7. CONSTRUCTION WILL DISTURB LESS THAN 5 ACRES, THUS AN NPDES STORM WATER DISCHARGE PERMIT WILL NOT BE REQUIRED. CONTRACTOR SHALL MEET THE PERMIT–BY–RULE (RULE 323.2190) HOWEVER FOR AREAS BETWEEN 1 ACRE AND 5 ACRES.
8. ALL ROADS WITHIN THE INFLUENCE OF THE PROJECT MUST REMAIN CLEAN AT ALL TIMES. CONTRACTOR SHALL SWEEP ROADS AS DIRECTED BY THE ENGINEER.
9. BEST MANAGEMENT PRACTICES FOR SOIL EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE USED ON THIS PROJECT AS SHOWN ON THE PLANS AND AS DEFINED BY THE ENGINEER.
10. ALL EROSION CONTROL MEASURES SHALL BE CONSTRUCTED AND MAINTAINED IN ACCORDANCE WITH THE CITY OF GRAND RAPIDS AND THE OFFICE OF THE KENT COUNTY DRAIN COMMISSIONER REQUIREMENTS AND PROJECT SPECIFICATIONS
11. ANY EROSION OR SEDIMENT FROM WORK ON THIS SITE SHALL BE CONTAINED ON THE SITE AND NOT ALLOW3ED TO COLLECT ON ANY OFF SITE AREAS OR IN WATERWAYS: WATERWAYS INCLUDE BOTH NATURAL AND MAN–MADE OPEN DITCHES, STREAMS, STORM DRAINS, LAKES AND PONDS.
12. WORK TO BE PERFORMED WITHIN THE GRAND RIVER FOR 2,756 FEET BETWEEN I–196 AND FULTON STREET AND ALONG THE GRAND RIVER FOR 900 FEET IN AH–NAB–AWEN PARK. STAGING AREAS 0 FEET AWAY FROM RIVER AT AH–NAB–AWEN PARK AND 25 FEET AWAY AT MONROE LOT.
13. THE SOIL TYPE WITHIN THE PROJECT IS IDENTIFIED AS URBAN LAND BY THE UNITED STATES DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
14. PROVIDE TRAFFIC CONTROL BARRICADES, SIGNS, LIGHTS, ETC. IN ACCORDANCE WITH THE LATEST EDITION OF THE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES AS NECESSARY FOR THE PROTECTION AND SAFETY OF THE PUBLIC. MAINTAIN THESE DEVICES AT ALL TIMES DURING CONSTRUCTION.
15. PROTECT TREES NOT SHOWN FOR REMOVAL FROM DAMAGE DURING CONSTRUCTION IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
16. ALL REMOVED MATERIALS ARE THE PROPERTY OF THE CONTRACTOR. CLEANUP AND DISPOSE OF ALL EXCESS MATERIALS OFF SITE AT A LOCATION DESIGNATED FOR THIS USE AND IN ACCORDANCE WITH LOCAL REGULATIONS OR AT N ON SITE LOCATION DESIGNATED BY THE OWNER, UNLESS OTHERWISE NOTED.
17. USE (2) TWO BENCH MARKS FOR VERIFICATION OF ALL CONSTRUCTION ELEVATIONS. SET ADDITIONAL BENCH MARKS TO COMPLY WITH THIS REQUIREMENT.
18. RESTORE ALL STREET SURFACES, DRIVEWAYS, CULVERTS, ROADSIDE DRAINAGE DITCHES, AND OTHER PUBLIC OR PRIVATE STRUCTURES THAT ARE DISTURBED OR DAMAGED AS A RESULT OF CONSTRUCTION ACTIVITIES TO A CONDITIONS EQUAL TO OR BETTER THAN EXISTING CONDITIONS AND TO THE SATISFACTION OF THOSE HAVING JURISDICTION, UNLESS NOTED OTHERWISE IN THE PLANS.

CONSTRUCTION SEQUENCE

1. IMPLEMENTATION OF TEMPORARY EROSION CONTROL MEASURES; SELECTIVE GRADING, DIVERSIONS AS REQUIRED IN FIELD, PROTECTION OF STORM SEWER FACILITIES
2. EXCAVATION AND STOCKPILING OF SOIL.
3. PERIODIC MAINTENANCE OF AFFECTED EROSION CONTROL MEASURES.
4. PERMANENT MEASURES; FINAL GRADING, SEEDING AND MULCHING.

SEE UNIFIED KEYING SYSTEM FOR EROSION CONTROL KEY NUMBERS

TO BE COMPLETED BY CONTRACTOR FOR PERMIT

SOIL EROSION / SEDIMENTATION CONTROL
OPERATION TIME SCHEDULE

CONSTRUCTION SEQUENCE	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
STRIP & STOCKPILE TOPSOIL													
ROUGH GRADE / SEDIMENT CONTROL													
TEMP. CONTROL MEASURES													
STORM FACILITIES													
TEMP. CONSTRUCTION ROADS													
FOUNDATION / BLDG. CONSTRUCTION													
SITE CONSTRUCTION													
PERM. CONTROL MEASURES													
FINISH GRADING													
LANDSCAPING													

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.



ZONES

ZONE 1

TYPE OF SEED	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	RATE OF APPLICATION * PER/1000 S.F.	PER ACRE
OATS / BARLEY ANNUAL RYE						15TH		2 LBS. 3/4 LB.	3 BUSHELS 25 LBS.
SUDANGRASS				15TH				1 LB.	35 LBS.
CEREAL RYE							15TH	1.5 LBS.	2 BU.
WINTER WHEAT						20TH	15TH	1.5 LBS.	2 BU.

TEMPORARY SEEDING GUIDE

RECOMMENDED PLANTING SEASON

* RATE OF APPLICATION APPLIES TO ALL ZONES

ZONE	TYPE OF IRRIGATION	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
ZONE 1	IRRIGATED and/or MULCHED							
	without IRRIGATION or MULCH							
ZONE 2	IRRIGATED and/or MULCHED							
	without IRRIGATION or MULCH							
ZONE 3	IRRIGATED and/or MULCHED							
	without IRRIGATION or MULCH							

PERMANENT SEEDING GUIDE

RECOMMENDED PLANTING SEASON

EGLE STREAM CROSSING NOTES

1. CONSTRUCTION OF STREAM CROSSING SHALL BE SUBJECT TO THE SPECIFICATIONS FOR PROTECTION OF NATURAL RESOURCES AT UTILITY CROSSING AS GIVEN IN THE ADMINISTRATIVE RULES PART NO. 301 OF PUBLIC ACT 451, AS AMENDED, 1994.
2. A SILTATION BARRIER SHALL BE CONSTRUCTED IMMEDIATELY DOWNSTREAM OF THE CONSTRUCTION SITE PRIOR TO THE COMMENCEMENT OF ANY CONSTRUCTION ACTIVITIES. (SEE MICHIGAN UNIFIED KEYING SYSTEM FOR SPECIFIED BARRIER) THE SILTATION BARRIER SHALL BE MAINTAINED IN GOOD WORKING ORDER THROUGHOUT THE DURATION OF THE PROJECT.
3. BACKFILL SHALL CONSIST OF INERT MATERIALS WHICH WILL NOT CAUSE SILTATION NOR CONTAIN SOLUBLE CHEMICALS OR ORGANIC MATTER WHICH IS BIODEGRADABLE. ALL FILL SHALL BE CONTAINED IN SUCH MANNER SO AS NOT TO ERODE INTO ANY WATERCOURSE.
4. ALL RAW BANKS SHALL BE STABILIZED WITH RIPRAP TO THREE FEET ABOVE ORDINARY HIGH WATER MARK, THEN SEEDED, FERTILIZED AND MULCHED, OR SODDED TO PREVENT EROSION
5. UPON PROJECT COMPLETION THE EXCESS SPOILS SHALL BE REMOVED AND DISPOSED IN AN APPROPRIATE UPLAND SITE.
6. SILTATION BARRIER MAY BE REMOVED UPON PLACEMENT OF PERMANENT EROSION CONTROL BARRIERS.

MICHIGAN UNIFIED KEYING SYSTEM SOIL EROSION & SEDIMENT CONTROL MEASURES

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

REVISIONS

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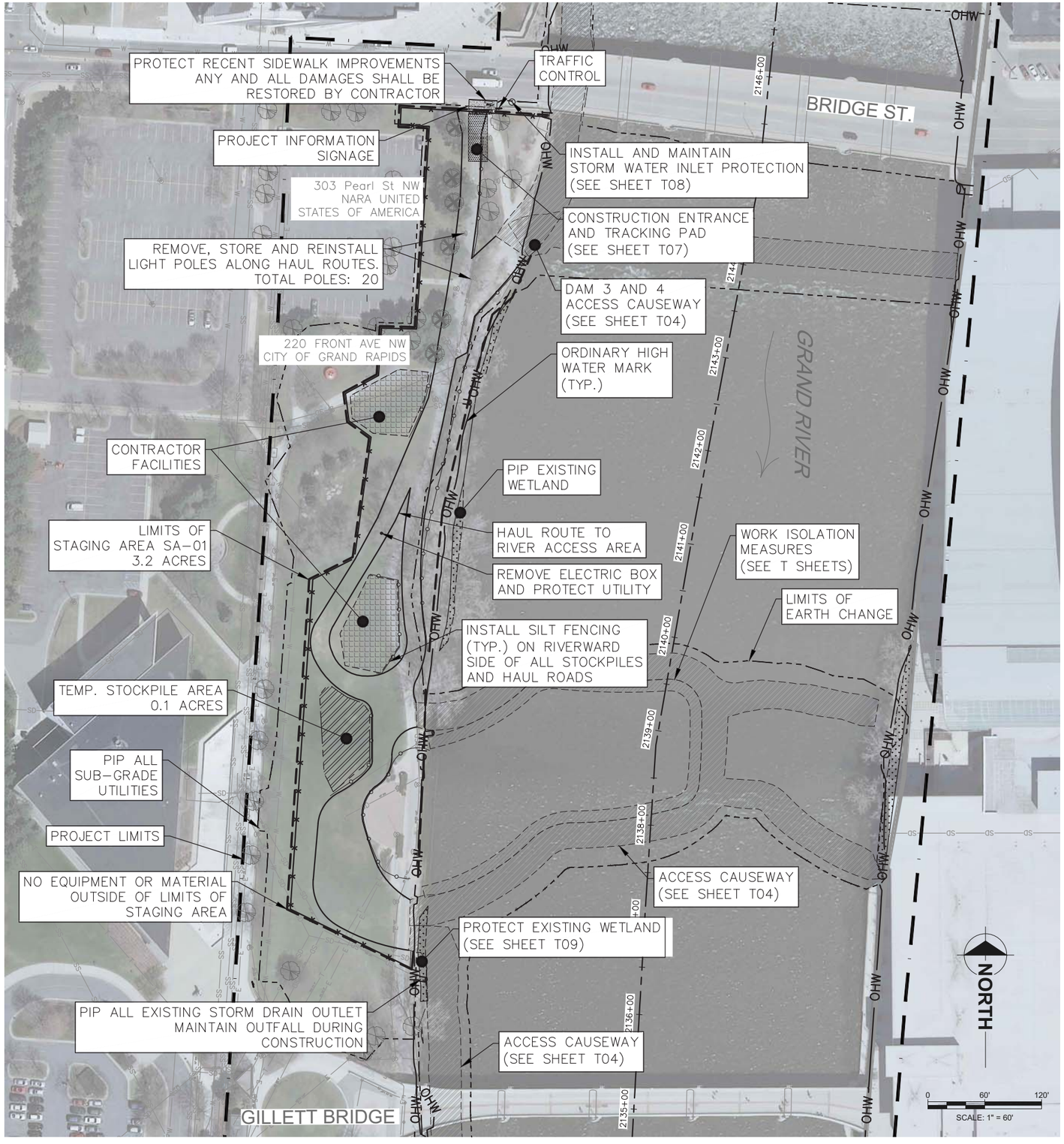
GPF No. 5315

Sheet No. 6 of 32 T01



LEGEND

- CONTRACTOR FACILITIES: INCLUDES TRAILER, SANITATION FACILITIES, FUELING AREA, ETC.
- STOCKPILE AREA: INCLUDES DEWATERING AREA
- CONSTRUCTION FENCING
- SILT FENCING
- GATE
- PIP TREE
- REMOVE TREE
- PIP LIGHT POLE
- DELINEATED WETLAND

GENERAL NOTES:

1. THE CONSTRUCTION STAGING PLAN SHOWN HERE IS FOR PERMITTING AND COST ESTIMATION PURPOSES ONLY. THIS CARE OF WATER PLAN IS BASED ON CORRESPONDENCE WITH THE CITY OF GRAND RAPIDS AND THE CONSTRUCTION MANAGER ADVISOR. THE CONTRACTOR WILL ULTIMATELY BE RESPONSIBLE FOR DEVELOPING AND MAINTAINING A CONSTRUCTION STAGING PLAN TO MEET PERMITTING CONDITIONS AND CONSTRUCTION NEEDS.
2. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL.
3. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
4. THE CONTRACTOR SHALL CONDUCT OPERATIONS IN COMPLIANCE WITH DIVISION 1 OF THE 2021 CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS AND THE PROVISIONS OF SECTIONS 107.15 "DUST CONTROL" AND 812 "TEMPORARY TRAFFIC CONTROL FOR CONSTRUCTION ZONE OPERATIONS" OF THE MDOT STANDARD CONSTRUCTION SPECIFICATIONS.
5. NO MATERIAL OR EQUIPMENT SHALL BE PLACED, STORED, OR OPERATED OUTSIDE THE STAGING AREA LIMITS SHOWN ON PLANS.
6. TEMPORARY EARTHWORK NECESSARY TO ESTABLISH STAGING AND ACCESS FACILITIES SHALL HAVE A MAXIMUM TOPSOIL REMOVAL DEPTH OF 1 FOOT.
7. THE CONTRACTOR IS RESPONSIBLE TO DEVELOP AND MAINTAIN A TRAFFIC CONTROL PLAN THROUGHOUT CONSTRUCTION.

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - AH-NAB-AWEN PARK STAGING

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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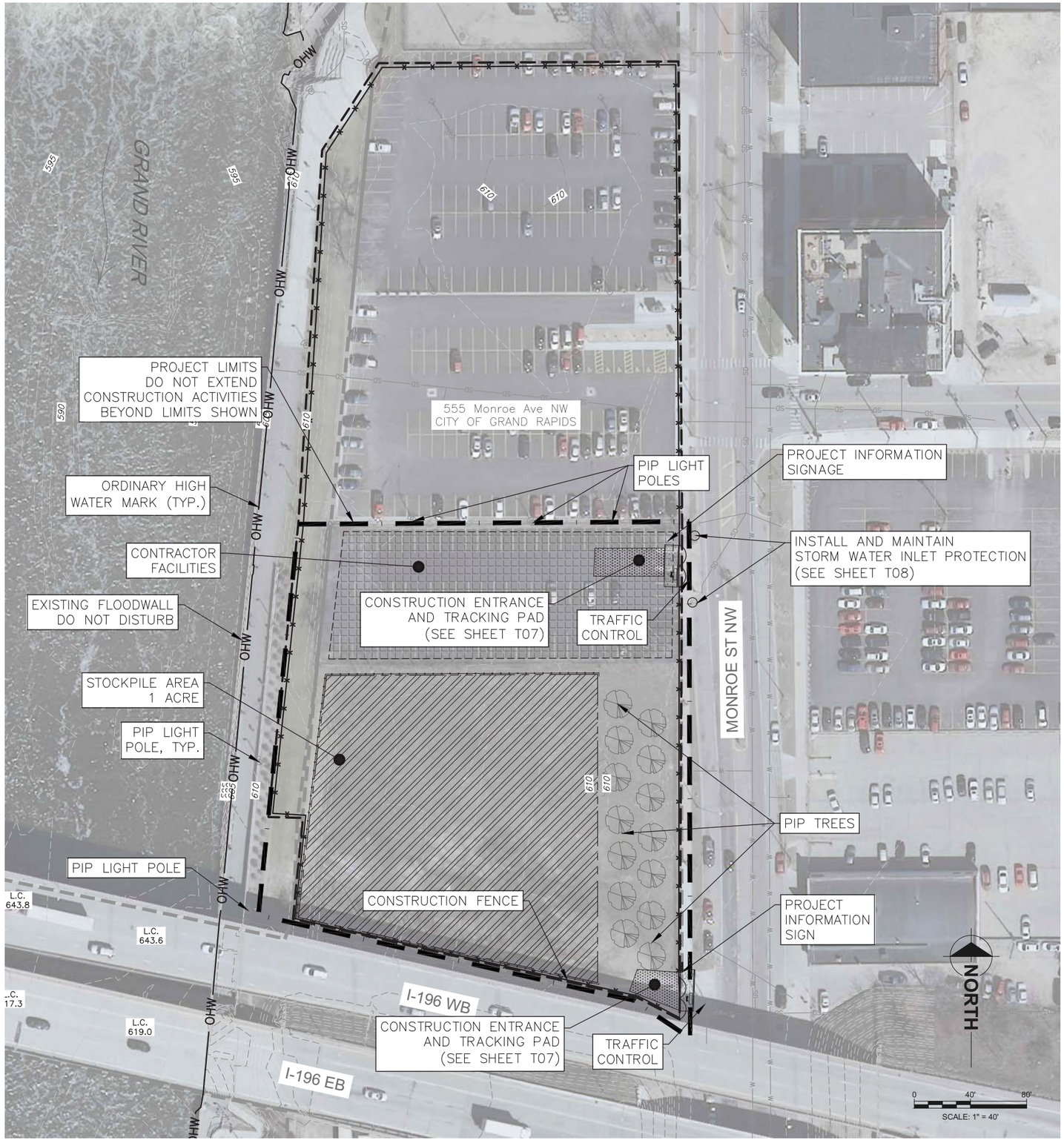
Sheet No. 7 of 32 T02



LEGEND

- CONTRACTOR FACILITIES: INCLUDES TRAILER, SANITATION FACILITIES, FUELING AREA, ETC.
- STOCKPILE AREA: INCLUDES DEWATERING AREA
- CONSTRUCTION FENCING
- SILT FENCING
- GATE
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GENERAL NOTES:

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2. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL.
3. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
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6. TEMPORARY EARTHWORK NECESSARY TO ESTABLISH STAGING AND ACCESS FACILITIES SHALL HAVE A MAXIMUM TOPSOIL REMOVAL DEPTH OF 1 FOOT.
7. THE CONTRACTOR IS RESPONSIBLE TO DEVELOP AND MAINTAIN A TRAFFIC CONTROL PLAN THROUGHOUT CONSTRUCTION.

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - 555 MONROE LOT STAGING

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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City of Grand Rapids
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IMPROVEMENTS ALONG THE

GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
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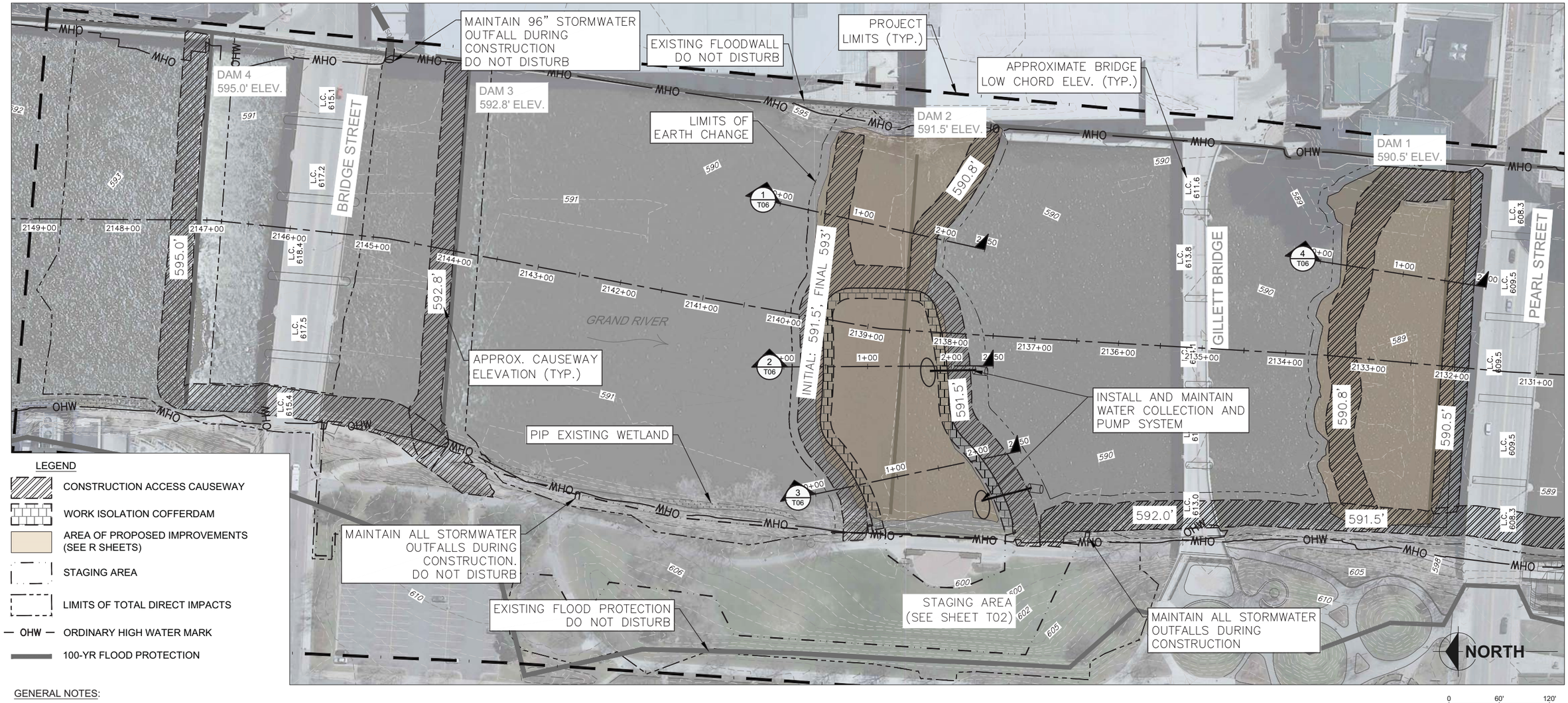
Sheet No. 8 of 32 T03



LEGEND

- CONSTRUCTION ACCESS CAUSEWAY
- WORK ISOLATION COFFERDAM
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- STAGING AREA
- LIMITS OF TOTAL DIRECT IMPACTS
- OHW — ORDINARY HIGH WATER MARK
- 100-YR FLOOD PROTECTION

0 60' 120'

SCALE: 1" = 60'

GENERAL NOTES:

1. THE CARE OF WATER PLAN AND TEMPORARY STRUCTURES SHOWN HERE ARE FOR PERMITTING AND COST ESTIMATION PURPOSES ONLY. THIS CARE OF WATER PLAN IS BASED ON CORRESPONDENCE WITH THE CITY OF GRAND RAPIDS AND THE CONSTRUCTION MANAGER ADVISOR. THE CONTRACTOR WILL ULTIMATELY BE RESPONSIBLE FOR DEVELOPING AND MAINTAINING A CARE OF WATER PLAN TO MEET PERMITTING CONDITIONS AND CONSTRUCTION NEEDS.
2. BRIDGE LOW CHORDS REPRESENT LOW CHORD OF BRIDGE DECKS. GILLETT AND PEARL STREET BRIDGES HAVE ARCHED BAYS; LOW CHORDS SHOWN REPRESENT APPROXIMATE HIGH POINT OF ARCHES.
3. ALL IN WATER WORK REQUIRES USE OF APPROVED BMP'S TO PREVENT IMPACTS TO WATER QUALITY.
4. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL OR IMPACT.
5. BE PREPARED TO UN-ISOLATE WORK AREA AND ALLOW FLOW ON BOTH SIDES OF CHANNEL UPON SHORT NOTICE IF OWNER'S REPRESENTATIVE DETERMINES BED SCOUR NEAR BRIDGE PIERS, FLOODWALLS, OR OTHER INFRASTRUCTURE SHOULD BE INSPECTED.
6. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
7. ACCESS CAUSEWAYS, WORK ISOLATION MEASURES, AND TEMPORARY GRADE CONTROLS SHALL BE INSTALLED IN THE FLOWING RIVER. REFER TO THE TECHNICAL SPECIFICATIONS FOR FLOW RATE AND DEPTH INFORMATION. CONTRACTOR SHALL SUBMIT PLAN TO PERFORM WORK IN THE FLOWING RIVER WITH MAXIMUM DEPTHS TO PERFORM WORK.
8. SURFACES FOR ALL TEMPORARY CAUSEWAYS AND COFFERDAMS CAN BE PROVIDED TO CONTRACTOR

CONSTRUCTION SEQUECNING NOTES:

1) CAUSEWAYS MUST BE INSTALLED BEFORE REMOVAL OF DAMS OR CONSTRUCTION OF PROPOSED IMPROVEMENTS CAN BEGIN AT ANY GIVEN LOCATION.
2) PROPOSED IMPROVEMENTS AT DAM 3 SHALL BE HELD UNTIL AFTER COFFERDAM AT DAM 2 HAS BEEN REMOVED.
3) PROPOSED IMPROVEMENTS AT DAM 4 SHALL BE HELD UNTIL AFTER COMPLETION OF PROPOSED IMPROVEMENTS AT DAM 2.

MUSSEL RELOCATION NOTES:

1) MUSSEL RELOCATION IS ANTICIPATED TO OCCUR BY OTHERS, PRIOR TO IN-CHANNEL CONSTRUCTION ACTIVITIES BEGINNING WITH THE EXCEPTION OF NOTE 3 BELOW.
2) LOCATIONS UNABLE TO BE ACCESSED FOR MUSSEL RELOCATION WOULD BE RELOCATED DURING CONSTRUCTION, IF FLOW CONDITIONS ALLOW AND RELOCATION IS ABLE TO BE COMPLETED AHEAD OF CONSTRUCTION ACTIVITIES.
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REVISIONS

NO.	DATE	DESCRIPTION

CONSTRUCTION PLAN LAYOUT

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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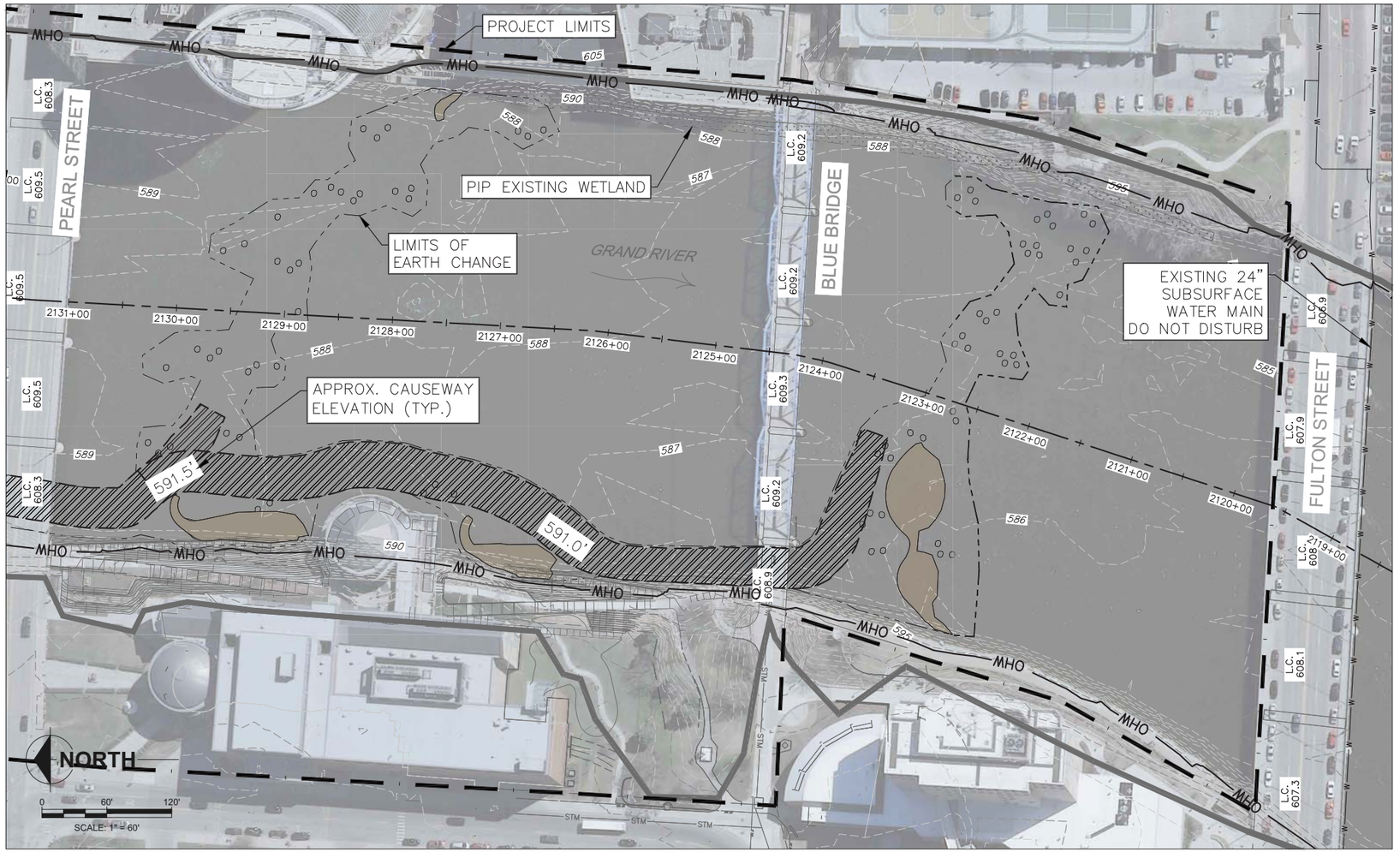
GPF No. **5315**

Sheet No. **9** of **32** **T04**

LEGEND

- CONSTRUCTION ACCESS CAUSEWAY
- WORK ISOLATION COFFERDAM
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- STAGING AREA
- LIMITS OF TOTAL DIRECT IMPACTS
- — OHW — ORDINARY HIGH WATER MARK
- 100-YR FLOOD PROTECTION



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REVISIONS

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CONSTRUCTION PLAN LAYOUT

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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Drawn by	GPF No.	Sheet No.
Check: Field	5315	10 of 32
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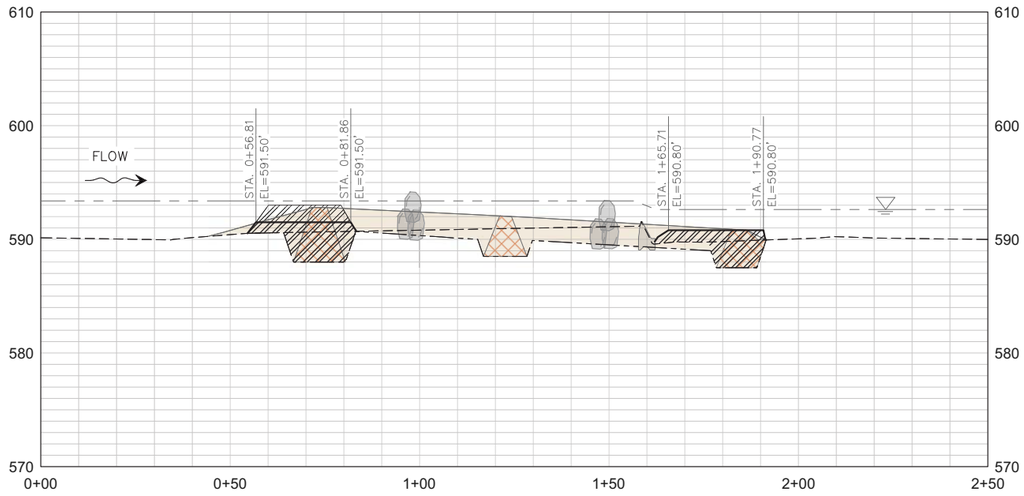
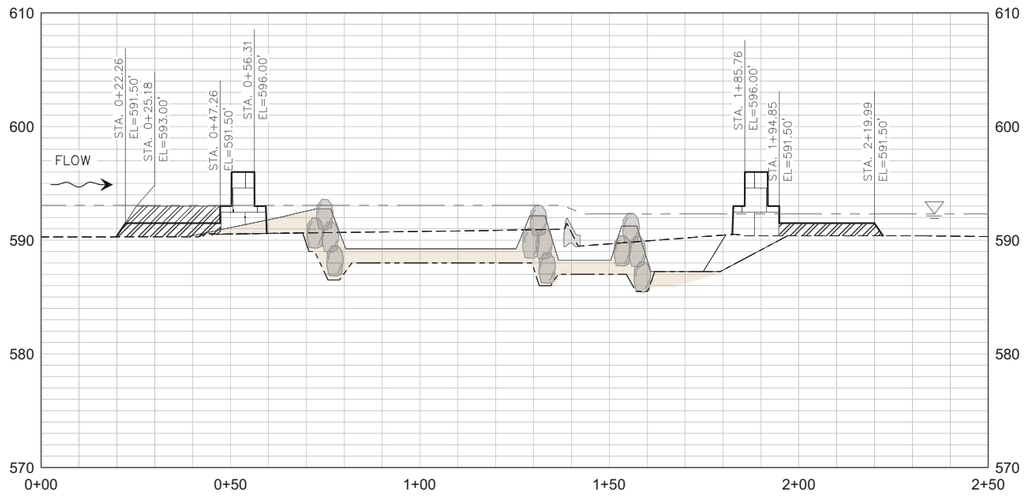
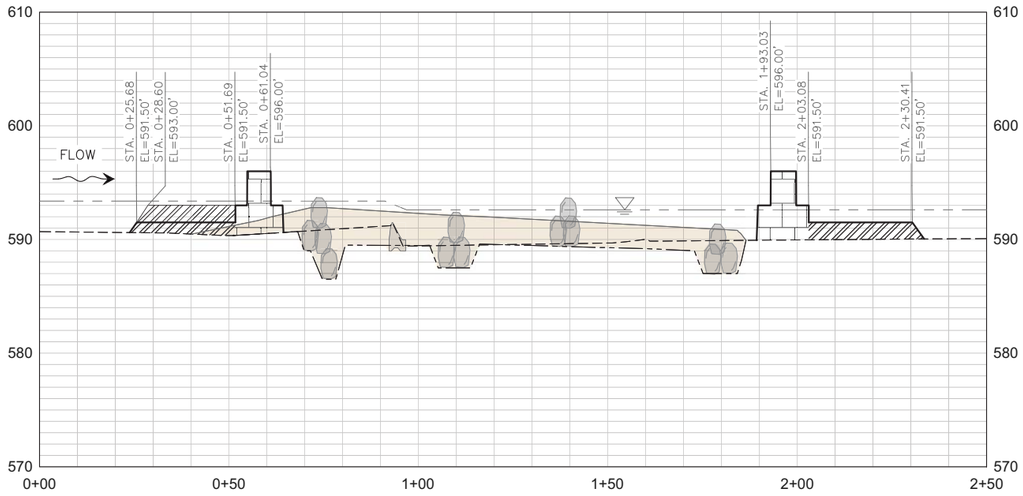


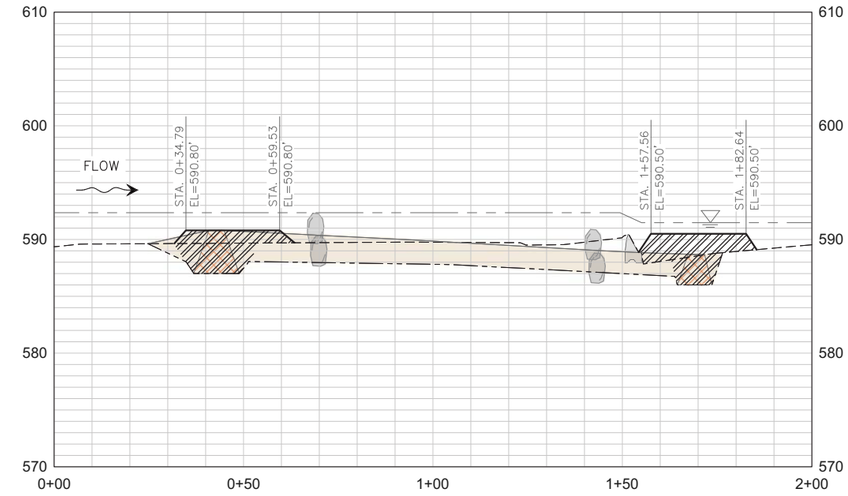
1 / T06 DESIGN PROFILE
CONSTRUCTED RIFFLE – EAST



2 / T06 DESIGN PROFILE
DIVERSIFIED BOULDER DROP STRUCTURES



3 / T06 DESIGN PROFILE
CONSTRUCTED RIFFLE – WEST



4 / T06 DESIGN PROFILE
CONSTRUCTED RIFFLE

0 20' 40'
SCALE: 1" = 20'

LEGEND

- CONSTRUCTION ACCESS CAUSEWAY, INTITIAL
- CONSTRUCTION ACCESS CAUSEWAY, FINAL
- WORK ISOLATION COFFERDAM
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- PROPOSED RIPRAP STRUCTURE
- PROPOSED BOULDER (SEE R SHEETS)
- EXISTING CONDITIONS WATER SURFACE ELEVATION, 3,900 CFS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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CONSTRUCTION PLAN DETAIL PROFILES

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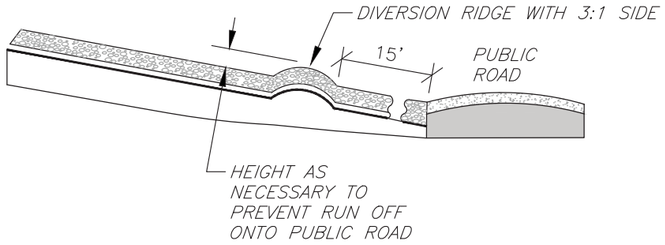
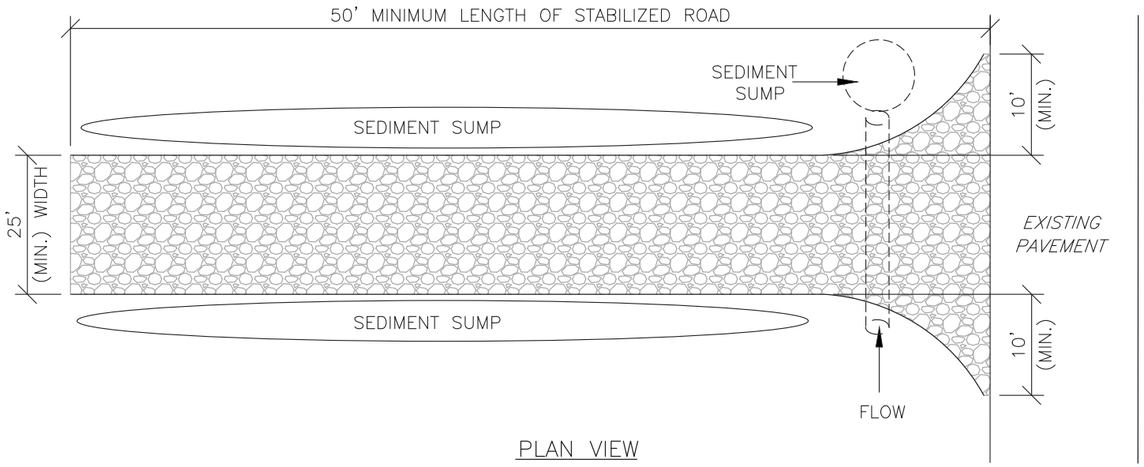
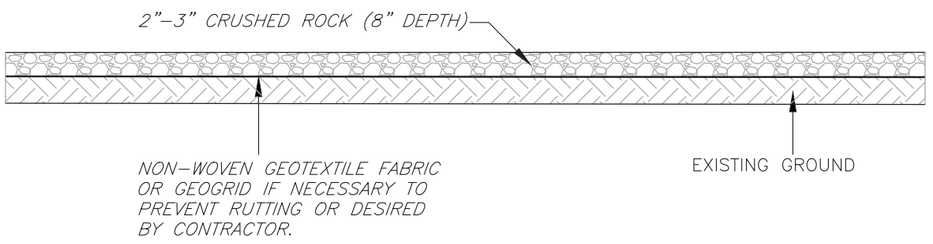
Sheet No. 11 of 32 T06



DIVERSION RIDGE CROSS–SECTION



PLAN VIEW



PROFILE

60 STABILIZED CONSTRUCTION ACCESS
NO SCALE

1
T07

NOTES:

1. ESTABLISH STABILIZED CONSTRUCTION ENTRANCE PRIOR TO THE INITIATION OF SITE CONSTRUCTION ACTIVITIES IN LOCATON SHOWN ON THE PLANS OR AS DIRECTED BY THE ENGINEER.
2. REMOVE ALL VEGETATION, TOPSOIL, AND OTHER OBJECTIONABLE MATERIAL FROM THE FOUNDATION AREA.
3. GRADE FOUNDATION AND CROWN FOR POSITIVE DRAINAGE AWAY FROM PUBLIC ROAD IF POSSIBLE. IF THE SLOPE OF THE CONSTRUCTION ENTRANCE IS TOWARD A PUBLIC ROAD AND EXCEEDS TWO PERCENT, CONSTRUCT AN EIGHT INCH HIGH DIVERSION RIDGE WITH A RATIO OF 3–TO–1 SIDE SLOPES ACROSS THE FOUNDATION AREA ABOUT 15 FEET FROM THE ENTRANCE TO DIVERT RUNOFF AWAY FROM THE ROAD.
4. INSTALL A CULVERT PIPE UNDER THE PAD IF NEEDED TO MAINTAIN PROPER PUBLIC ROAD DRAINAGE.
5. PLACE AGGREGATE TO THE DIMENSIONS AND GRADE SHOWN IN THE CONSTRUCTION PLANS, LEAVING THE SURFACE SMOOTH AND SLOPED FOR DRAINAGE.
6. DIVERT ALL STORM WATER RUNOFF AND DRAINAGE FROM THE INGRESS,/EGRESS PAD TO A SEDIMENT TRAP OR BASIN.
7. INSPECT DAILY.
8. RESHAPE PAD AS NEEDED FOR DRAINAGE AND RUNOFF CONTROL.
9. TOP DRESS WITH CLEAN AGGREGATE AS NEEDED.
10. IMMEDIATELY REMOVE MUD AND SEDIMENT TRACKED OR WASHED ONTO PUBLIC ROADS.
11. FLUSHING SHOULD ONLY BE USED IF THE WATER CAN BE CONVEYED INTO A SEDIMENT TRAP OR BASIN.

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - CONSTRUCTION ENTRANCE AND TRACKING PAD DETAIL

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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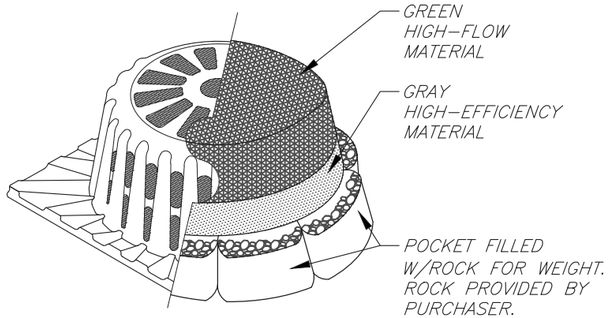
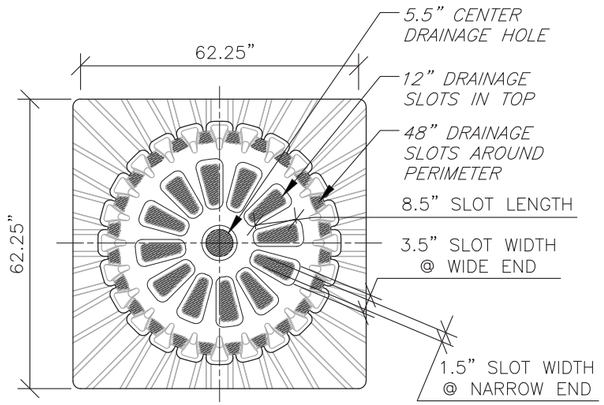
GPF No. **5315**

Sheet No. 12 of 32 T07

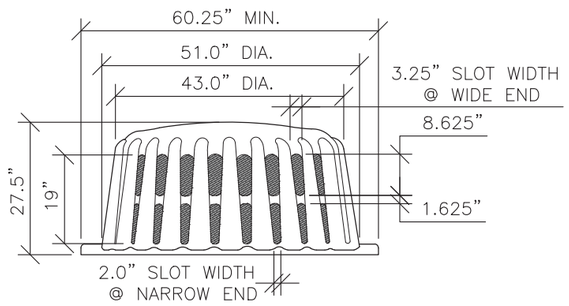


ISOMETRIC VIEW

SHOWN WITH ROADWAY PROJECTS FILTER HAT



PLAN VIEW



ELEVATION VIEW

Model #S–200A
REPLACEMENT FILTERS: MODEL #S–240

FILTER OPTIONS

FILTER HAT IS AVAILABLE IN THREE OPTIONS:
1) ALL HIGH–FLOW MATERIAL
2) ALL HIGH–EFFICIENCY MATERIAL
3) HIGH–FLOW MATERIAL ON TOP HALF OF HAT, HIGH–EFFICIENCY MATERIAL ON BOTTOM HALF (THIS FILTER COVER IS RECOMMENDED FOR ALL ROADWAY PROJECTS.)

IT IS THE PURCHASERS RESPONSIBILITY TO PURCHASE APPROPRIATE FILTER HAT. PURCHASER SHALL PROVIDE ROCK FOR FILTER POCKETS.

FILTER HAT INSTALLATION

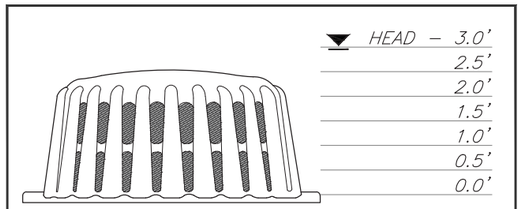
FILTER HAT SLIDES DIRECTLY OVER FILTER FRAME. TO KEEP FILTER FRAME IN PLACE OVER STORM STRUCTURE, ROCK POCKETS ARE SEWN DIRECTLY INTO FILTER HAT MATERIAL. EVERY FILTER HAT COMES IN ONE PIECE FOR EASY INSTALLATION.

MAINTENANCE

ALL TEMPORARY EROSION, SEDIMENTATION, & POLLUTION CONTROL PRACTICES SHOULD BE INSPECTED DAILY. CONTRACTOR SHALL REMOVE SEDIMENT AND DISPOSE OF IN A PROPER MANNER. INSPECT S–200A DAILY FOR CUTS, ABRASIONS, AND PROPER INSTALLATION. REPLACE OR REPOSITION AS NECESSARY.

SPECIFICATIONS

FILTER FABRIC SILT–SAVER HAT SHALL BE BASED ON DESIGN PROFESSIONAL'S SPECIFICATIONS.



FRAME & FILTER DISCHARGE ANALYSIS

HEAD (FT)	EQUATION USED	OPENING AREA (SF)	FRAME FLOW (CFS)	FILTER AREA (SF)	FILTERED FLOW (CFS)
0.5	O	2.1	7	6	2
1.0	O	3.9	19	12	3
1.5	O	7.0	41	18	5
2.0	O	8.0	54	24	7
2.5	O	9.2	70	30	9
3.0	O	9.2	77	—	77

DUE TO NARROW SLOT, A TRANSITION WILL OCCUR BETWEEN WEIR AND ORIFICE CONDITIONS. ORIFICE FLOW WILL PROVIDE A MORE CONSERVATIVE ESTIMATE OF FLOW, THEREFORE THE LESSER OF THE ORIFICE AND WEIR FLOWS WILL BE USED FOR EACH STAGE CALCULATION.

FILTER MATERIAL ALLOWS 129 gpm/SF OR 0.29cfs/SF
ORIFICE EQUATION (O) = Q=0.6A(2gh)^0.5
P = FEET PERIMETER
h = HEAD IN FEET
Q = CAPACITY IN cfs
A = FREE OPEN AREA OF FRAME
g = 32.2 FEET-PER-SECOND/SECOND

FRAME MATERIAL: BLACK 0.25" HMWPE

FILTER FABRIC MATERIAL: REFER TO SPEC

SCALE: NOT TO SCALE

55 SQUARE FRAME & FILTER ASSEMBLY
NO SCALE

1 / T08

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - STORM WATER INLET PROTECTION DETAIL

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

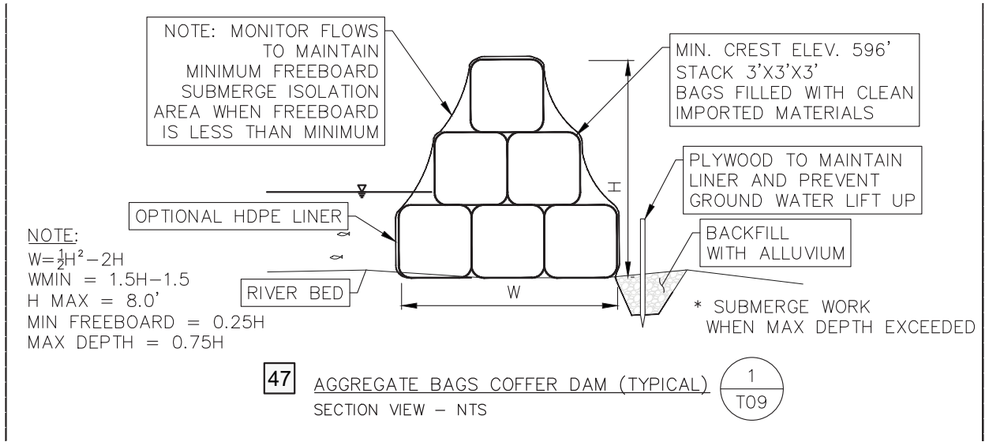
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

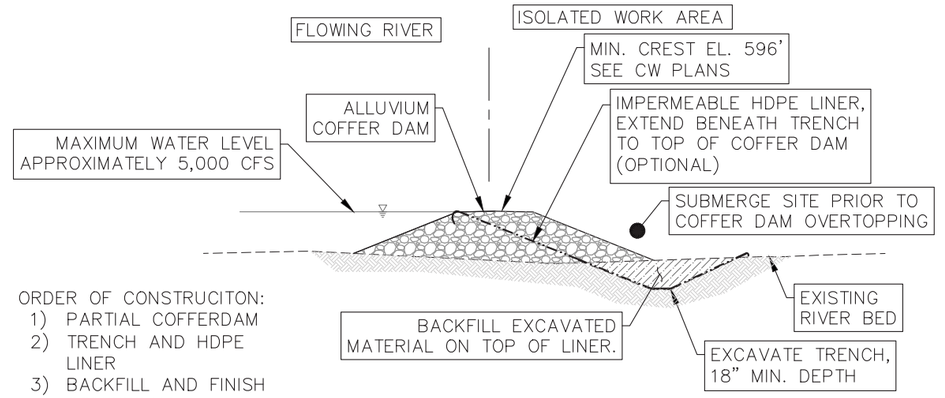
GPF No. 5315

Sheet No. 13 of 32 T08



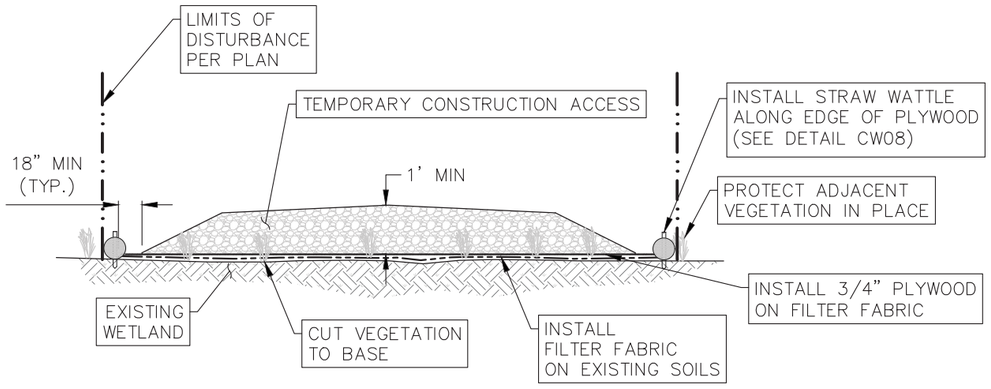
47 AGGREGATE BAGS COFFER DAM (TYPICAL) — 1 / T09

SECTION VIEW – NTS



47 ALLUVIUM COFFER DAM WITH LINER (TYPICAL) — 2 / T09

SECTION VIEW – NTS



TEMPORARY WETLAND PROTECTION — 3 / T09

NTS

LEGEND: 47 MICHIGAN UNIFIED KEYING SYSTEM – SOIL EROSION & SEDIMENTATION CONTROL MEASURES – SEE SHEET CW00

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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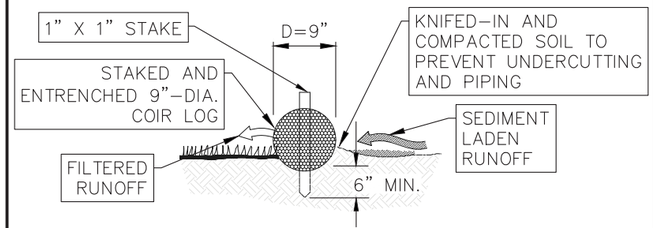
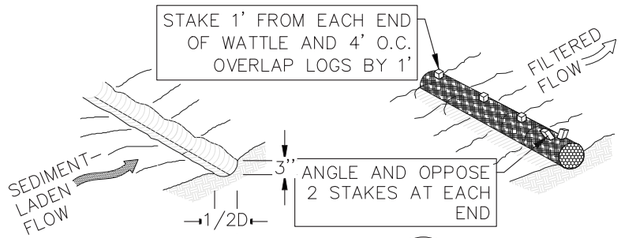
	5315	14 of 32 T09



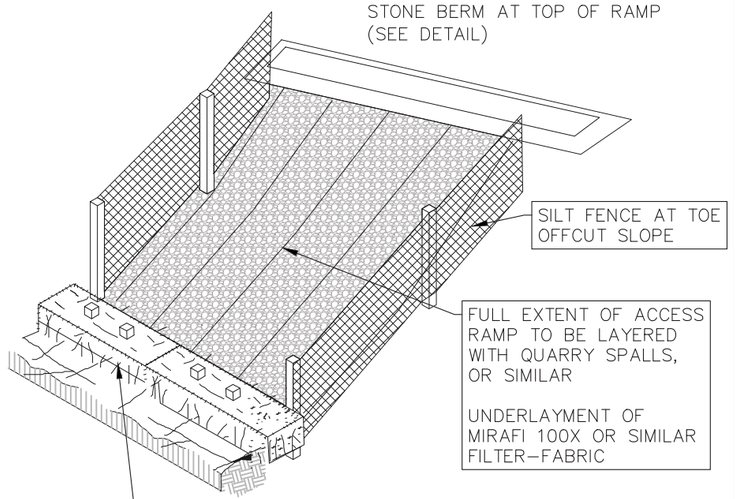
PROPERLY INSTALLED COIR LOG
(CROSS-SECTION)

INSTALLATION STEPS:
1. EXCAVATE THE TRENCH
2. PLACE AND STAKE STRAW WATTLES
3. PLACE SPOILS UP-SLOPE FROM LOG, KNIFE-IN AND COMPACT



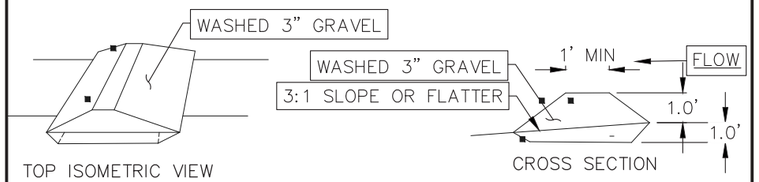
COIR LOG (TYPICAL)
NTS

1
T10



TEMPORARY EQUIPMENT ACCESS (TYPICAL)
NTS

2
T10

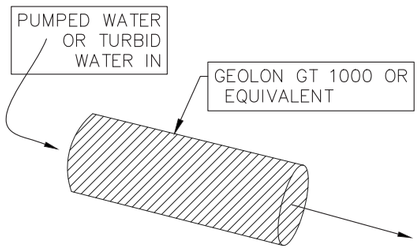


TOP ISOMETRIC VIEW

CROSS SECTION

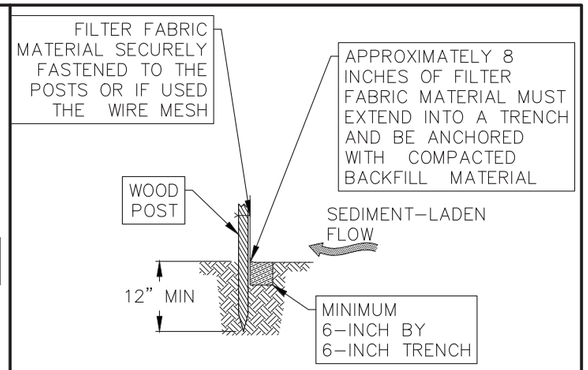
21 STONE BERM
NTS

3
T10

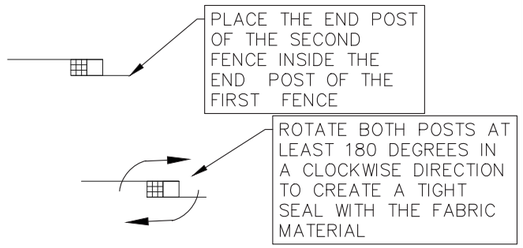


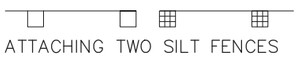
GEO-TUBEFILTER (TYPICAL)
NTS

5
T10

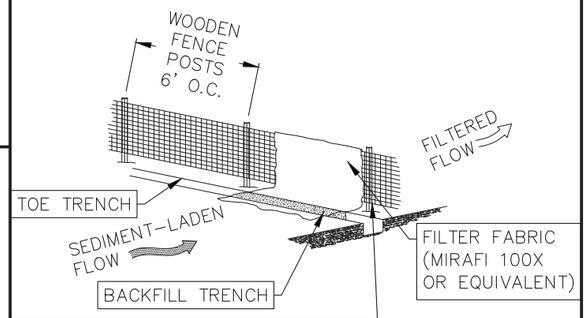


TOE TRENCH
(CROSS SECTION)





ATTACHING TWO SILT FENCES



21A SILT FENCE (TYPICAL)
NTS

6
T10

LEGEND:

47 MICHIGAN UNIFIED KEYING SYSTEM – SOIL EROSION & SEDIMENTATION CONTROL MEASURES – SEE SHEET CW00

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - DETAILS

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

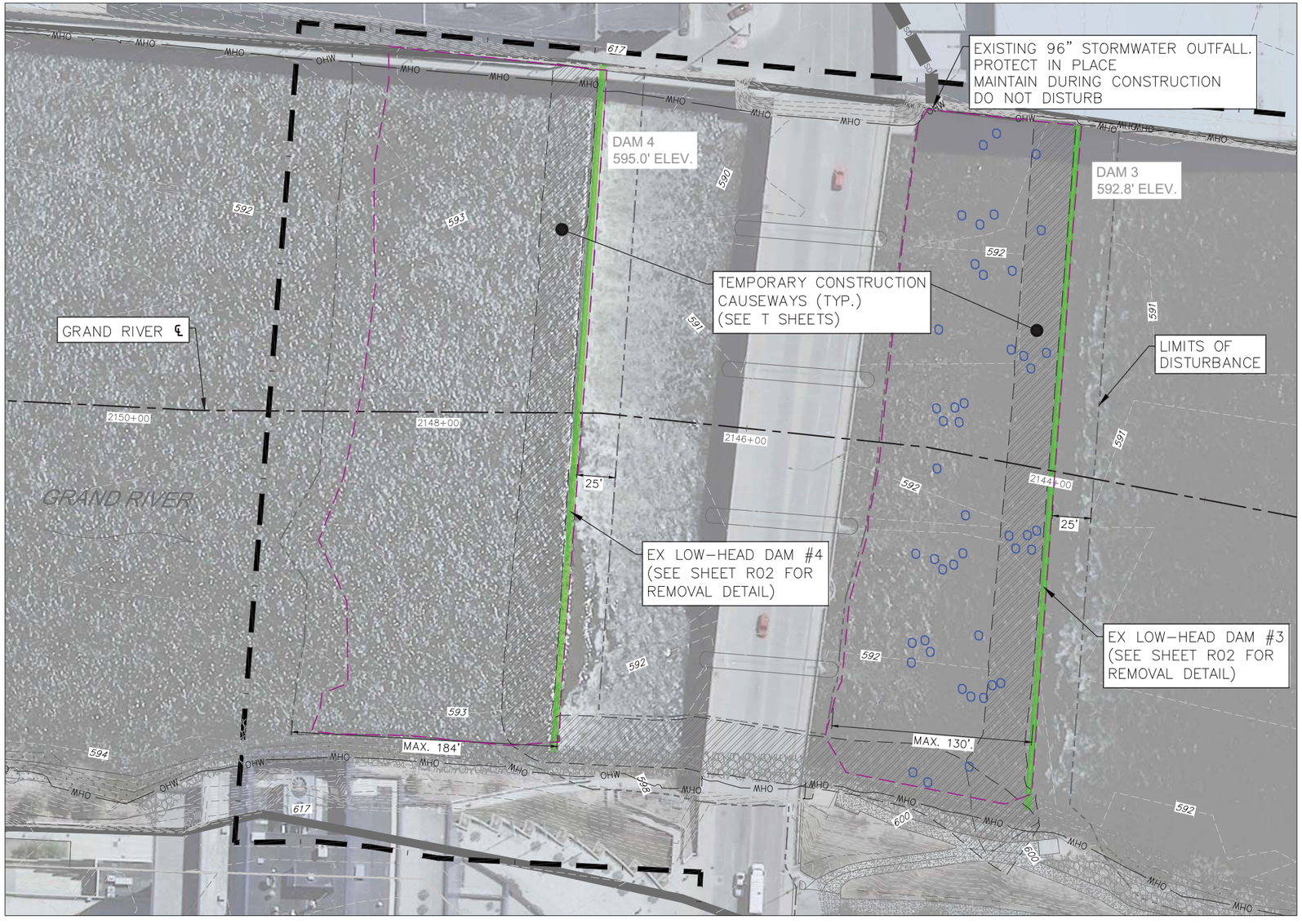
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 15 of 32 T10



LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

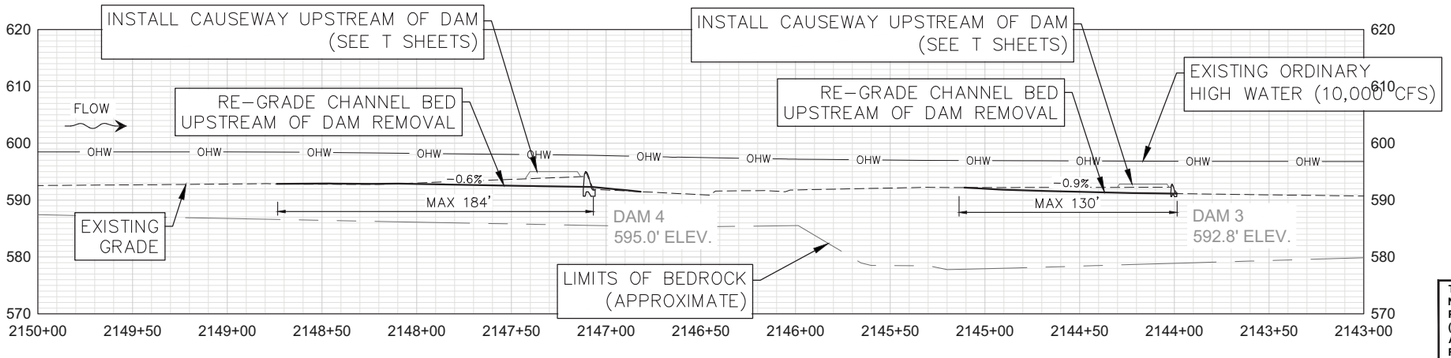
NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

SEE SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED

NORTH

0 40' 80'

SCALE: 1" = 40'



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REVISIONS

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DAMS 3 AND 4
REACH

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Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

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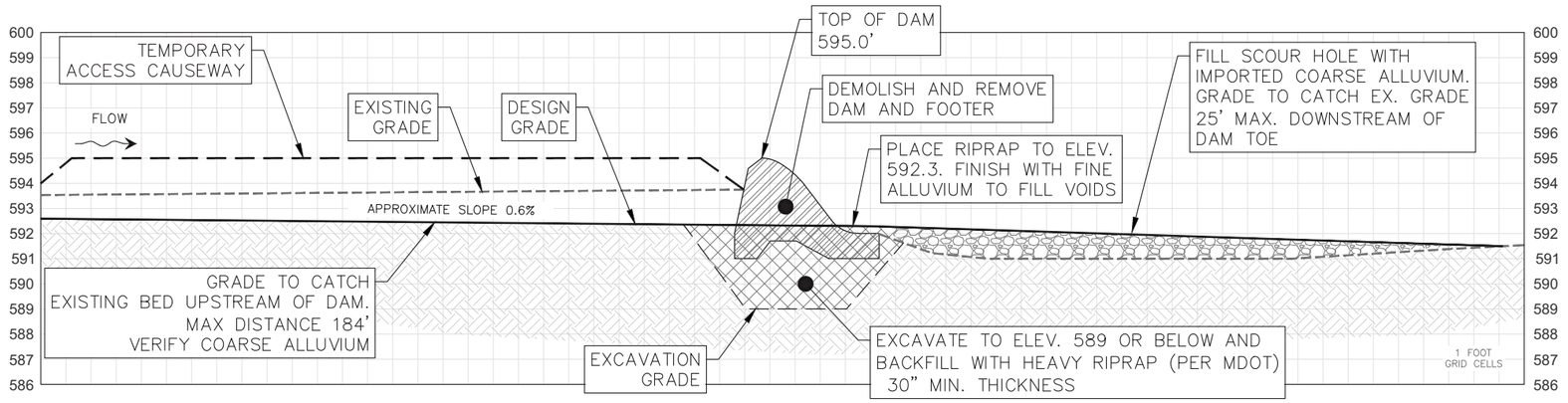
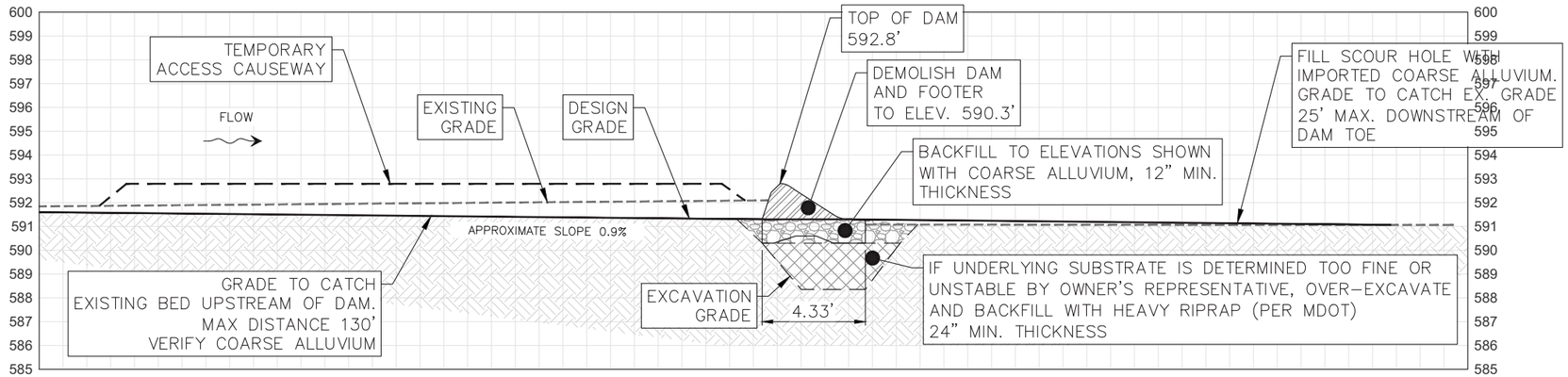
Sheet No. 16 of 32 R01



1 / R02 DEMOLITION AND REMOVAL OF DAM 4



2 / R02 LOW-HEAD DAM 3 DEMOLITION

NOTE:

VERIFY PRESENCE OF COARSE ALLUVIUM GRADATION OR LARGER AT EXCAVATION GRADE BENEATH HEAVY RIPRAP. IF UNSUITABLE, NOTIFY OWNERS REPRESENTATIVE. IF DETERMINED NECESSARY, OVER-EXCAVATE 12 INCHES MINIMUM AND BACKFILL WITH COARSE ALLUVIUM TO EXCAVATION GRADE.

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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DAMS 3 AND 4 REMOVAL DETAIL

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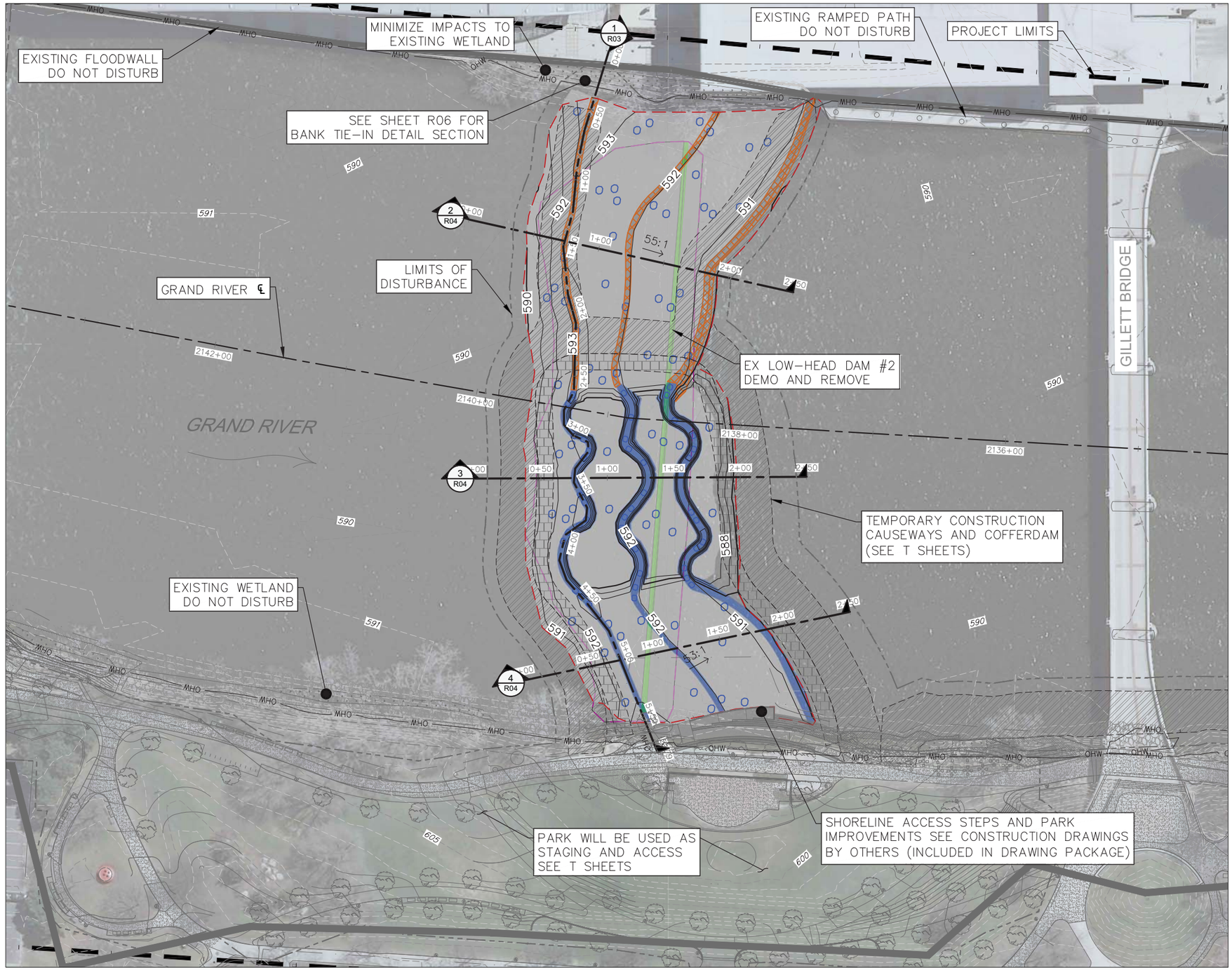
Sheet No. 17 of 32 R02



LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

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NORTH

0 40' 80'

SCALE: 1" = 40'

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REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH

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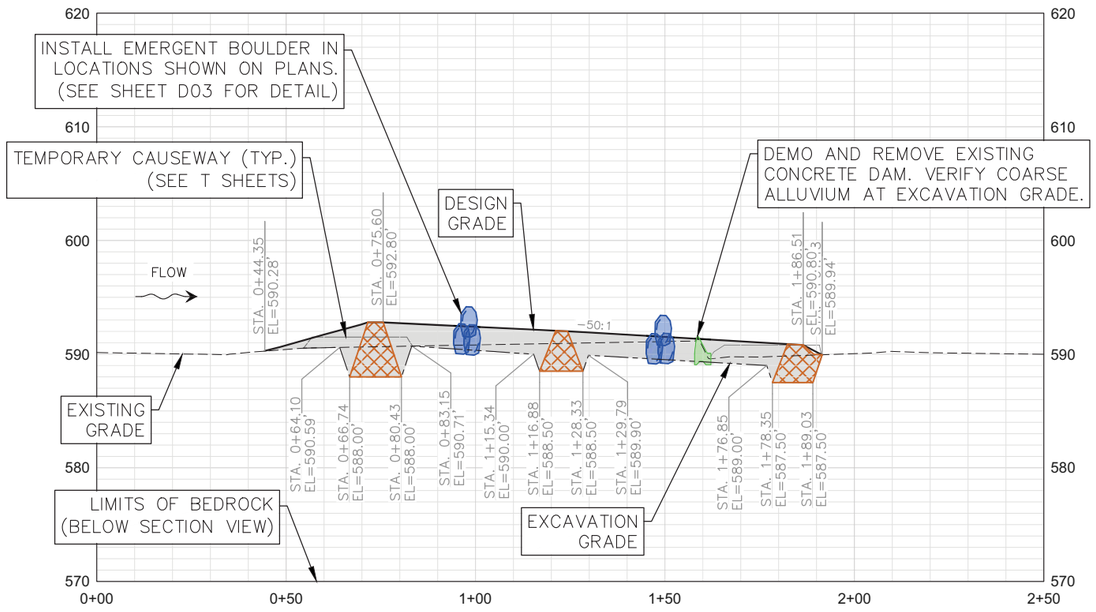
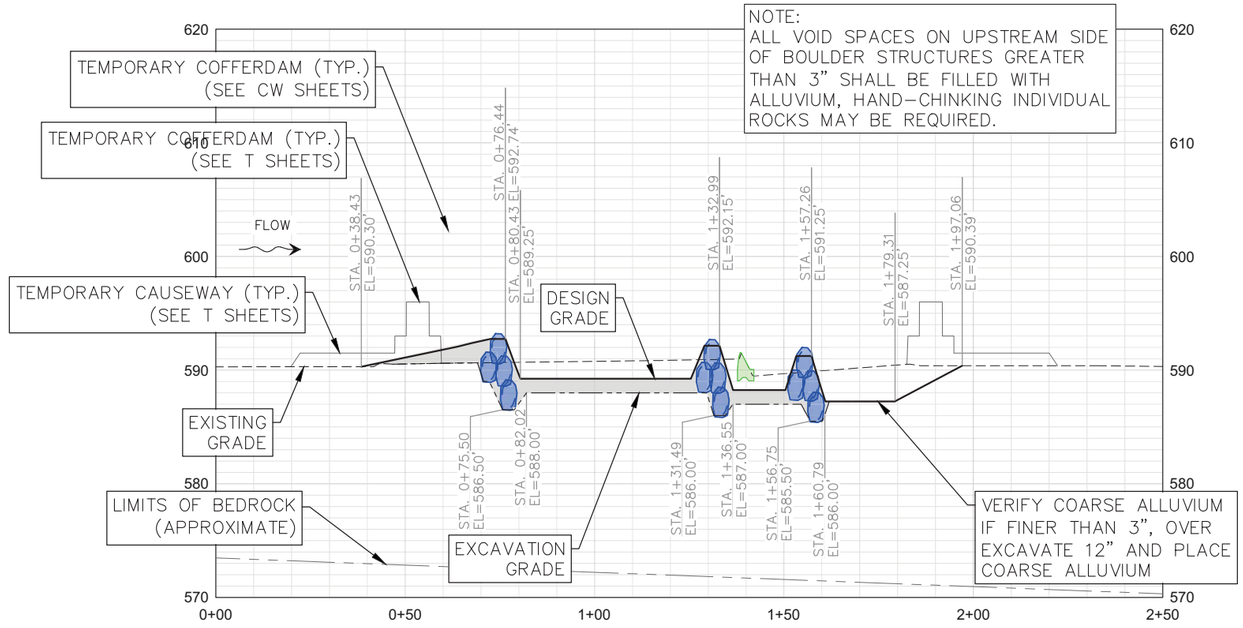
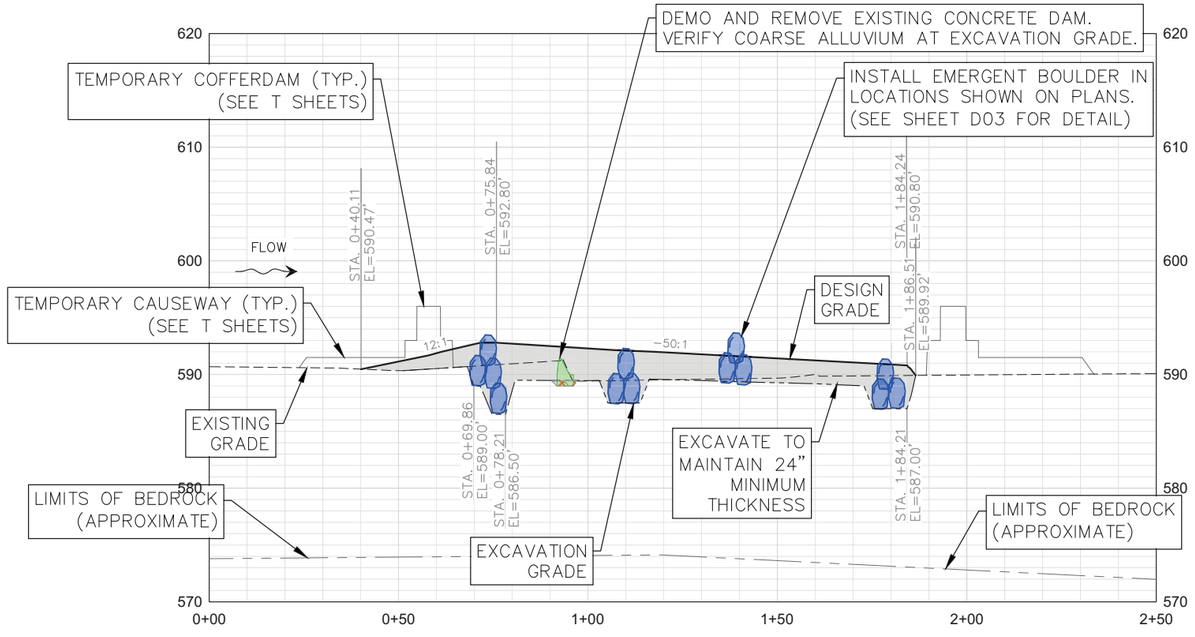
Sheet No. 18 of 32 R03



2 R04 DESIGN PROFILE
CONSTRUCTED RIFFLE – EAST



3 R04 DESIGN PROFILE
DIVERSIFIED BOULDER DROP STRUCTURES



4 R04 DESIGN PROFILE
CONSTRUCTED RIFFLE – WEST

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 2 REACH PROFILES

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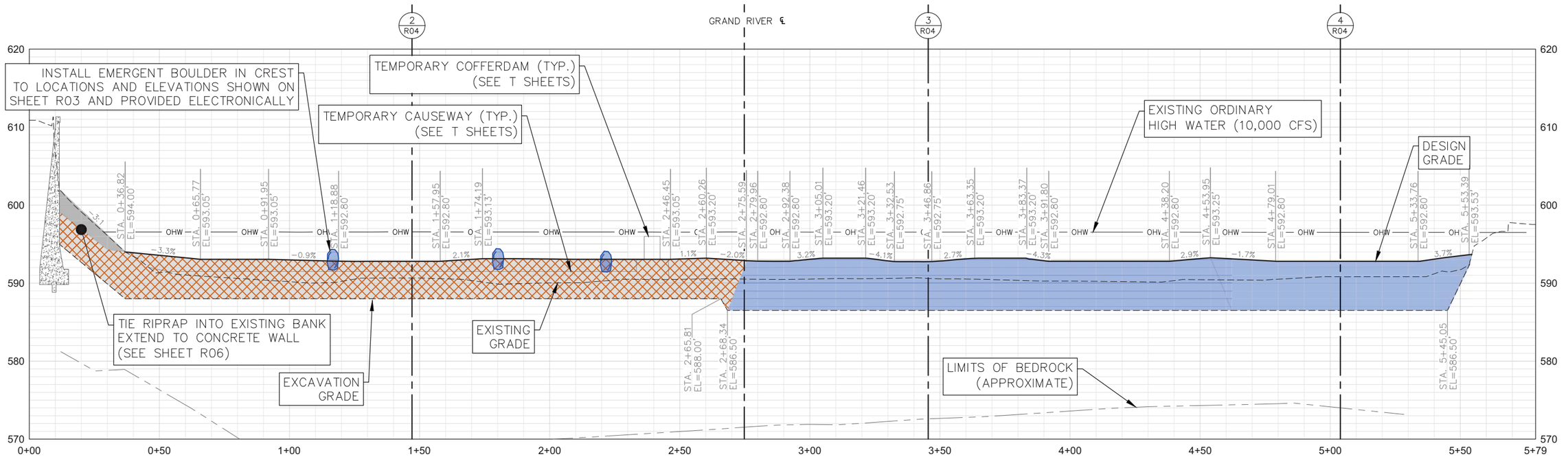
Sheet No. 20 of 32 R05



1 R03 DESIGN SECTION
CREST INVERT

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- BOULDER (PLAN) SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

DAM 2 REACH CROSS SECTION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

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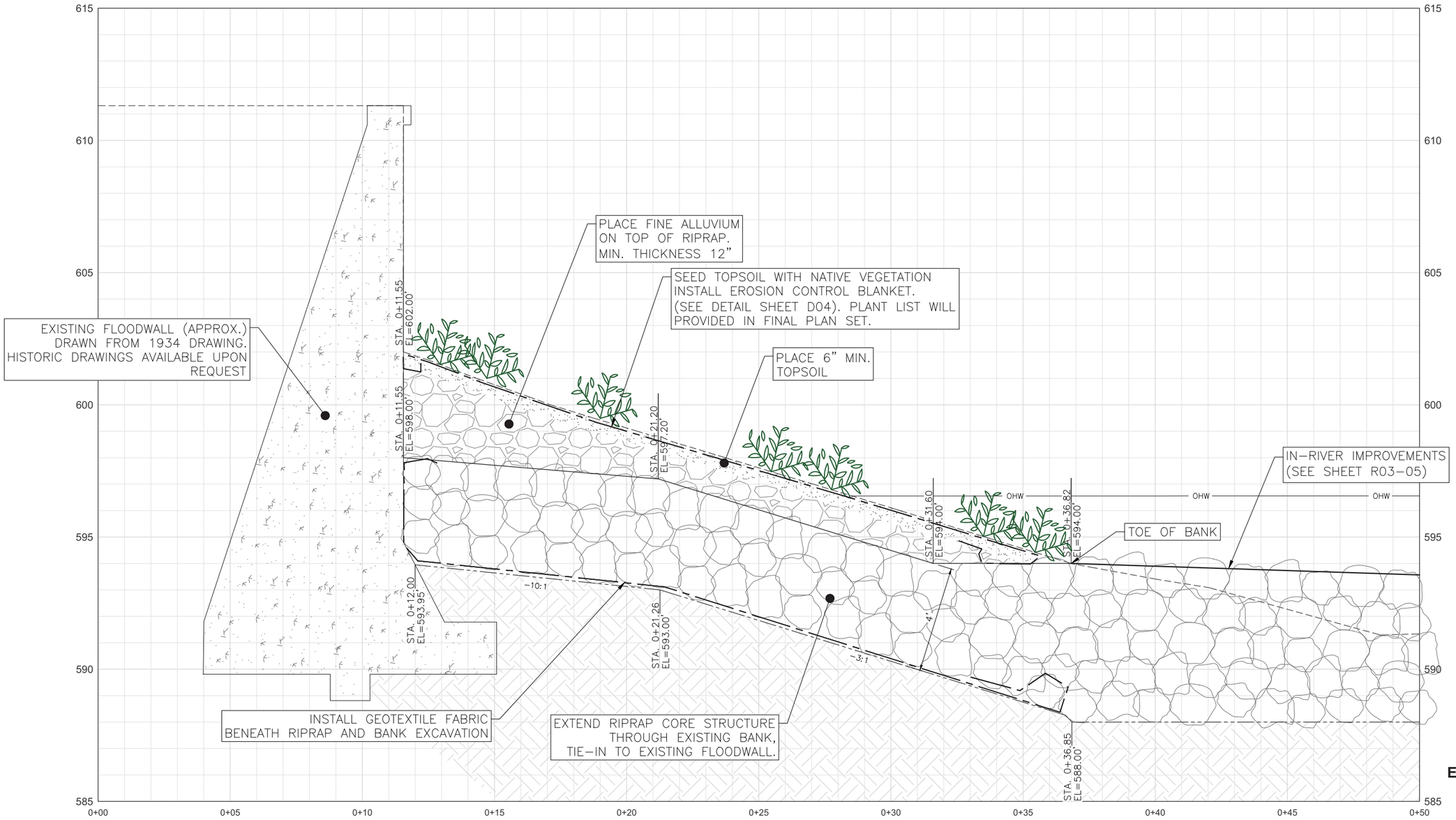
GPF No. 5315

Sheet No. 19 of 32
R04



1 R06 EAST TIE-IN DETAIL SECTION

DAM 2 REACH
EAST TIE-IN DETAIL SECTION

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

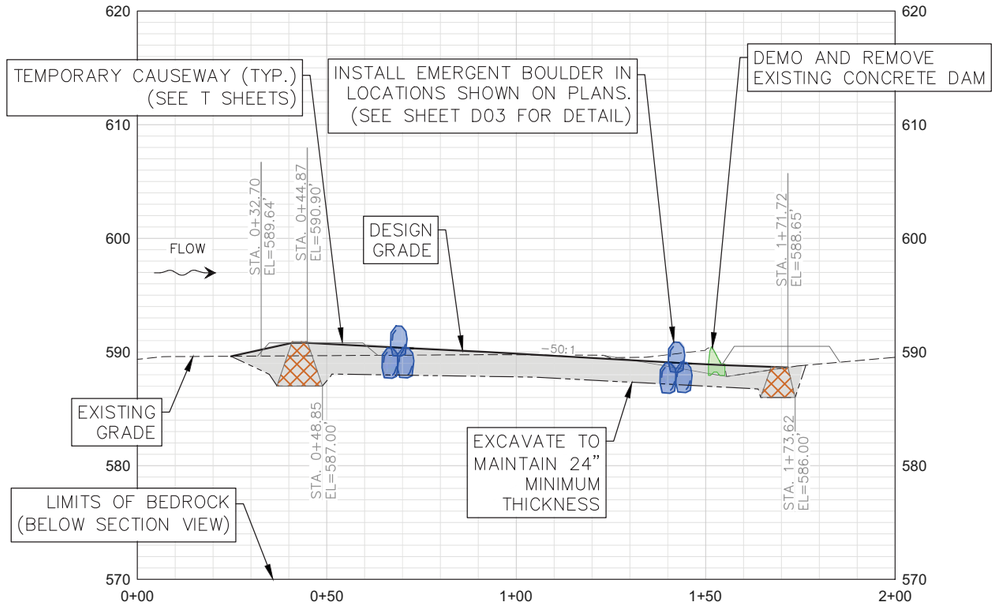
IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

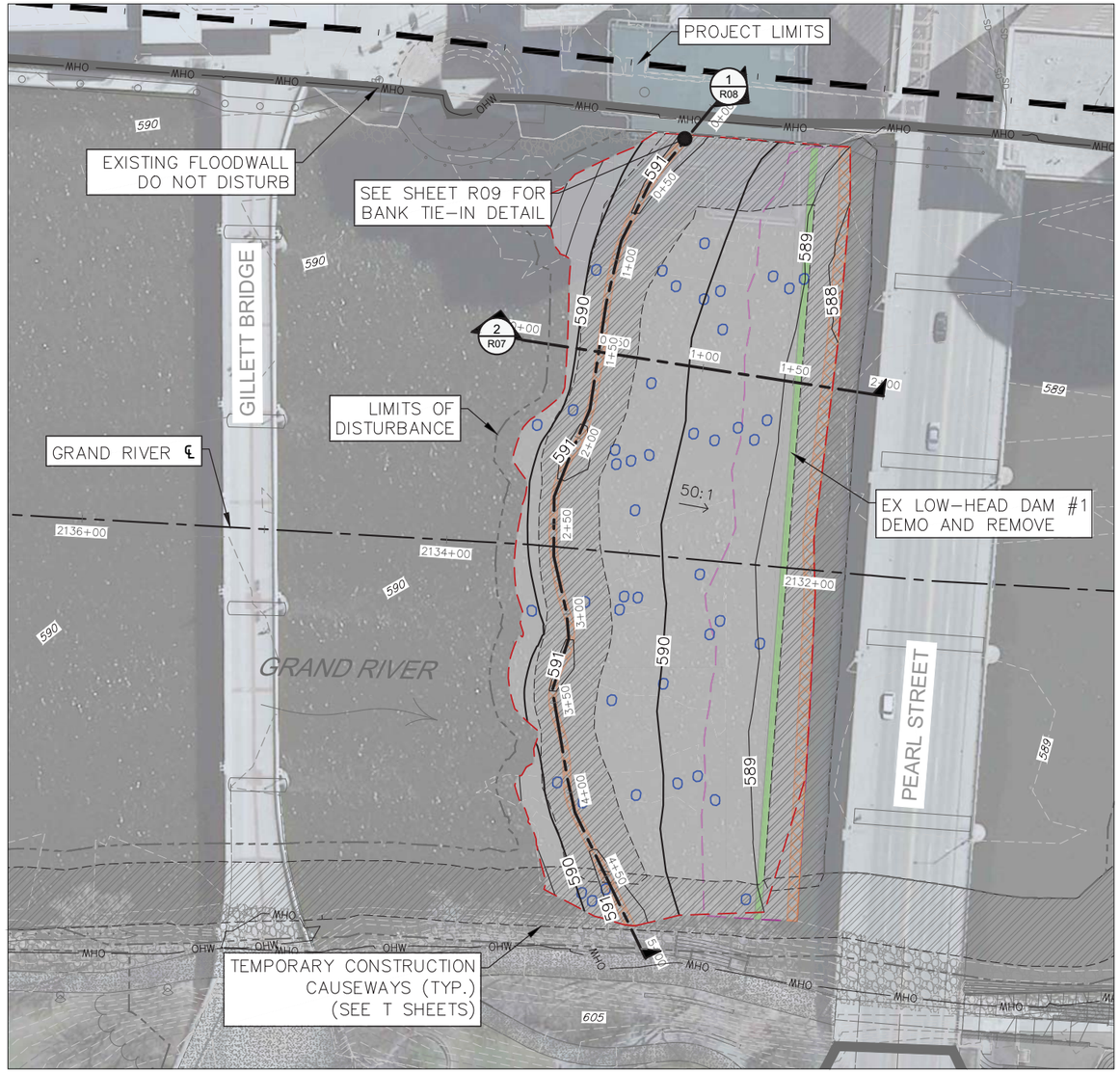
(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by	GPF No.	Sheet No.
Check: Field	5315	21 of 32
Check: Office		R06



2 R07 DESIGN PROFILE
CONSTRUCTED RIFFLE

0 20' 40'
SCALE: 1" = 20'



NORTH
0 40' 80'
SCALE: 1" = 40'

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

SEE SHEET D01 FOR HABITAT BOULDER INSTALLATION DETAILS. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 1 REACH

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GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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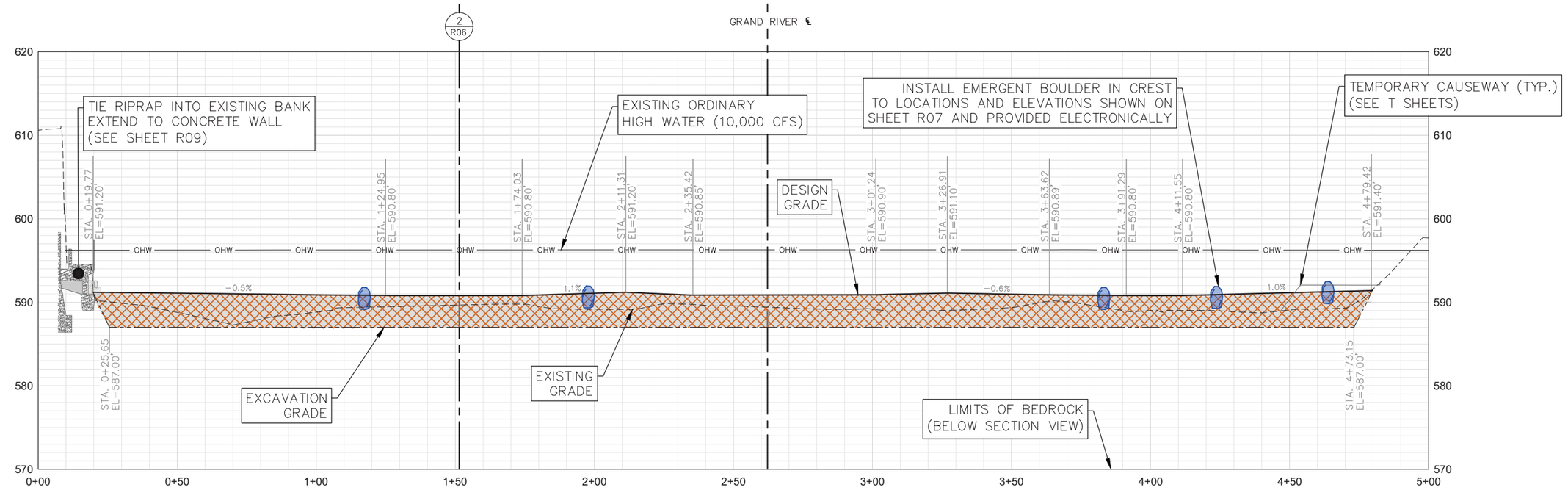
GPF No. 5315

Sheet No. 22 of 32 R07



1 R07 DESIGN SECTION
CREST INVERT

0 20' 40'
SCALE: 1" = 20'

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- EMERGENT HABITAT BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 1 REACH
CROSS SECTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
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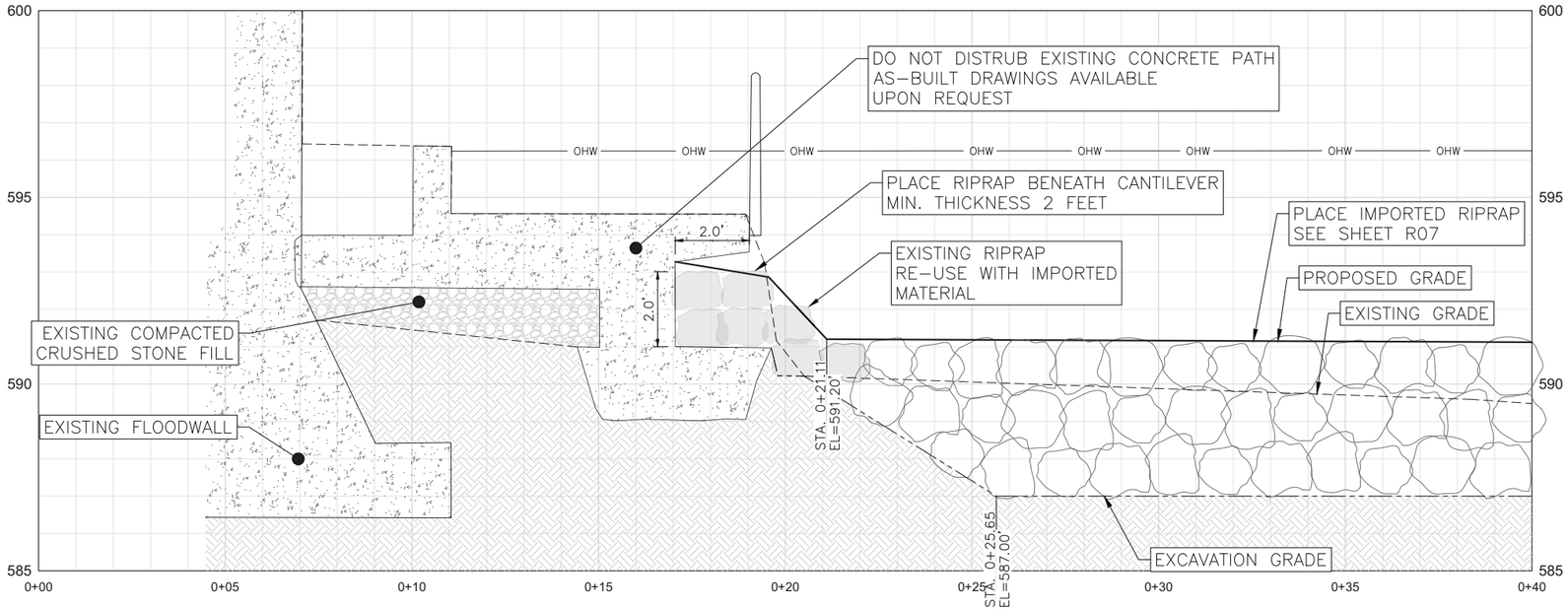
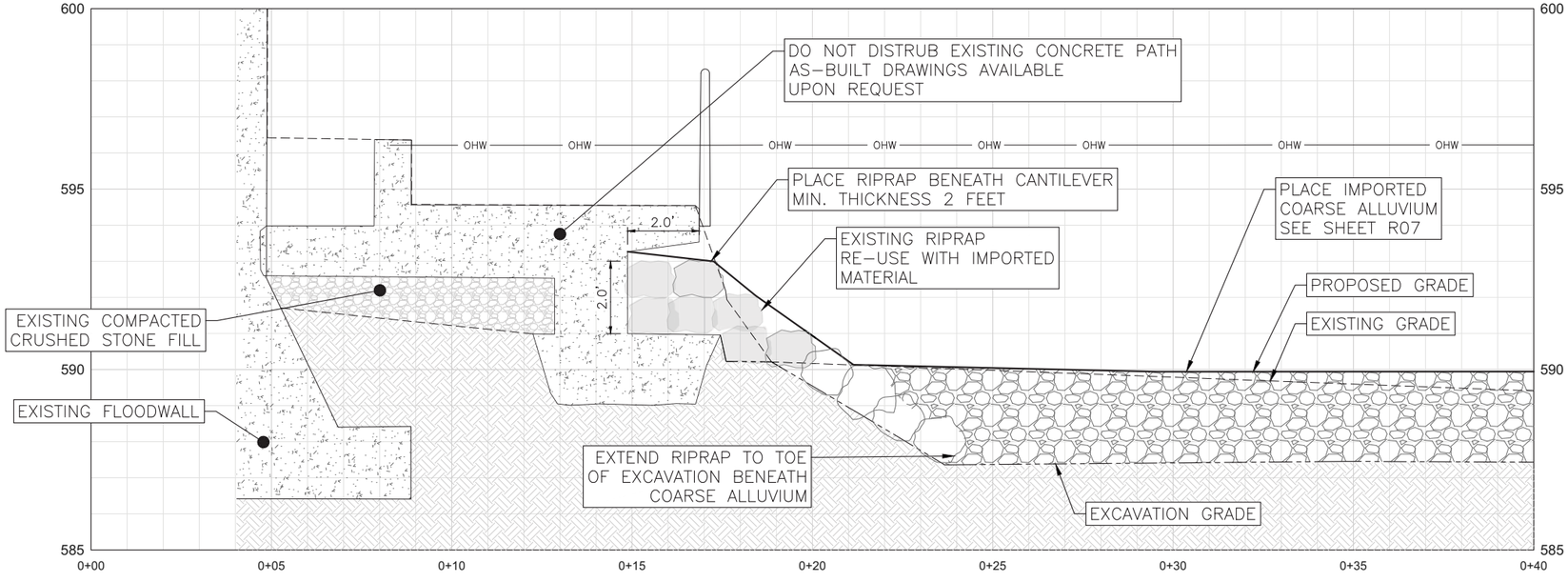
GPF No. 5315

Sheet No. 23 of 32
R08



1 / R09 EAST BANK TIE-IN, RIPRAP SUBSTRUCTURE CREST GRADE



2 / R09 EAST BANK TIE-IN, ALLUVIUM RIFFLE GRADE

0 2' 4'
SCALE: 1" = 2'

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DAM 1 REACH
TIE-IN SECTIONS

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 24 of 32 R09

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (STABLE IMPORTED ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
- TEMPORARY CONSTRUCTION ACTIVITIES (SEE T SHEETS)

NOTE:
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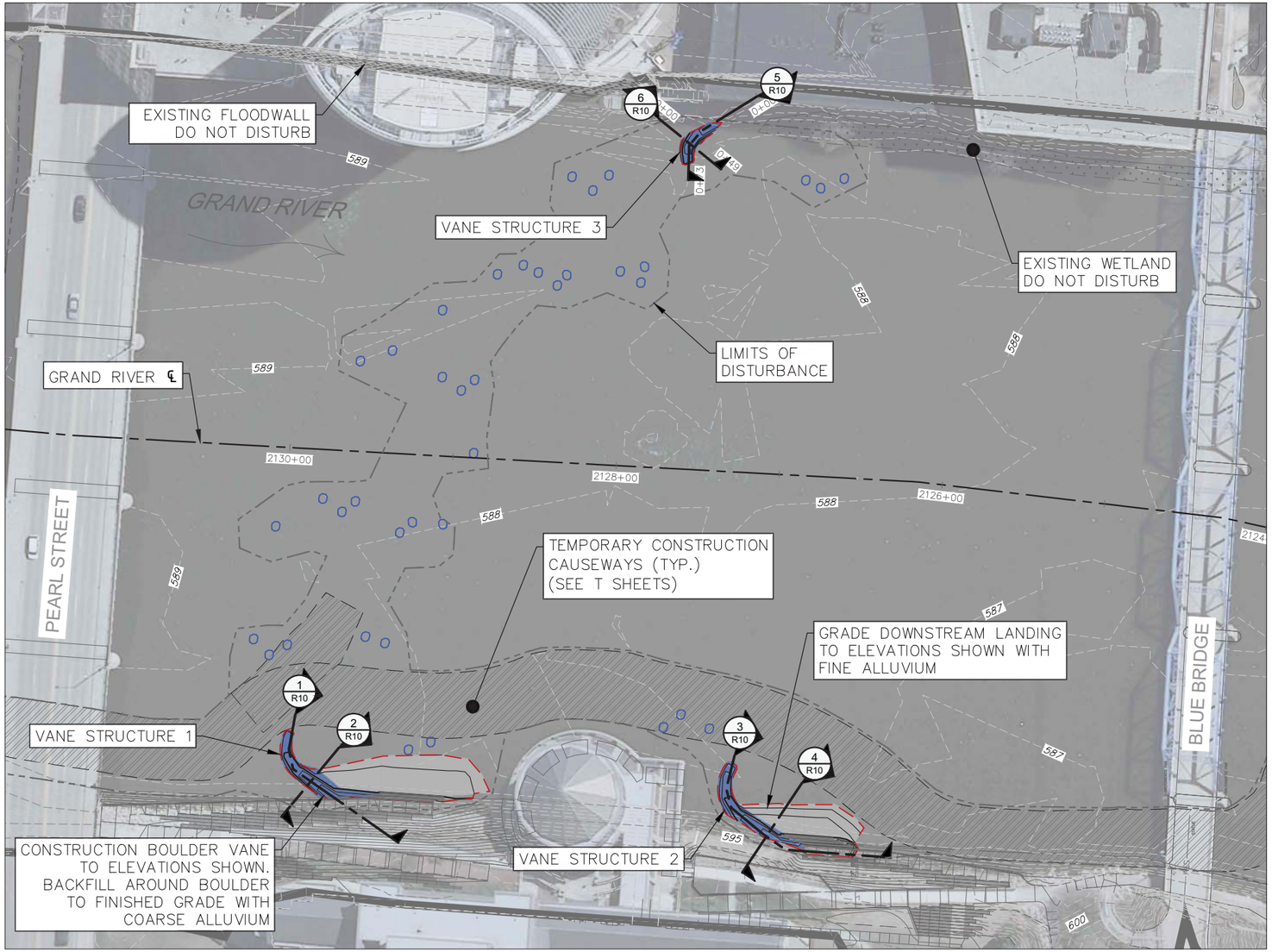

NORTH

0 60' 120'

SCALE: 1" = 60'

PEARL ST. TO BLUE BRIDGE REACH

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
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REVISIONS

NO.	DATE	DESCRIPTION

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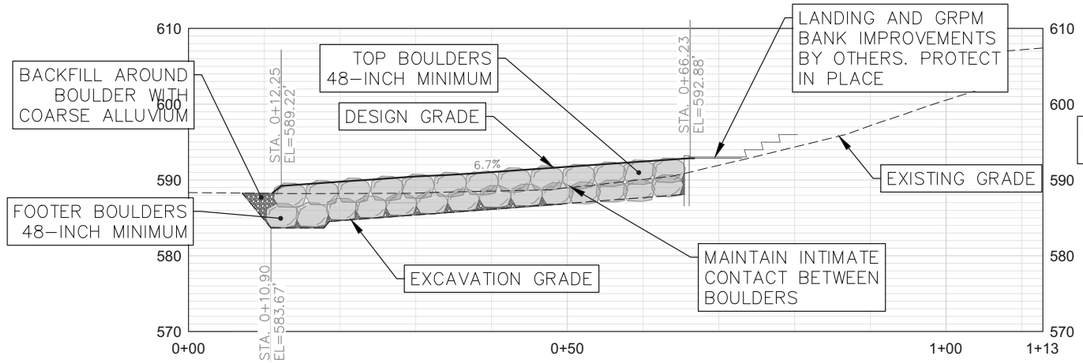
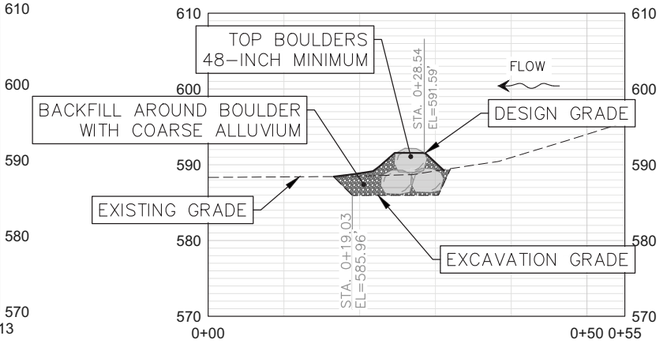
GPF No. 5315

Sheet No. 25 of 32 R10

VANE STRUCTURE 1



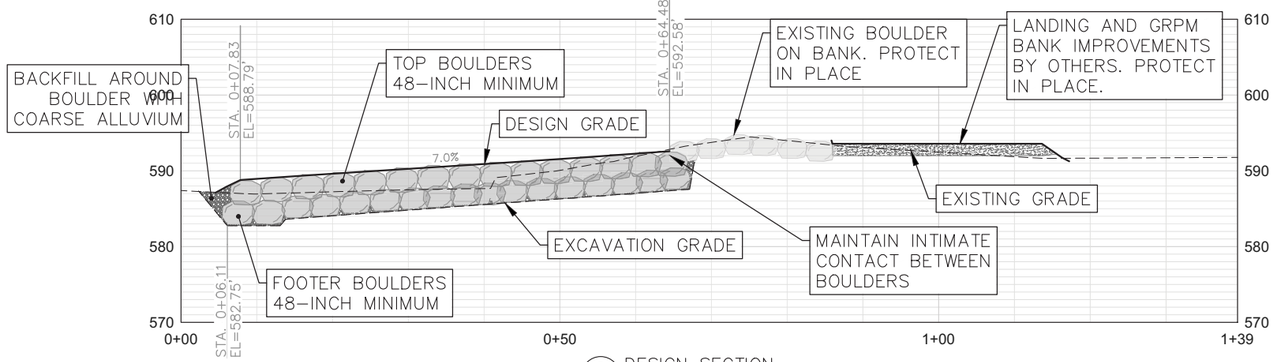
1 R10 DESIGN SECTION
VANE STRUCTURE 1



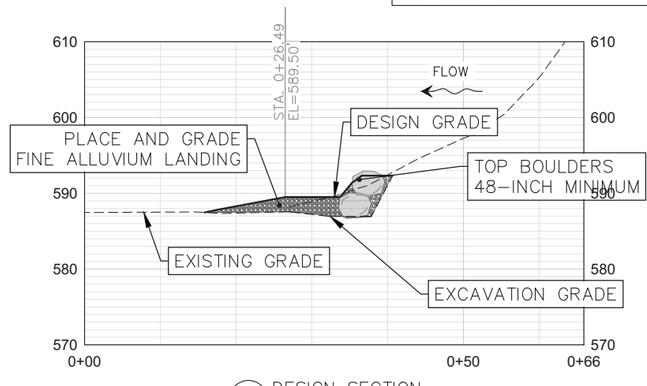
2 R10 DESIGN SECTION
VANE STRUCTURE 1

NOTE:
ALL VOID SPACES ON UPSTREAM SIDE OF BOULDER STRUCTURES GREATER THAN 3" SHALL BE FILLED WITH ALLUVIUM, HAND–CHINKING INDIVIDUAL ROCKS MAY BE REQUIRED.

VANE STRUCTURE 2

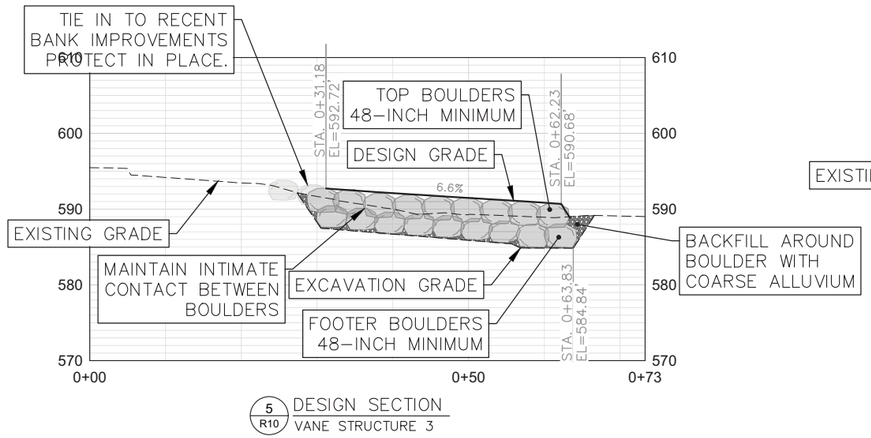


3 R10 DESIGN SECTION
VANE STRUCTURE 2

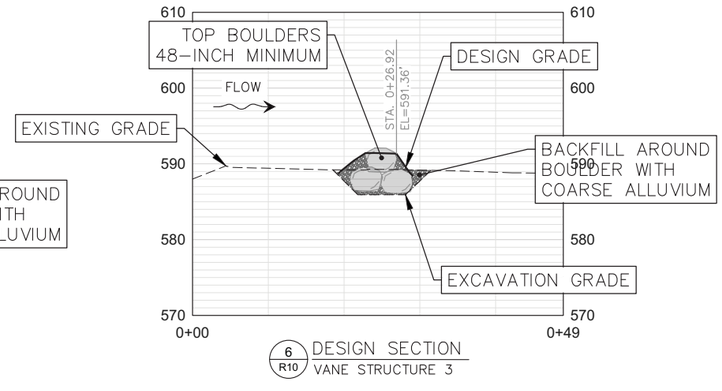


4 R10 DESIGN SECTION
VANE STRUCTURE 2

VANE STRUCTURE 3



5 R10 DESIGN SECTION
VANE STRUCTURE 3



6 R10 DESIGN SECTION
VANE STRUCTURE 3

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REVISIONS

NO.	DATE	DESCRIPTION

PEARL ST. TO BLUE BRIDGE CROSS SECTIONS

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
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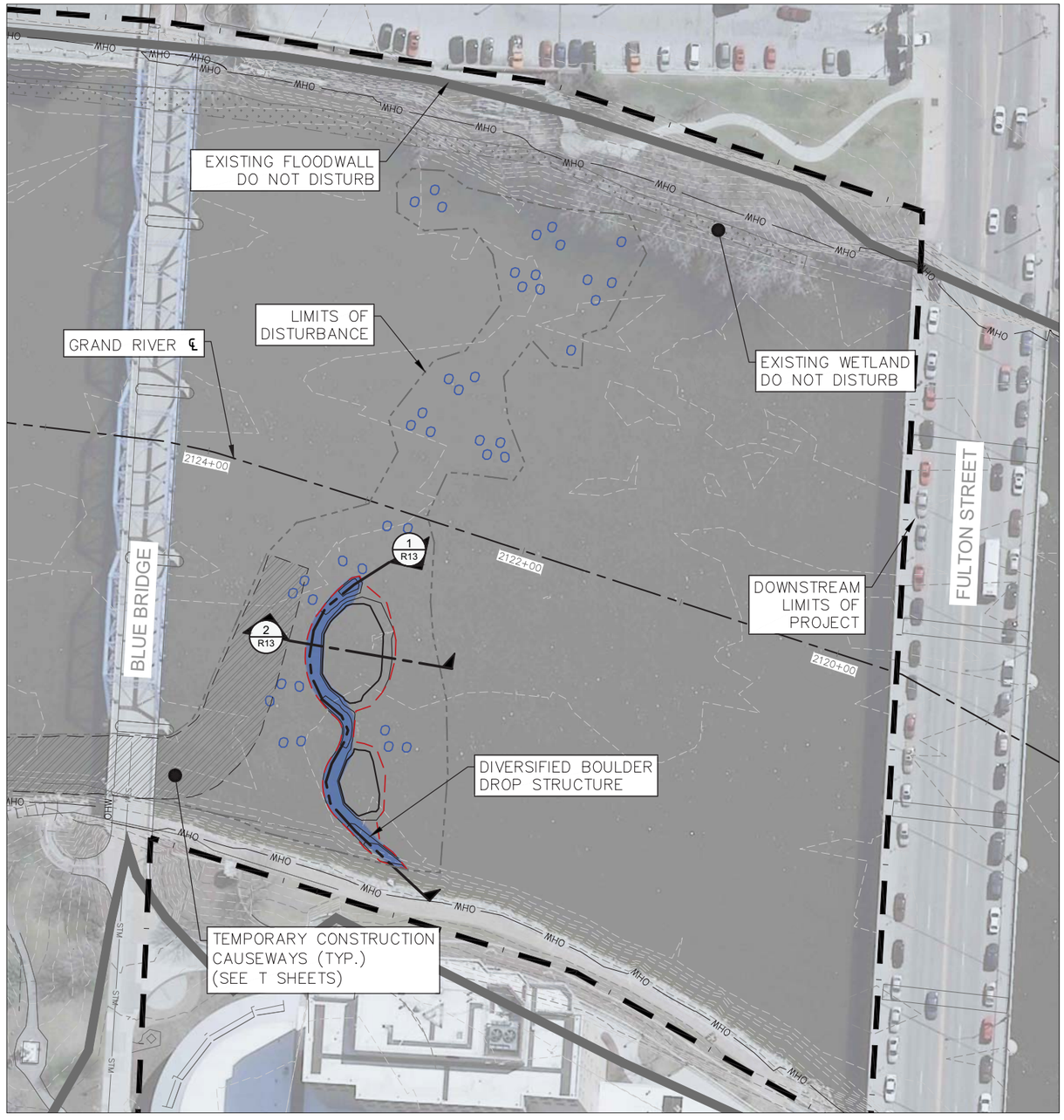
GPF No. 5315

Sheet No. 26 of 32 R11



NORTH

0 60' 120'

SCALE: 1" = 60'

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER (SECTION AND PROFILE)
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")
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NOTE:
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REVISIONS

NO.	DATE	DESCRIPTION

BLUE BRIDGE TO FULTON ST. REACH

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Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

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(GRAND RIVER REVITALIZATION PROJECT)
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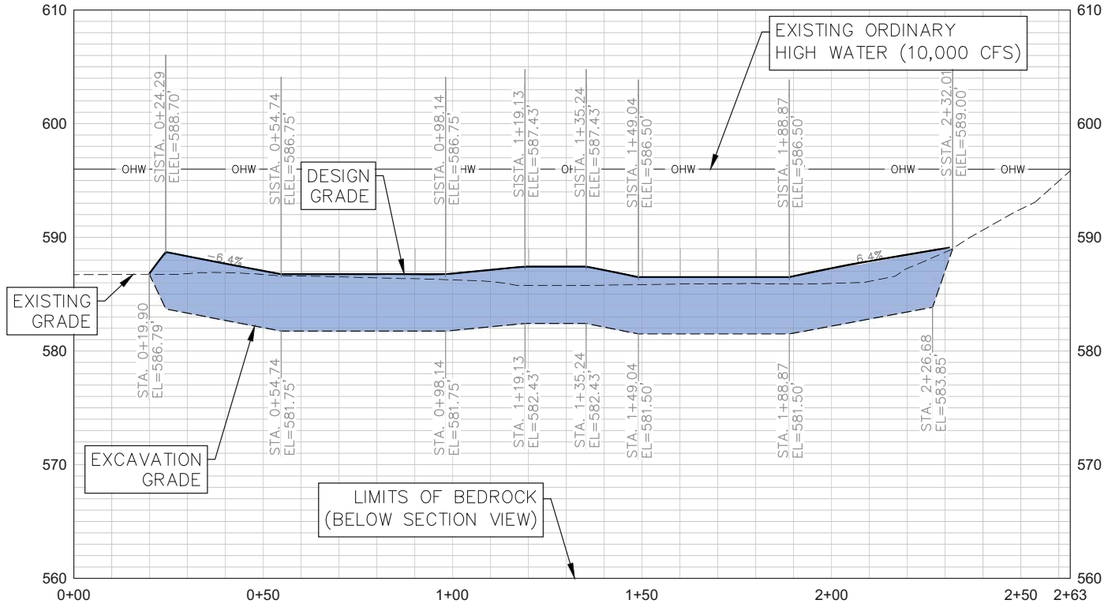
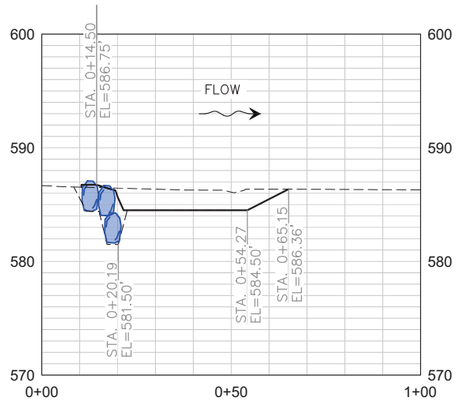
GPF No. 5315

Sheet No. 27 of 32
R12



1/R13 DESIGN SECTION
CREST INVERT

0 20' 40'
SCALE: 1" = 20'
3X VERTICAL EXAGGERATION



2/R13 DESIGN PROFILE
DIVERSIFIED BOULDER DROP STRUCTURE

LEGEND

- EXISTING LOW-HEAD DAM: DEMO AND REMOVE
- DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- EMERGENT HABITAT BOULDER (SECTION AND PROFILE)
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NO.	DATE	DESCRIPTION

BLUE BRIDGE TO FULTON
CROSS SECTIONS

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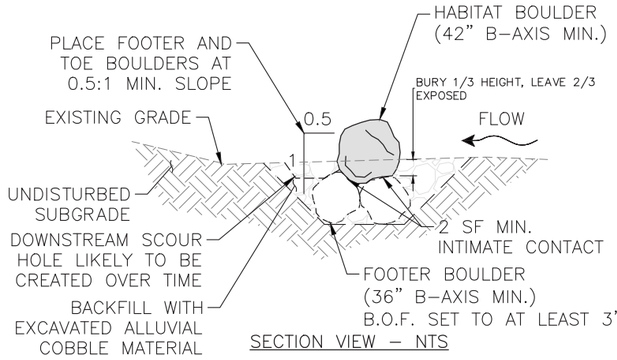
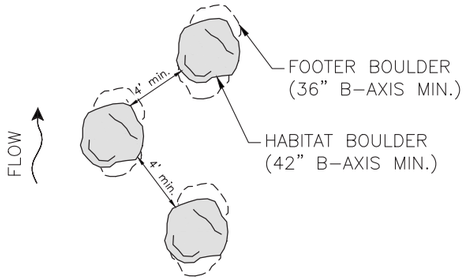
GPF No. **5315**

Sheet No. **28** of 32
R13



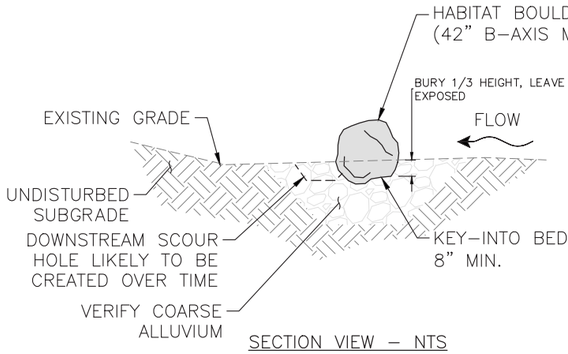
SECTION VIEW – NTS

NOTES:
1. FOOTER BOULDERS SHALL BE INSTALLED AS DIRECTED BY OWNERS REPRESENTATIVE, BASED ON EXISTING SUBSTRATE SIZE AND LEVEL OF ARMORING OBSERVED IN THE FIELD. AT LEAST ONE BOULDER IN EACH CLUSTER SHALL HAVE FOOTER BOULDERS INSTALLED.
2. FOOTER BOULDERS ARE NOT REQUIRED IF BEDROCK IS PRESENT.



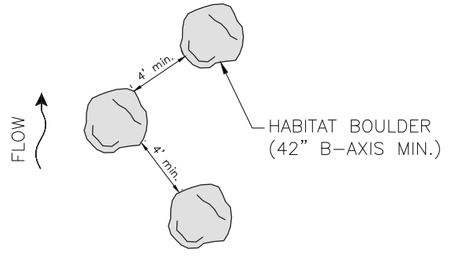
NOTES:
1. SPACE BOULDERS A MIN. OF 4' IN TRIANGLE PATTERN.
2. OFFSET BOULDERS FROM MAIN CURRENT.

1 / D01 HABITAT BOULDER CLUSTER WITH FOOTER (TYP) – LOWEST RISK OF CONTINUED SETTLING
PLAN VIEW – NTS



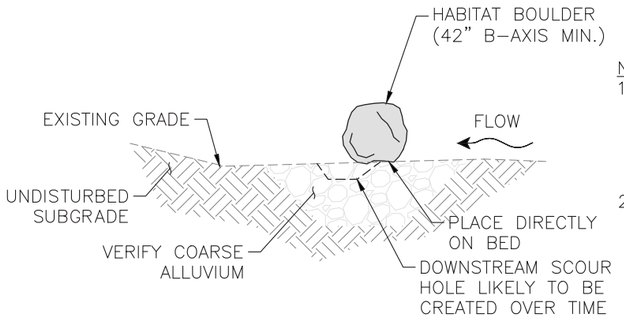
SECTION VIEW – NTS

NOTES:
1. INCREASED LIKELIHOOD FOR BOULDERS TO SHIFT OR SETTLE OVER TIME IF FOOTER BOULDERS ARE OMITTED



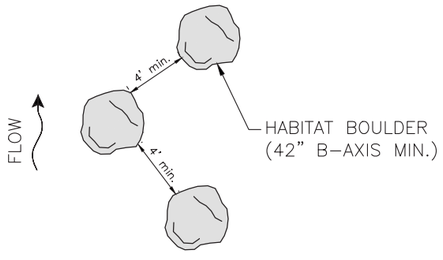
NOTES:
1. SPACE BOULDERS A MIN. OF 4' IN TRIANGLE PATTERN.
2. OFFSET BOULDERS FROM MAIN CURRENT.

2 / D01 HABITAT BOULDER CLUSTER, KEYED IN (TYP) – SOME RISK OF CONTINUED SETTLING
PLAN VIEW – NTS



NOTES:
1. INCREASED LIKELIHOOD FOR BOULDERS TO SHIFT OR SETTLE OVER TIME IF FOOTER BOULDERS ARE OMITTED
2. INCREASED LIKELIHOOD THAT BOULDER WILL EVENTUALLY ROLL INTO SCOUR HOLE CREATED AT TOE IF NOT KEYED INTO EXISTING COARSE ALLUVIAL BED

SECTION VIEW – NTS



NOTES:
1. SPACE BOULDERS A MIN. OF 4' IN TRIANGLE PATTERN.
2. OFFSET BOULDERS FROM MAIN CURRENT.

3 / D01 HABITAT BOULDER CLUSTER, PLACED (TYP) – HIGHEST RISK OF CONTINUED SETTLING
PLAN VIEW – NTS

NOTE:
EMERGENT HABITAT BOULDERS SHALL BE INSTALLED TO LOCATIONS SHOWN ON PLANS. BOULDERS SHALL RANGE FROM 1.5–3 FEET IN HEIGHT OFF OF SURROUNDING GRADE. SPECIFIC LOCATIONS AND ELEVATIONS OF TOP OF BOULDER CAN BE PROVIDED TO THE CONTRACTOR ELECTRONICALLY.

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REVISIONS

NO.	DATE	DESCRIPTION

DETAIL SHEET:
EMERGENT HABITAT BOULDER

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

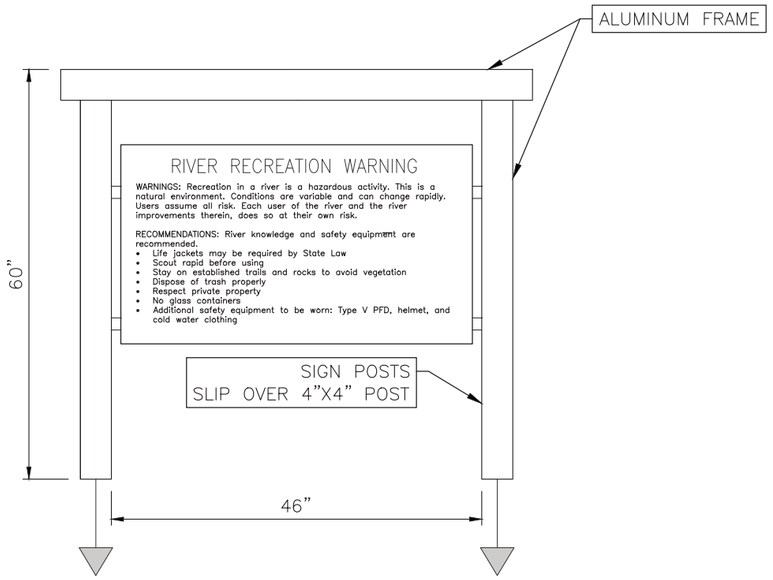
IMPROVEMENTS ALONG THE
GRAND RIVER
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

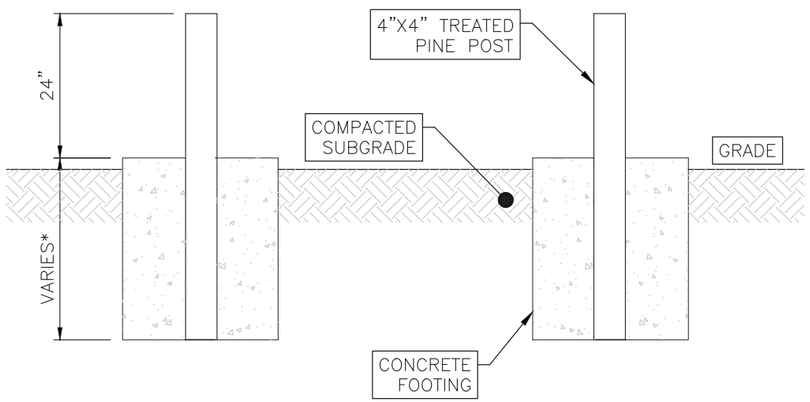
GPF No. 5315

Sheet No. 29 of 32 D01





2 D02 RIVER WARNING SCOUT SIGNS
BRIDGE SIGN – N.T.S.



*NOTE:
1. FOOTING DEPTH SUBJECT TO LOCAL CODES AND CONDITIONS.
2. LANGUAGE PRESENTED IS DRAFT; FINAL LANGUAGE TO BE DETERMINED PRIOR TO CONSTRUCTION

1 D02 RIVER WARNING INFORMATIONAL SIGNS
ACCESS POINT SIGN – N.T.S.

NOTES:

1) SPECIFIC DIMENSIONS, LOCATIONS, AND INFORMATION OF ALL SIGNAGE WILL BE DETERMINED THROUGH FINALIZATION OF THE DESIGN AND CONSTRUCTION PLANS.

2) RIVER WARNING INFORMATIONAL SIGNS SHOULD BE PLACED ON BOTH SIDES OF THE RIVER, UPSTREAM OF ALL PROPOSED CHANGES TO THE RIVER AND IN AN POPULAR PEDESTRIAN AREAS NEAR THE SHORELINES.

3) RIVER WARNING SCOUT SIGNS SHOULD BE INSTALLED IMMEDIATELY UPSTREAM OF BRIDGE STREET ON BOTH SIDES OF THE RIVER, EITHER ALONG PATHWAYS OR ON UPSTREAM FACES OF BRIDGES AND IN EYE–SIGHT OF BOATERS IN THE RIVER.

DETAIL SHEET:
RIVER WARNING SIGN

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

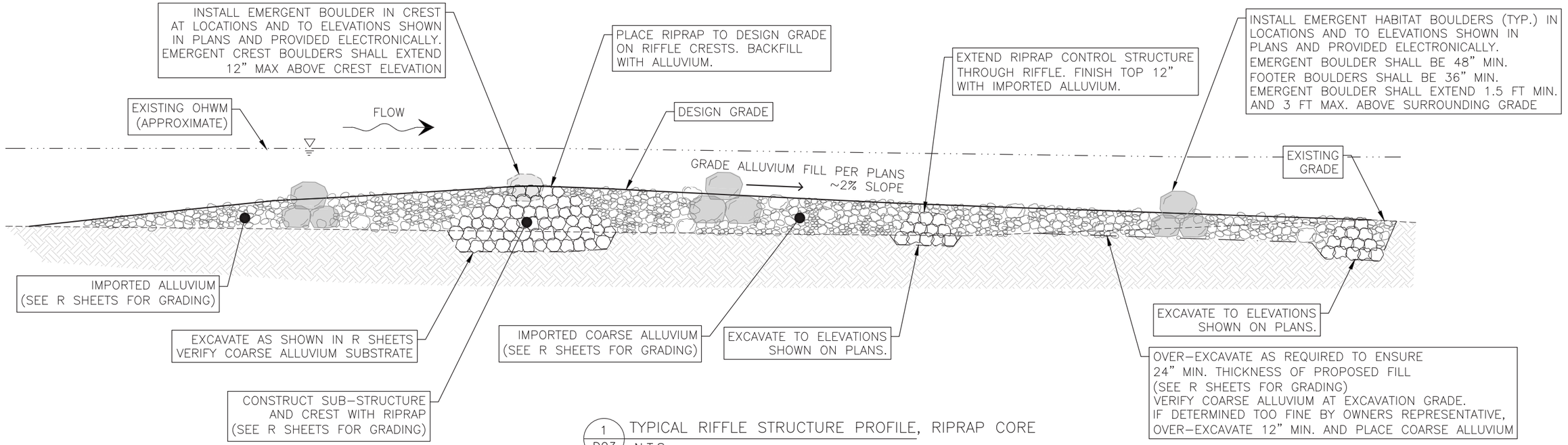
GPF No. 5315

Sheet No. 30 of 32 D02

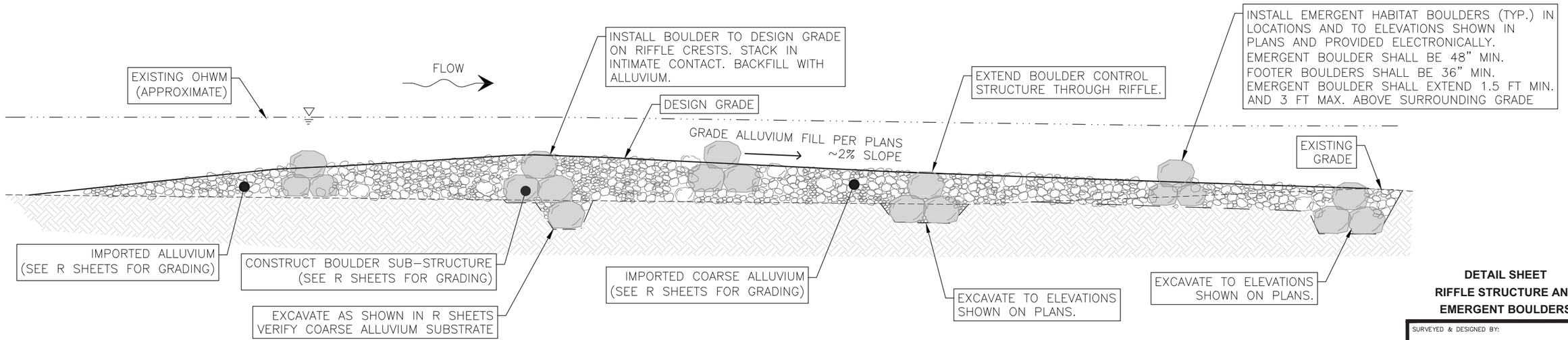
THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION



1/D03 TYPICAL RIFFLE STRUCTURE PROFILE, RIPRAP CORE
N.T.S.



2/D03 TYPICAL RIFFLE STRUCTURE PROFILE, BOULDER CORE
N.T.S.

DETAIL SHEET
RIFFLE STRUCTURE AND EMERGENT BOULDERS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. **5315**

Sheet No. 31 of 32 D03

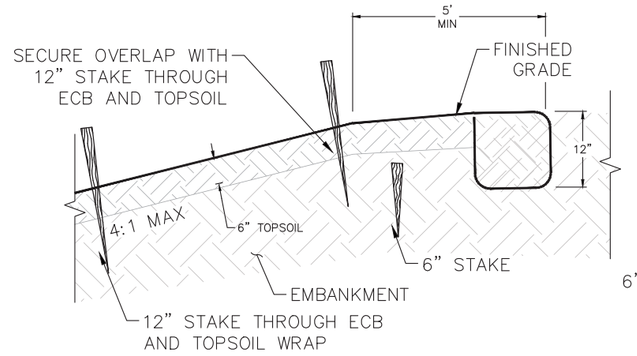


FIGURE A: SECURE ECB AT TOP OF BANK – NTS

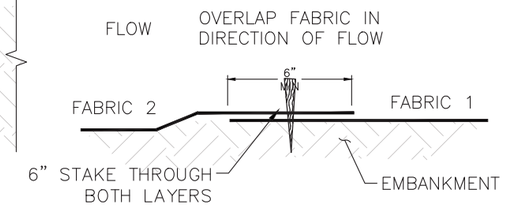


FIGURE B: CROSS SECTION VIEW OF OVERLAP – NTS

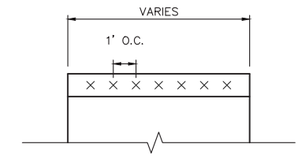
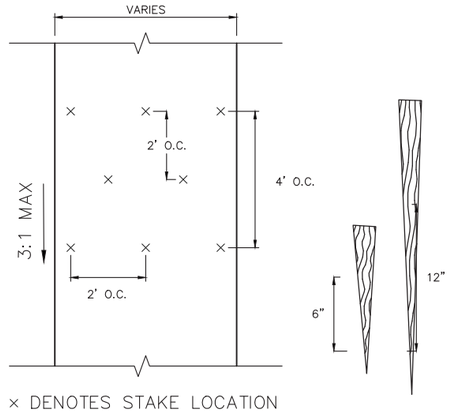


FIGURE C: TOB STAKE SPACING PLAN VIEW – NTS



× DENOTES STAKE LOCATION
(APPROXIMATELY 0.7 STAPLES PER SY)

FIGURE D: STAKE SPACING PLAN VIEW – NTS

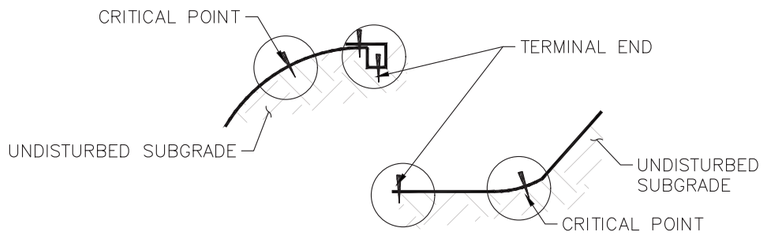
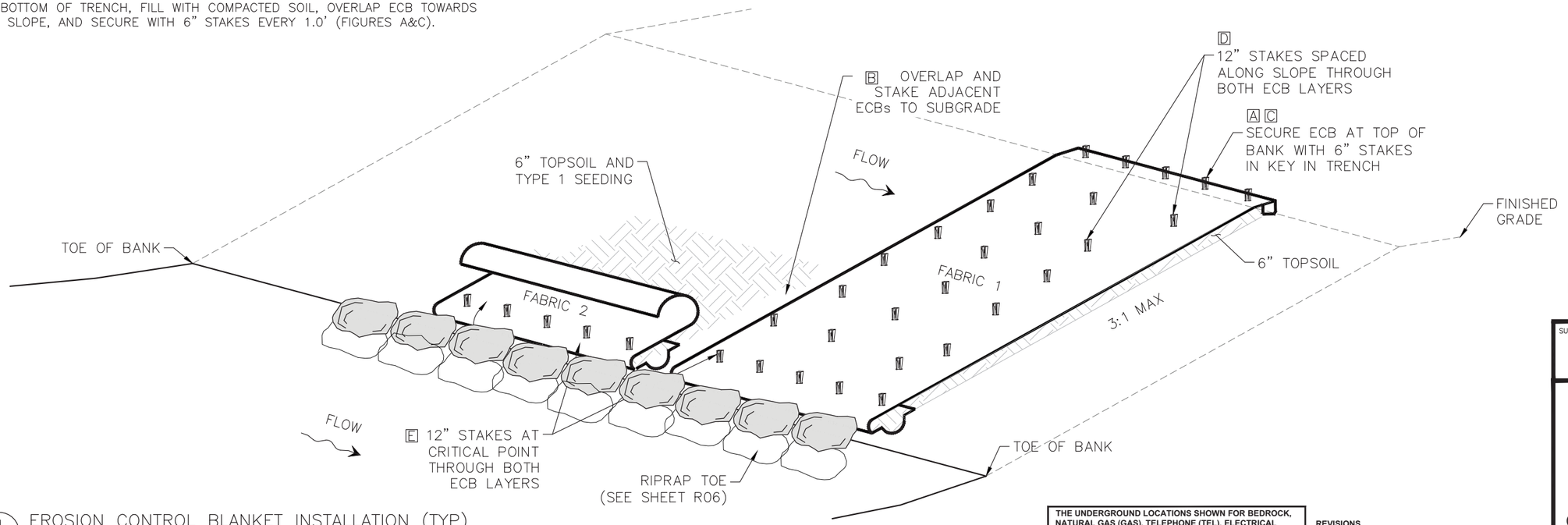


FIGURE E: CRITICAL POINT SECURING – NTS

ECB INSTALLATION NOTES:

1. CONTRACTOR SHALL USE ALL NATURAL 100% BIODEGRADABLE COIR NAG 700BN EROSION CONTROL BLANKETS (ECBs) OR APPROVED EQUIVALENT. STAKES SHALL ALSO BE 100% BIODEGRADABLE. SEE SPECIFICATIONS AND MANUFACTURER'S INSTALLATION GUIDELINES FOR ADDITIONAL INFORMATION.
2. PLACE ECB BEHIND BOULDER TOE TO A DEPTH OF 18" BELOW FINISHED GRADE AND SECURE IN PLACE PER STAKING PLAN (FIGURE D). ECB MUST BE PLACED LOOSELY OVER GROUND SURFACE. DO NOT STRETCH.
3. EDGES OF PARALLEL ECBs MUST BE STAKED WITH AN APPROXIMATE 6" OVERLAP (FIGURE B). UPSTREAM ROLL MUST BE ON TOP OF DOWNSTREAM ROLL. IF NEEDED, CONSECUTIVE ECBs SPLICED DOWNSLOPE MUST BE OVERLAPPED END–OVER–END (SHINGLED) WITH AN APPROXIMATE 3" OVERLAP.
4. IN THE FOLLOWING ORDER, APPLY TOPSOIL, SEED MIX, BONDED FIBER MATRIX, THEN WRAP ECB AT THE TOE TOWARDS THE TOP OF BANK.
5. EXCAVATE A 1.0' WIDE BY 1.0' DEEP TRENCH 5' BEHIND THE TOP OF THE SLOPE. THE TRENCH SHALL RUN ALONG THE LENGTH OF THE INSTALLATION. STAKE ECB ALONG BOTTOM OF TRENCH, FILL WITH COMPACTED SOIL, OVERLAP ECB TOWARDS TOE OF SLOPE, AND SECURE WITH 6" STAKES EVERY 1.0' (FIGURES A&C).



1 / D04 EROSION CONTROL BLANKET INSTALLATION (TYP)
NTS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

DETAIL SHEET
EROSION CONTROL BLANKET INSTALLATION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____ / Check: Field _____ / Check: Office _____	GPF No. 5315	Sheet No. 32 of 32 D03

Appendix D. Construction and Post Project hydraulic influence at the 6th Street Dam.

REPORT J1a
Post-Project Hydraulic Influence at the 6th Street Dam
GRAND RIVER REVITALIZATION PROJECT
GRAND RAPIDS, MICHIGAN

DRAFT

Evaluation of Sea Lamprey (*Petromyzon marinus*) Hydraulic Conditions at the 6th Street Dam Under Post-Project Conditions for the Grand Rapids Revitalization Lower Reach Project

Prepared for:
City of Grand Rapids

Prepared by:
RiverRestoration.org, LLC
P.O. Box 248
Carbondale, CO 81623

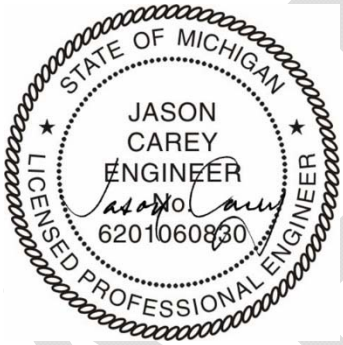
March 2024

Grand Rapids WhiteWater

RIVER RESTORATION.ORG

CITY OF GRAND RAPIDS

This document entitled Post Project Hydraulic Influence at the 6th Street Dam, Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org LLC (RiverRestoration) for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.



Approved by
Jason Carey, P.E.

DRAFT

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DRAFT

1.0 INTRODUCTION

The concrete 6th Street Dam in the Grand River at Grand Rapids, MI has been assumed to be an effective barrier to upstream migration of the invasive sea lamprey (*Petromyzon marinus*) (Great Lakes Fishery Commission (GLFC), 2018). Proposed modifications to the Grand River associated with the Grand River Revitalization Lower Reach Project include the demolition of four low-head dams and construction of naturalized instream restoration features between Bridge Street and Fulton Street. Hydraulic conditions at the 6th Street Dam under post-project conditions have been modeled to show that the hydraulics of 6th Street Dam will not be impacted to result in reduced effectiveness in blocking sea lamprey as compared to corrected effective conditions. This evaluation and corresponding hydraulic modeling results are reported in this memorandum.

Hydraulic comparisons are made to channel conditions prior to recent instream work conducted by Michigan Department of Transportation (MDOT). This is referred to as the Existing Conditions Configuration herein.

2.0 MODELING RESULTS EVALUATION OF EXISTING AND PROPOSED CONDITIONS

Flow rates below bankfull flow of 13,000 cfs, were evaluated in SRH-2D and comparisons were made between existing and proposed conditions. Flood flows, greater than bankfull flow, were evaluated and compared using the effective HEC-RAS FEMA flood model.

Tailwater elevations were taken from both models directly downstream of 6th Street Dam, at River Station 2160+20.2; Table 1 compares the calculated rating curves. The crest of 6th Street Dam is submerged by tailwater at the 5-year flood (26,000 cfs). Proposed Conditions tailwater elevations were modeled to remain at or at or below Existing Conditions, within modeling error, for all flow rates evaluated. An 18" vertical separation between tailwater and crest was maintained for similar flow rates as existing conditions.

Table 1: Comparison of modeled tailwater elevations at 6th Street Dam

Flowrate (cfs)	Existing Conditions (ft)	Proposed Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	595.62	-0.30	SRH-2D
2,500	596.64	596.33	-0.31	
3,900	597.26	596.93	-0.33	
5,000	597.67	597.35	-0.32	
7,500	598.5	598.19	-0.31	
10,000 (1-year)	599.2	598.96	-0.24	
13,000 (Bankfull)	599.9	599.88	-0.02	HEC-RAS
18,000 (2-year)	601.84	601.86	0.02	
26,000 (5-year)	604.34 (1)	604.32 (1)	-0.02	
31,000 (10-year)	605.98 (1)	605.93 (1)	-0.05	
38,000 (25-year)	608.17 (1)	608.04 (1)	-0.13	
44,000 (50-year)	610.26 (1)	610.11 (1)	-0.15	
50,000 (100-year)	612.92 (1)	612.72 (1)	-0.20	

(1) Less than 18" vertical separation between tailwater and crest of dam

3.0 WATER TEMPERATURE

Water temperature plays a major role in predicting when sea lampreys may be migrating upriver. The following information is included to corelate flow rates and water temperature to various times of year. The project will not have an impact on these correlations. Sea lampreys typically spawn in the Grand River in the late winter through spring months (February through June) (USFWS, *personal communication*). Table 2 provides the calculated mean-monthly flow rates and corresponding average temperatures. For the flow data. forty-years of discharge data were obtained from USGS Gage 04119000 and a mean-monthly flow rate was calculated from the mean-daily rate. For water temperatures, 10°C has been identified as a target, with migration beginning as temperatures sustain above 10°C. The annual hydrograph is summarized along with water temperature in Figure 1.

Table 2: Mean monthly flow rates for active spawning months

Month	Mean daily flow	Mean monthly water temp.
-	ft^3/s	^oC
February	4,878	2
March	7,725	4
April	7,387	10
May	5,696	15
June	4,024	21

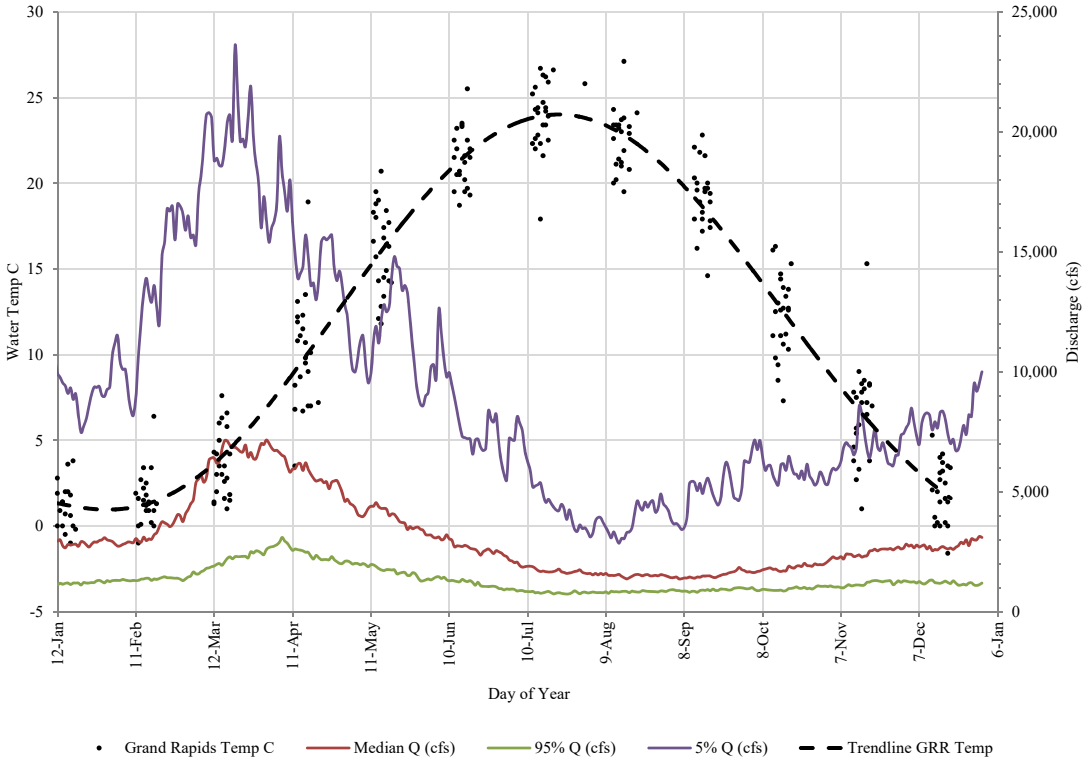


Figure 1: Annual hydrograph with water temperature

4.0 CONCLUSION

The hydraulic function of 6th Street Dam as a barrier to sea lampreys is not anticipated to be negatively affected by the Lower Reach project. The systemic processes of the river and hydraulic characteristics of the dam that contribute to blockage of sea lampreys is not explicitly understood and blockage is likely a combination of various components, including water temperature, vertical free over-fall from tailwater to crest, as well as velocity of flow over and through the dam.

The project would have no effect on water temperatures or on the dam structure itself.

Modeling results indicate that tailwater elevations would remain at or below existing conditions, within modeling error. Based on this evaluation, the function of 6th Street Dam as a barrier to sea lampreys is anticipated to remain as effective as the existing condition.

DRAFT

5.0 REFERENCES

Great Lakes Fishery Commission (2018). "Sea lamprey control needs and considerations – Grand River, Lake Michigan." Draft – January 2018.

Hanson, L.H. (1980). "1980 Study to determine the burst swimming speed of spawning-run sea lampreys (*Petromyzon marinus*)." *Research Completion Report,* U.S. F.W.S. Millerburg, Michigan

Hunn, J.B. and Youngs, W.D. (1980). "Role of physical barriers in the control of sea lamprey (*Petromyzon marinus*)." *Can. J. Fish Aq. Sci.* 37, 2118-2122.

McAuley, T.C. (1996). "Development of an instream velocity barrier to stop sea lamprey (*Petromyzon marinus*) migrations in Great Lakes Streams." Master of Science Thesis. University of Manitoba, Department of Civil Engineering. Winnipeg, Manitoba.

RiverRestoration (2018). "Grand River revitalization project – sea lamprey blockage theory at existing and proposed conditions." Draft – June 2018. Prepared for Grand Rapids Whitewater.

REPORT J1b
Temporary Construction Hydraulic Influence at the 6th Street Dam
GRAND RIVER REVITALIZATION PROJECT
GRAND RAPIDS, MICHIGAN

DRAFT

Evaluation of Sea Lamprey (*Petromyzon marinus*) Hydraulic Conditions at the 6th Street Dam Under Temporary Project Construction Actions for Grand Rapids Revitalization Lower Reach Project

Prepared for:
City of Grand Rapids

Prepared by:
RiverRestoration.org, LLC
P.O. Box 248
Carbondale, CO 81623

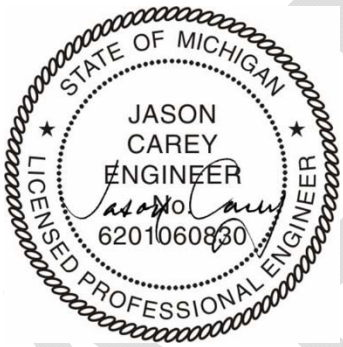
March 2024

Grand Rapids WhiteWater

RIVER RESTORATION.ORG

CITY OF GRAND RAPIDS

This document entitled Temporary Construction Hydraulic Influence at the 6th Street Dam, Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org LLC (RiverRestoration) for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.



Approved by
Jason Carey, P.E.

DRAFT

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DRAFT

1.0 INTRODUCTION

The concrete 6th Street Dam in the Grand River at Grand Rapids, MI has been assumed to be an effective barrier to upstream migration of the invasive sea lamprey (*Petromyzon marinus*) (Great Lakes Fishery Commission (GLFC), 2017). Proposed modifications to the Grand River associated with the Grand River Revitalization Lower Reach Project (project) include the demolition of four low-head dams and construction of naturalized instream restoration features, located between Bridge Street and Fulton Street. Hydraulic conditions at the 6th Street Dam under permanent project actions for the project have been modeled to show that the hydraulics of 6th Street Dam will not be impacted to result in reduced effectiveness in blocking sea lamprey as compared to existing conditions (see Report J1a). Temporary conditions during construction have also been modeled to evaluate impacts to tailwater conditions at 6th Street Dam. The evaluation of hydraulics during temporary construction conditions and corresponding hydraulic modeling results are reported in this report.

Hydraulic comparisons are made to channel conditions prior to recent instream work conducted by Michigan Department of Transportation (MDOT). This is referred to as the Existing Condition herein.

2.0 MODELING RESULTS EVALUATION OF EXISTING AND TEMPORARY CONSTRUCTION CONDITIONS

The project is proposed to be constructed by access provided from a staging area in Ah-Nab-Awen Park and in-channel causeways accessing each work area from the park. At Dam 2, the west half of the proposed improvements would be constructed within isolation conditions after installing a cofferdam around the work area and diverting flow to the east side of the channel. Construction activities will be limited by flow depths in the river are anticipated to be performed during flow rates less than approximately 4,000 cfs. Above this flow, depths would likely exceed those for safe and efficient construction in the flowing water and would begin to overtop the cofferdam at the Dam 2 location. Additionally, because construction would only occur during the lower flow periods, the temporary structures (causeways and cofferdam) are proposed to remain in the river during periods of higher flows when construction is unable to occur. Removing temporary structures prior to 4,000 cfs being exceeded would not provide for feasible construction of the project.

The proposed hydraulic feature at the Dam 2 location replaces the grade control function of Dam 3 and part of Dam 4. In order to maintain stable grade control within the reach until the completion of the proposed new hydraulic feature, the removal of Dams 3 and 4 is proposed to be done after the completion of the feature at Dam 2.

Refer to the construction sequencing discussion in Report D1 and the temporary care of water sheets (T Sheets) in permit drawings for reference.

Three temporary conditions models have been evaluated for potential impacts to tailwater at 6th Street Dam:

- Temporary Conditions Model 1 assumes that causeways to Dams 1 and 2, as well as causeways to all work downstream of Pearl Street have bene installed and all dams remain in place.
- Temporary Conditions Model 2 assumes that the cofferdam at the Dam 2 location has been installed in addition to all causeways as described in model 1. All dams remain in place

- Temporary Conditions Model 3 assumes that the cofferdam has been removed and all proposed improvements have been completed, but all causeways still need to be removed from the channel.

These temporary conditions models make conservative assumptions as to what all would potentially be in the river at one time. This is to provide the contractor flexibility to perform the work as efficiently as possible, while still adhering to the sequencing detailed in Report D1.

Modeling results for tailwater at 6th Street Dam are compared and discussed for each temporary condition below. Low flows, which include flow rates below bankfull flow of 13,000 cfs, were evaluated in SRH-2D and comparisons were made between existing and temporary conditions. High flows, which includes flow rates greater than bankfull flow, were evaluated and compared using the effective HEC-RAS FEMA flood model. Tailwater elevations were taken from both models directly downstream of 6th Street Dam, at River Station 2160+20.2.

2.1 *Temporary Conditions Model 1*

Table 1 compares the calculated rating curves for Existing Conditions and Temporary Conditions; the crest of 6th Street Dam is submerged by tailwater at the 5-year flood (26,000 cfs). Modeling results indicate potential for increased tailwater elevations of up to 0.37 feet and an 18" vertical separation from tailwater to dam crest being maintained for flow rates below 18,000 cfs.

Table 1: Comparison of modeled tailwater elevations at 6th Street Dam for Temporary Conditions Model 1

Flowrate (cfs)	Existing Conditions (ft)	Temporary Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	596.25	0.33	SRH-2D
2,500	596.64	596.96	0.32	
3,900	597.26	597.58	0.32	
5,000	597.67	598.00	0.33	
7,500	598.5	598.83	0.33	
10,000 (1-year)	599.2	599.57	0.37	
13,000 (Bankfull)	599.9	600.13	0.23	HEC-RAS
18,000 (2-year)	601.84	602.04 (1)	0.2	
26,000 (5-year)	604.34 (1)	604.52 (1)	0.18	
31,000 (10-year)	605.98 (1)	606.14 (1)	0.16	
38,000 (25-year)	608.17 (1)	608.29 (1)	0.12	
44,000 (50-year)	610.26 (1)	610.36 (1)	0.1	
50,000 (100-year)	612.92 (1)	612.98 (1)	0.06	

(1) Less than 18" vertical separation between tailwater and crest of dam

2.2 Temporary Conditions Model 2

Table 2 compares the calculated rating curves for Existing Conditions and Temporary Conditions. Modeling results indicate potential for increased tailwater elevations of up to 0.33 feet and an 18" vertical separation from tailwater to dam crest being maintained for flow rates below 18,000 cfs.

Table 2: Comparison of modeled tailwater elevations at 6th Street Dam for Temporary Conditions Model 2

Flowrate (cfs)	Existing Conditions (ft)	Temporary Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	596.23	0.31	SRH-2D
2,500	596.64	596.94	0.3	
3,900	597.26	597.55	0.29	
5,000	597.67	597.97	0.3	
7,500	598.5	598.80	0.3	
10,000 (1-year)	599.2	599.53	0.33	
13,000 (Bankfull)	599.9	600.07	0.17	HEC-RAS
18,000 (2-year)	601.84	602.05 (1)	0.21	
26,000 (5-year)	604.34 (1)	604.54 (1)	0.2	
31,000 (10-year)	605.98 (1)	606.15 (1)	0.17	
38,000 (25-year)	608.17 (1)	608.3 (1)	0.13	
44,000 (50-year)	610.26 (1)	610.37 (1)	0.11	
50,000 (100-year)	612.92 (1)	612.99 (1)	0.07	

(2) Less than 18" vertical separation between tailwater and crest of dam

2.3 Temporary Conditions Model 3

Table 3 compares the calculated rating curves for Existing Conditions and Temporary Conditions. Modeling results indicate potential for increased tailwater elevations of up to 0.08 feet and an 18" vertical separation from tailwater to dam crest being maintained for flow rates below 18,000 cfs.

Table 3: Comparison of modeled tailwater elevations at 6th Street Dam for Temporary Conditions Model 2

Flowrate (cfs)	Existing Conditions (ft)	Temporary Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	595.59	-0.33	SRH-2D
2,500	596.64	596.3	-0.34	
3,900	597.26	596.91	-0.35	
5,000	597.67	597.33	-0.34	
7,500	598.5	598.18	-0.32	
10,000 (1-year)	599.2	598.99	-0.21	
13,000 (Bankfull)	599.9	599.94	0.04	HEC-RAS
18,000 (2-year)	601.84	601.92 (1)	0.08	
26,000 (5-year)	604.34 (1)	604.39 (1)	0.05	
31,000 (10-year)	605.98 (1)	605.99 (1)	0.01	
38,000 (25-year)	608.17 (1)	608.09 (1)	-0.08	
44,000 (50-year)	610.26 (1)	610.16 (1)	-0.1	
50,000 (100-year)	612.92 (1)	612.80 (1)	-0.12	

(3) Less than 18" vertical separation between tailwater and crest of dam

DRAFT

3.0 WATER TEMPERATURE

Water temperature plays a major role in predicting when sea lampreys may be migrating upriver. The following information is included to corelate flow rates and water temperature to various times of year. The project will not have an impact on these correlations. Sea lampreys typically spawn in the Grand River in the late winter through spring months (February through June) (USFWS, *personal communication*). Table 4 provides the calculated mean-monthly flow rates and corresponding average temperatures. For the flow data. forty-years of discharge data were obtained from USGS Gage 04119000 and a mean-monthly flow rate was calculated from the mean-daily rate. For water temperatures, 10°C has been identified as a target, with migration beginning as temperatures sustain above 10°C. The annual hydrograph is summarized along with water temperature in Figure 1.

Table 4. Mean monthly flow rates for active spawning months

Month -	Mean daily flow ft^3/s	Mean monthly water temperature ^oC
February	4,878	2
March	7,725	4
April	7,387	10
May	5,696	15
June	4,024	21

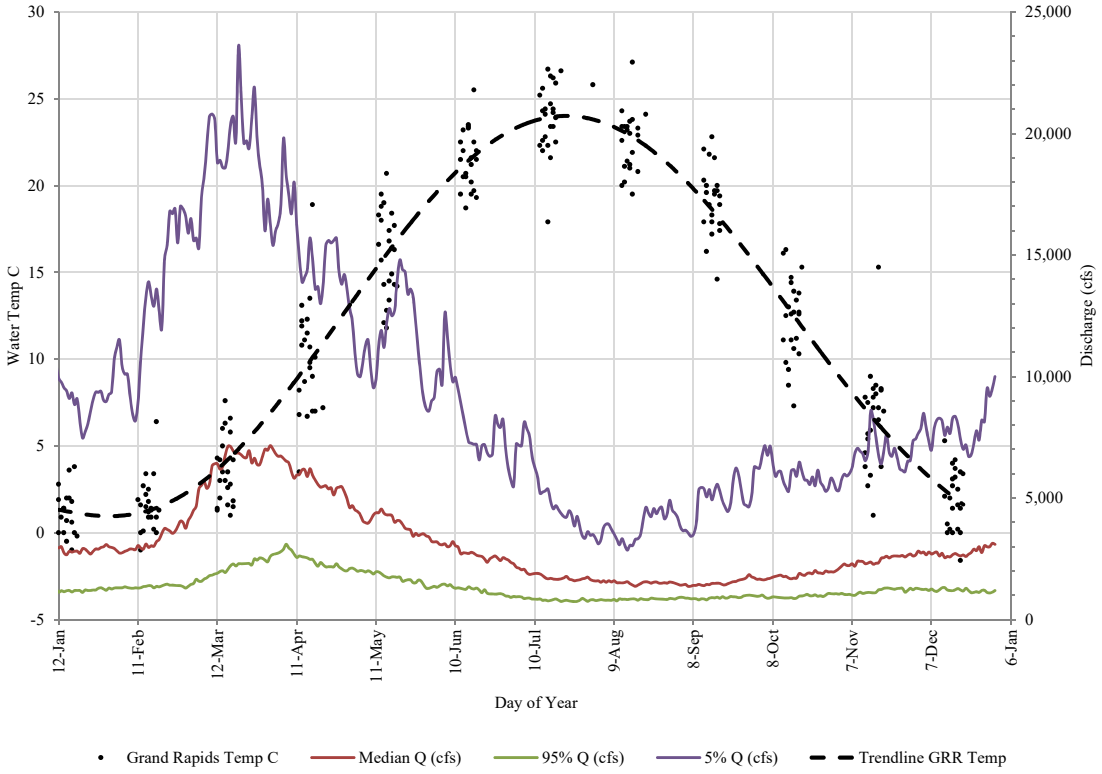

Figure 1: Annual hydrograph with water temperature

4.0 CONCLUSION

The systemic processes of the river and hydraulic characteristics of the 6th Street Dam that contribute to blockage of sea lampreys is not explicitly understood and blockage is likely a combination of various components, including water temperature, vertical free over-fall from crest to tailwater, as well as velocity of flow over and through the dam.

The removal of Dams 3 and 4 would be sequenced after the completion of the proposed feature at Dam 2 as means to maintain stable grade control within the reach through construction. The addition of obstruction associated with the temporary causeways and cofferdam resulted in small, modeled increases in tailwater at 6th Street Dam. For this reason, installation of temporary structures would begin immediately following sea lamprey migration season (July 1st) if flow conditions allow. If flows are low enough before sea lamprey migration season ends, isolation measures would be installed if approved after coordination with the USFWS Sea Lamprey Control Program.

Construction is anticipated to be potentially completed in one season but will be dependent on flow conditions throughout the season. If conditions do not allow for full completion of work in one season, some temporary causeway material may be left in the channel over winter (along with all constructed proposed improvements). Potential increases in modeled tailwater elevations that may result if this is the case have been minimized by prioritizing the removal of Dams 3 and 4 immediately following the completion of the feature at Dam 2. Potential modeled impacts to tailwater over winter are represented by temporary conditions models 2 and 3; condition 2 assumes Dams 3 and 4 remain in place and condition 3 assumes they've been removed, which would be the more likely scenario given the anticipated construction schedule.

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Appendix E. Impacts to Fish Passage in the Grand River between Bridge Street and Fulton Street in Grand Rapids, Michigan

Impacts to Fish Passage in the Grand River between Bridge Street and Fulton Street in Grand Rapids, Michigan



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GRAND RAPIDS WHITEWATER

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Appendix A. Project area features, velocity, and substrate of the current design.

Appendix B. The project area with depth and depth-averaged velocity at 2500, 3900, 5000 and 7500 cfs.

Appendix C. Depth and velocity heatmaps of project area during difficult hydraulic conditions depicting 15 swimpaths. Figures display the depth, velocity and percent of swimming distance expended for a fish traveling along each of the swimpaths.

ACKNOWLEDGEMENTS

This Fish Passage Assessment was completed under contract to Grand Rapids Whitewater (GRWW) as part of the efforts to restore and revitalize the Grand River in Grand Rapids. Mr. Matt Chapman (GRWW), Mr. Michael Staal (City of Grand Rapids [CGR]), and Mr. Scott Prins (River Restoration [RRO]) provided project details. Mr. Patrick Ertel, Dr. Tammy Newcomb, Mr. Jay Wesley (Michigan Department of Natural Resources [MDNR]), and Luke Trumble and Amy Lounds (Michigan Department of Environment, Great Lakes, and Energy [EGLE]) provided advice throughout the informal consultation process. Dr. Ted Castro-Santos (United States Geological Survey), Ms. Susan Wells (United States Fish and Wildlife Service), and Dr. Robert McLaughlin (Michigan State University) provided critique of the fish passage analysis methodology.

1.0 INTRODUCTION

The City of Grand Rapids is pursuing to improve aquatic habitat in the Lower Grand River where it flows through downtown Grand Rapids, Kent County, Michigan (GVMC, 2011). Goals of the project include developing a river design that is aesthetically and functionally natural as possible, within the constraints of a large urban river, and to achieve fish passage and aquatic habitat enhancement targets as determined by the Michigan Department of Natural Resources (MDNR) and the project team. The lower reach of the Grand River Revitalization project is located on the Grand River mainstem in the City of Grand Rapids, Michigan from approximately 40 meters (131 ft) upstream of Bridge Street to Fulton Street (Figure 1-1).

1.1 Purpose of the Document

The purpose of the fish passage report is to review the design plans for the Grand River Revitalization project and evaluate the passage of desirable fish species in the lower reach project area. A fish passage report was previously submitted in 2020 (ESC 2020), for a permit application that was withdrawn in March 2023. Following the withdrawal, a new design (proposed design) was developed during focused and frequent consultation between Grand Rapids WhiteWater (GRWW), the City of Grand Rapids (CGR), Michigan Department of Environment, Great Lakes and Energy (EGLE) and MDNR. One of the primary objectives for the proposed design was to maximize fish passage and aquatic habitat while minimizing impacts. This evaluation report focuses on the proposed design where habitat elements were removed while others were added.



1.2 Proposed Action

The stated purpose of revitalizing the rapids in Grand Rapids is described in the Biological Assessment (Dunn 2024) as, "To restore the rapids, improve public safety, restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species, and enhance river access and use." This action includes removing the four low head dams which are barriers to several species of fish, and to construct habitat features known to successfully pass fish. The proposed features of the action include riffles, boulder drop structures, bank vane structures,

and emergent habitat boulders that are found in many nature-like fishway designs and the historic condition of the rapids. In fall of 2023, the design was modified to avoid and minimize impacts to freshwater mussel and fish species. Appendix A (modified from Dunn 2024) shows the current design that was coordinated with EGLE and MDNR and evaluated in this report. The current design has reduced the construction and permanent impacts from the previous while incorporating elements that have successfully been used to pass fish in Michigan. Changes that were incorporated into the current design are described as follows (Dunn 2024):

Between Blue Bridge and Fulton Street

- The boulder wave structure on the west side of the channel was replaced with an augmented boulder vane structure with a reduced footprint and surrounding scattered boulders.
- The previous design included a recovery pool downstream of the wave that has been removed from the design. A small scour pool is included directly downstream of the vane structure, similar to other Michigan projects that have implemented weir or Aadland (2010) rock arch designs.

Between Pearl and Blue Bridge

- The hydraulic feature in this area, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with scattered boulder and a series of bank vane structures to provide slack water near designated access points on the bank.
- The recovery pool of the previous design has been removed.

Between Gillett and Pearl Street (Location of Dam 1)

- The hydraulic feature at Dam 1, which included a boulder wave structure on the west side connected to a constructed riffle structure on the east, has been replaced with a single constructed riffle with emergent habitat boulders and moved downstream to have more overlap with the Dam 1 removal footprint.
- The recovery pool of the previous design has been removed.

Between Bridge St and Gillet (Location of Dam 2)

- The hydraulic feature at Dam 2, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with a hydraulic feature that combines constructed riffles on either side of the river with a series of boulder drop structures in the center of the channel. The new hydraulic feature has a reduced footprint.
- The recovery pool of the previous design has been removed. Small scour pools are included directly downstream of the boulder drop structures, similar to other Michigan projects that have implemented W-weir or Aadland rock arch designs.

Between Bridge St and Gillet (Location of dam 3)

- The dam removal limits have been expanded, based on coordination with EGLE, to include a re-grading of the channel upstream of Dam 3
- Scattered habitat boulders are proposed to be placed within the dam removal footprint.

Location of Dam 4

- The dam removal limits have been expanded, based on coordination with EGLE, to include re-grading of the channel upstream of Dam 4.

2.0 AFFECTED ENVIRONMENT AND BIOLOGICAL RESOURCES

2.1 Lower Grand River Fishery

The project area provides an important and diverse recreational fishery for resident fish species including walleye (*Sander vitreus*), sucker spp., channel catfish (*Ictalurus punctatus*) and smallmouth bass (*Micropterus dolomieu*). Seasonal opportunities exist for migrating fish and include walleye and steelhead (*Oncorynchus mykiss*) in the Spring, and Chinook salmon (*Oncorynchus tshawytscha*) in the Fall. Maintaining, and maximizing, these fishing opportunities is important to all partners involved in the revitalization project. The fish community in the project area is highly diverse, includes many tolerant species, and has changed from its historic condition because of the reduction in rapid and riffle habitat. Many of the fish species in the project area are ubiquitous throughout the mainstem and not associated with swift water habitats. For an extensive review of the Grand River fishery see Hanshue and Harrington (2017).

Two State Threatened fish species are found in the project area. There is a small lake sturgeon (*Acipencer fulvescens*) population that persists in the project area and is only suspected to spawn near Plaster Creek (~1.25 mi. downstream of Fulton Street) and in the project area downstream of 6th Street dam. The Grand River population has been placed into the 'small declining' category based on a low suspected adult population size and declining population trajectory (Hayes and Caroffino 2012). The 6th Street dam is a barrier to historic spawning grounds of lake sturgeon (Hanshue and Harrington 2017) and incidental catch by fisherman occurs each spring. Lake sturgeon recruitment has been documented during two years of a five-year study that has occurred below the project area by a locally-based team of researchers during fall assessments (Grand Rapids Public Museum 2024). The river redhorse (*Moxostoma carinatum*) is a large-bodied sucker species found in the Grand River. There have been recent obseravations in the project area during their spring spawning period (S. Hanshue, MDNR personal communication).

3.0 FISH PASSAGE EVALUATION CONSIDERATIONS

The following sections describe criteria that were developed for the fish passage evaluation, the areas where analysis occurred, methods used for hydraulic model development, and details of fish passage evaluation procedures and results.

3.1.1 General Considerations

The proposed design uses design and construction criteria, that when achieved, will improve fish passage conditions in the Grand River for the diverse fish community. The proposed action includes rock arch rapids, boulder clusters, and small hooks which are design aspects found in nature-like fishways (Aadland 2010). Nature-like design principles have been published by many sources including MDNR, Aadland (2010), Newbury (2013, 2010) and have been successful in meeting fish passage objectives. Fundamental to the design of nature-like fishways is that they pass a broad range of species, emulate habitats found in natural systems, are resilient to a range of flows, and are stable through extreme conditions.

During consultation with MDNR specific design targets were developed and consistent with nature-like fishways, that if met, would result in environmental conditions that are within the swimming abilities of desirable fish species and should accommodate passage of the broader fish community. Specific design targets included and met in the proposed action:

- **Headloss per weir of ≤0.24 m (0.8 ft):** The proposed design, when not submerged by tailwater, would have a maximum headloss of 0.61 m (2 ft) with an average headloss of ~0.54 m (~1.8 ft). The dam 1 riffle starts to see reduced headloss of tailwater levels around 5000 cfs and the dam 2 feature around 7,500-10,000k cfs.
- **Boulder weir gap width between 0.15 – 91 m (0.5 – 3 ft):** Gaps between raised boulders on the crest of the boulder drops have a minimum spacing of 0.61 m (2 ft) with a maximum of 3.66 to 4.57 m (12 to 15 ft) where flow paths are desirable for boat passage.
- **Mild downslopes at riffles:** Constructed riffles have a target slope of 50:1 and the grading will not be steeper than ~45:1 over the riffles.
- **Center depth in deep pools at ≥1.68 m (5.5 ft):** Maximum pools depths are designed at 2.1 m (7 ft) while active and not submerged with an average depth (3,900 cfs) of 1.68 m (5.5 ft).
- **Minimum pool depth of 0.91 m (3 ft):** Minimum pools depths are designed at 1.07 m (3.5 ft).

The fish passage analysis provides a quantitative tool to assess if the design will meet fish passage objectives. Two species were identified as indicator species to use in the analysis because they are both important members of the native fish community, have considerable public interest, and represent different fish swimming groups and swimming performance abilities. For instance, the river redhorse has the same fatigue equation to walleye in the model used for analysis. This allows for evaluating walleye passage along with river redhorse and a suite of other species in the model. The decision was made to evaluate the two species during a range of hydraulic conditions and design features (riffles, weir features, etc.). **Important to this analysis is that fish passage was evaluated at the more extreme modeled conditions** assuming that if passage was achieved at locations and conditions of "worst case scenario" that passage would also be achieved at other locations with less challenging hydraulic conditions.

3.1.2 Fish Groupings Considered in Passage Evaluation

Walleye and lake sturgeon were the target fish species selected based upon a series of criteria, including 1) consultation with management agencies, 2) conservation status, 3) availability of peer-reviewed, locally applicable habitat use and swimming capabilities, and 4) known movement and/or migratory behavior.

3.1.3 Hydraulic Modelling

For modelling of flow velocity and flow depth, SRH-2D models were used. Calculations were based upon depth-averaged velocity and near-bottom velocity. SRH-2D solves two-dimensional dynamic wave equations to resolve depth-averaged hydraulics for a variety of scales and applications. The software has been widely implemented and validated. Applied to the Grand River, the model resolves hydraulic parameters (e.g. depth, velocity at a resolution of 0.15 m (0.5 ft) across the spatial domain of the river system.

Hydraulic conditions used in evaluation:
2,500 CFS: 75% exceeded average daily flow rate and a common summertime flow
3,900 CFS: 50% exceeded average daily flow rate
5,000 CFS: Near 25% exceeded average daily flow rate and within range of spring spawning flow
7,000 CFS: Near 10% exceeded average daily flow rate and mid- to higher range of spring spawning flow

The flows were selected in consultation with MDNR to account for temporal and environmental variability and to represent expected seasonal conditions encountered in the Grand River. Hydraulic model outputs for the project reach at the four evaluated discharges are presented in Appendix B.

3.1.4 Velocity

Two velocity values were computed; 1) depth-averaged velocity, and 2) near-bed velocity. Both velocity estimators have advantages and limitations but together provide utility for evaluating fish passage. Depth-averaged velocity is widely used for evaluating fish passage and assessing whether current velocity would pose a burst or exhaustive swim barrier. Its use here seems appropriate to characterize the variable local hydraulic conditions (i.e. velocity and depth), found across the project river channel. In some cases, near-bed velocity will also be presented using methodology developed by Vacher (2005) and with spreadsheets developed by EGLE and MDNR to calculate velocity at 80% depth using average velocity and average depth estimates. The velocity reduction in near-bed flows has been shown to provide significant benefit to fish when it is fully accessible (Jensen 2014). The use of near-bed velocity is only appropriate when a fish has adequate “headroom” or available depth to effectively use the reduced velocity near-bed layer. Therefore, near-bed velocity will be used in cases where adequate headroom exists and during times where average velocity may show a fish passage barrier. The average depth

calculations will be the primary velocity metric because it represents a more challenging passage scenario for fish than the near-bed velocity parameter.

3.1.5 Depth

Desired conditions for fish passage are maintained when deeper relative depths are available for a range of fish body sizes and life-stages. As body size increases for fish, so does the need for greater relative depths. Minimum depth design targets from comparable fish passage projects typically ranged from 0.23 to 0.31 m (0.75 to 1 ft) depth. The Little Rapids (Chippewa County, MI) project targeted a minimum of 0.31 m (1 ft) depth to accommodate spawning walleye (USDOC 2014) and the River Raisin (Monroe County, MI) project targeted minimum depths of ≥0.23 m (9 in) in the roughened boulder areas to accommodate walleye, lake sturgeon, and other target species (Cardno-JF New 2013). A minimum depth criterion of 0.31 m (1 ft) was suggested for spawning sturgeon by Threader et al. (1998). For this analysis the depth target was accordingly set at 0.31 m (1 ft) in the roughened boulder areas during springtime flows (approximately 5,000-7,500 cfs) to accommodate lake sturgeon movement during spawning.

4.0 ANALYSIS BACKGROUND

Prior to completing the fish passage analysis methodology, MDNR hosted a meeting with Encompass Socio-ecological Consulting (ESC), CGR and GRWW to discuss the methodology with a panel of fish passage experts from across North America. The purpose was to determine if the model was precautionary in its predictions and to gather recommendations for improvements. Following the meeting, the model was finalized, and data were analyzed using the procedure.

To evaluate the impact of the proposed design on fish passage, fifteen swimpaths were established across four reaches of the project area (Appendix C). Each swimpath was placed to begin downstream of a habitat feature and extend upstream until the hydraulic influence of the feature was passed. The project features were collaboratively evaluated by MDNR and ESC by reviewing heat maps across several discharges (2,500 – 7,500 cfs) with the intent of selecting difficult swimpath routes that were often the 'worst case scenario'. Accordingly, the difficult routes were assessed based on velocity and depth, and varied between site, channel feature and discharge. Locations were also selected to evaluate different types of channel features found in the project design. For example, in all project reaches are laterally positioned boulder clusters intended to provide conditions for successful fish passage and by evaluating one representative boulder cluster we could effectively extrapolate to other analogous features within the design.

The fifteen swimpaths were distributed across four project reaches in a downstream to upstream numbering (Appendix C):

Fulton Street to Blue Bridge: Swimpaths 11-15.

Analysis performed at 2,500 cfs because of relatively shallow depths and higher flow velocities. Evaluated features included boulder clusters, a mid-channel riffle, and nearshore riffles.

Grand Rapids Public Museum to Pearl Street: Swimpaths 7-10.

Analysis performed at 3,900 CFS because of relatively shallow depths and higher flow velocities on the rivers north side. Evaluated features included two small j-hooks and mid-channel/near-shore riffles.

Pearl Street to Gillett Bridge: Swimpaths 4-6.
Analysis performed at 5,000 cfs because of relatively shallow depths and higher velocities on the rivers west side. The 7,500 cfs condition was similar hydraulically but not selected because of deeper depths that would provide more headroom for fish to exploit near-bed velocities. Evaluated features included a mid-channel boulder cluster and riffles on the rivers west side.

Above Gillett Bridge: Swimpaths 1-3.
Analysis performed at 5,000 cfs because the conditions represent those during spawning migrations for walleye, salmon and sturgeon. The 7,500 cfs condition functioned similarly hydraulically but not selected because of deeper depths that would provide more headroom for fish to exploit near-bed velocities. Evaluated features included a modified W-weir with resting pool habitat, a mid-channel riffle, and a boulder cluster on the east side of the river.

To identify barriers to fish passage along swimpath routes an Excel model was developed (RiverRestoration and ESC) based on swimming performance curves from Katopodis and Gervais (2016). The code identified locations at which a fish shifted from passive to prolonged swimming mode based on stream velocity. Once the mode shift occurred a hydraulic barrier was identified, and an energetic function was applied that calculated the distance a fish was capable of swimming at prolonged or burst mode at a given velocity. Between each 0.5 m (1.64 ft) increment along the swim path the amount of energy expended, and a cumulative distance function calculated the percent of total distance remaining that a fish could travel. When the energy budget was expended over the hydraulic pathway, a complete barrier was identified.

To calculate the 0.5 m (1.64 ft) incremental distance, velocity/distance curves were fit using the fish swimming performance database "Icthyomechanics" from Katopodis and Gervais (2016) and validated these data with other relevant sources (Peake et al. 2011, Scruton et al. 1998, Castro-Santos 2005, Threader et al. 1998). The swimming performance variables used in the model included swimming speed (Body Lengths per Second) and time to fatigue statistics. The Ichthyomechanics database calculates swimming performance data by using taxonomic classifications to group fish species of similar swimming modes and swimming performances. Combining species into groups was found to improve the statistical analysis especially in cases of inadequate data and where inconsistent sampling methodologies occurred between studies. To evaluate walleye (and salmon) passage, distance curves were fit with total lengths of 0.38 m, 0.43 m and 0.51 m (15 in, 17 in, and 20 in) to be representative of spawning size fish. For the sturgeon group, two lengths were fit at 1.5 m and 1.86 m (60 in and 72 in). For each swimpath, the likelihood that 50% of a total length group would pass was used. The likelihood percentage was developed from the average distance a fish could travel at a velocity value and incorporated the

associated confidence bounds from Katopodis and Gervais (2016). The relationship between water velocity and estimated distance of travel for the walleye group and the sturgeon group is presented in Figure 4-1 for reference.

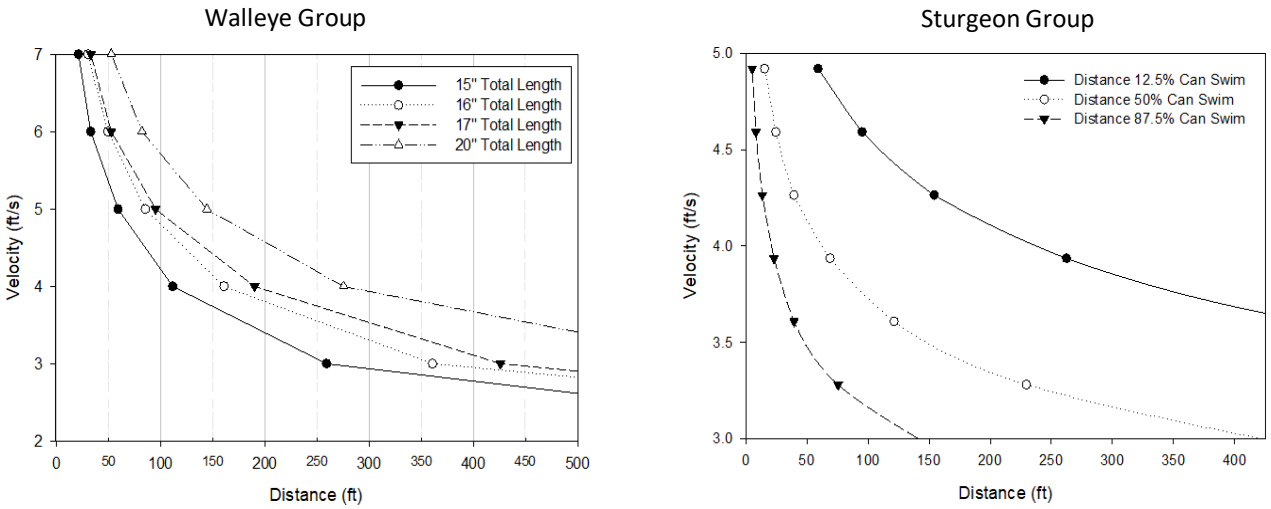

Figure 4-1. Relationship between water velocity (ft/s) and distance of travel (ft) for Salmon and Walleye group and Sturgeon.

5.0 RESULTS

5.1 Walleye Group Passage

A total of 15 swimpaths were analyzed using the model described above. Appendix C provides a depiction of each swimpath, velocity and depth values along the route, and a determination of passability based on the proportion of distance that a fish expended during upstream travel at 0.5 meter increments. Overall, the model predicted full passage at 10 of the 15 swimpaths for all three walleye length groups (Table 5-1).

Table 5-1. Estimated passage success for three length groups of walleye using average velocity at difficult swimpaths. A 'Y' designation indicates at least 50% of the population would pass.

			Total Length Groups		
Location	CFS	Swimpath #	0.38 m TL (15 in)	0.43 m TL (17 in)	0.51 m TL (20in)
Fulton Street to Blue Bridge	5,000	1	Y	Y	Y
		2	N	N	N
		3	Y	Y	Y
Grand Rapids Public Museum to Pearl Street	5,000	4	Y	Y	Y
		5	N	N	Y
		6	Y	Y	Y
Pearl Street to Gillet Bridge	3,900	7	Y	Y	Y
		8	N	N	Y
		9	Y	Y	Y
		10	Y	Y	Y
Fulton Street to Blue Bridge	2,500	11	N	N	Y
		12	N	N	N
		13	Y	Y	Y
		14	Y	Y	Y
		15	Y	Y	Y

The boulder cluster swimpaths (3, 6, and 14) were passable at each location for all walleye lengths. The backwater effect from the boulders, and decreased local flow where fish can rest, were discernable in the line graphs and showed a benefit to the modelled energy expended along the swimpaths. The depth along all swimpaths was >0.4 m except for Swimpath 6 when the path approached boulders, although deeper depths could be easily accessed by a fish if it's the path was altered slightly. Boulder clusters are a common design feature in each of the four reaches. Accordingly, passage of walleye and other similar species would be predicted to pass at each of the boulder cluster structures that were not analyzed.

Riffle feature swimpaths were placed at nine locations (Swimpaths 2, 4, 5, 8, 9, 11-13, 15) and at varying discharge conditions (Appendix C). Four of the eight swimpaths were estimated to have complete passage for all length groups of walleye, while two other swimpaths allowed passage of the largest length group. In Swimpath 2, a barrier to all length groups was due to a long travel distance at velocities near 1.5 m/s. For passage, fish would need to alter their route to exploit the lower sustained velocities near the riffle margins, use adjacent boulder areas, or exploit near-bed flows. In Swimpath 12, the barrier was largely produced by 2 m/s velocities at the crest of the weir structure, although fish could pass by accessing the margins of the crest where lower velocities exist. Even during low-flow conditions (2,500 cfs) the swimpaths maintained depths >0.4 m and would allow for fish to exploit reduced velocity near-bed flows.
Two swimpaths (7, 10) were positioned at near shore (margin) areas and used to evaluate small, j-hook structures in the design. The features are adjacent to the Grand Rapids Public Museum and just below the JW Marriott hotel. Both features produced conditions to pass walleye from all length groups. Below the proposed j-hook adjacent to the Grand Rapids Public Museum is a similar structure 83 m downstream where passage would also be expected.

A unique feature of the design is a modified W-weir (rock arch) design located between boulder clusters and constructed riffle features above the Gillett Bridge. Swimpath 1 was routed through the W-weir at the highest velocity and shallowest depth and passed over three-grade structures and three pools. The feature was passable for all length groups evaluated with a maximum of ≤50% energy reserves used during the swimpath. Over the middle weir feature the peak velocity reached 2 m/s, however because of the short distance, the fish could burst over the feature and into the recovery pool with little energy expenditure. This finding was consistent with how constructed rock arch structures are designed to function by providing hydraulic drop and resistance while allowing for a fish to pass with efficient bursts and recover in an upstream pool.

Although average velocity was the primary evaluation tool during the fish passage analysis, there were minimum depths along most of the swimpaths which exceeded 0.5 m. This amount of depth would allow adequate headroom for walleye to exploit a 0.15 m to 0.28 m (6 in to 11 in) near-bed area where reduced flows could be found. When near-bed velocities were placed into the model all 15 of the swimpaths were passable for all three size groups. The impact of near-bed flows on fish passage success is displayed for Swimpath 5 in Figure 5-1. In this example, using

average velocity calculations only the largest body sized fish was predicted to pass. However, when the near-bed velocity reduction was applied, all three body sizes were able to pass with only a small percentage of their ability to complete the swimpath used.

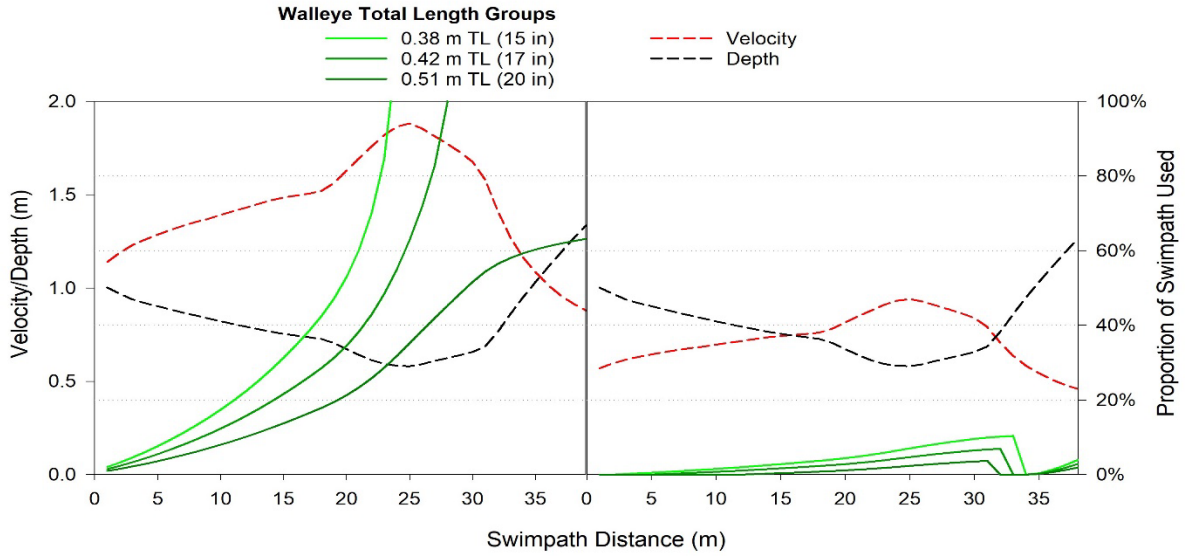

Figure 5-1. Comparison of fish passage success between depth averaged and near-bed velocities. Y-axis represents the amount of swimpath used and if 100% is reached a barrier to passage exists.

Based on these findings the proposed design is expected to function effectively to pass walleye and similar species at all habitat features. If a velocity barrier exists, near-bed velocities and less challenging routes are available.

5.2 Sturgeon Group Passage

Passage of lake sturgeon was evaluated at a boulder cluster and the W-weir. The model predicted full passage for both length groups at the boulder cluster swimpath (Swimpath 6) when using depth averaged flow velocity (5-2). As with the walleye group, the boulders provided discernable flow refugia in the line graphs by producing abrupt velocity reductions and an obvious benefit to the modelled energy expended along the route. The depth along the swimpath was greater than >0.5 m except when approaching a boulder. Deeper depths could be used by a sturgeon by altering its course slightly. The boulder cluster is a common design feature and found throughout the project area. Accordingly, passage of sturgeon would be likely at most analogous boulder features and provide upstream passage.

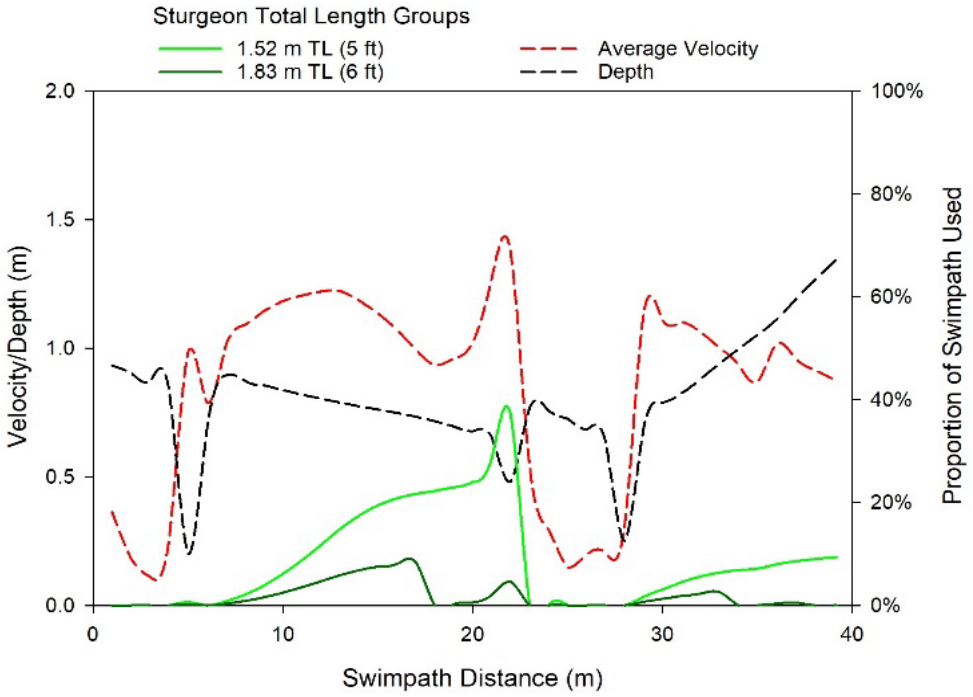

Figure 5-2. Fish passage success of lake sturgeon at boulder cluster (Swimpath 6). Y-axis represents amount of swimpath used – if 100% is reached a barrier to passage exists.

The Swimpath 1 route was used to evaluate W-weir passage and was found to be a barrier when using average velocity (Figure 5-3). The barrier was due to velocity over the middle weir crest briefly spiking to >2 m/s. Therefore, if using average velocity values, sturgeon would need to alter their route to the lower velocity areas found near the weir edges or the adjacent boulder clusters. However, using near bed velocity is an appropriate estimator for lake sturgeon if adequate depth is available for the large-bodied fish. The most challenging area along the swimpath is found at the middle weir crest with an average depth of 1.1 m (47.2 in) across a 3 m path where headroom would average 0.22 - .25 m (9-10 in). Peak velocities would be around 1.1 m/s, however, large recovery pools appropriate for sturgeon would be available immediately

above and below each crest for refugia (Daugherty et al. 2009). Sturgeon would be proficient at using the near bed conditions as they moved upstream by touching, or being close to, the river bottom where they would navigate their direction through subtle adjustments of their body in the current, and use small bursts to ascend barriers to an upstream recovery pool (Auer 2013). When using near bed velocity in the model both size groups were predicted to ascend the barrier with little energy expended (Figure 5-3). Other areas of the W-weir contain lower average and near-bed velocities with deeper depths and should provide passage at most locations.

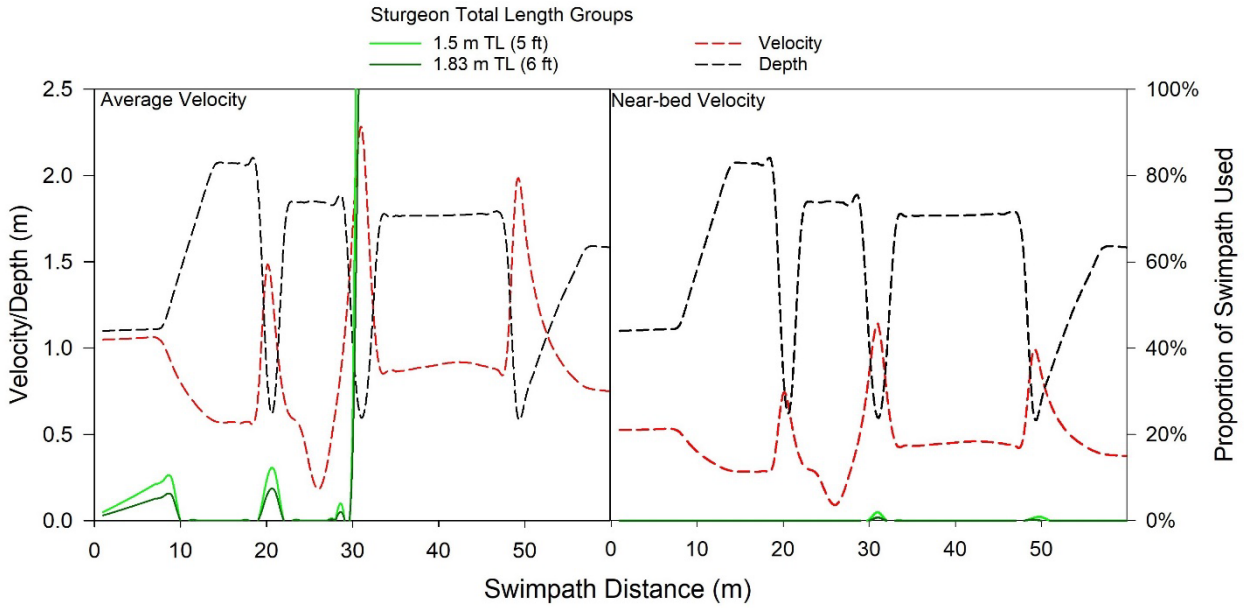

Figure 5-3. Comparison of fish passage success between depth averaged and near-bed velocities. Y-axis represents the amount of swimpath used and if 100% is reached a barrier to passage exists.

6.0 SUMMARY AND CONCLUSION

The findings of this report reinforce how the proposed design facilitates fish passage and that the naturalized design will function as predicted. Within the model used, fish passage was predicted to occur at most difficult hydraulic scenarios and for each of the design elements – boulder clusters, W-weir, and riffles. These findings also suggest that the design will allow a suite of other species to pass that have similar or greater swimming performance including the State Threatened river redhorse, other sucker species, and salmon. The current low-head dams provide a significant barrier to migration up to the 6th Street dam. The proposed design offers hydraulic conditions that facilitate fish passage for a broad group of species and at a wide range of flow conditions and incorporates natural features within the constraints of an urbanized channel.

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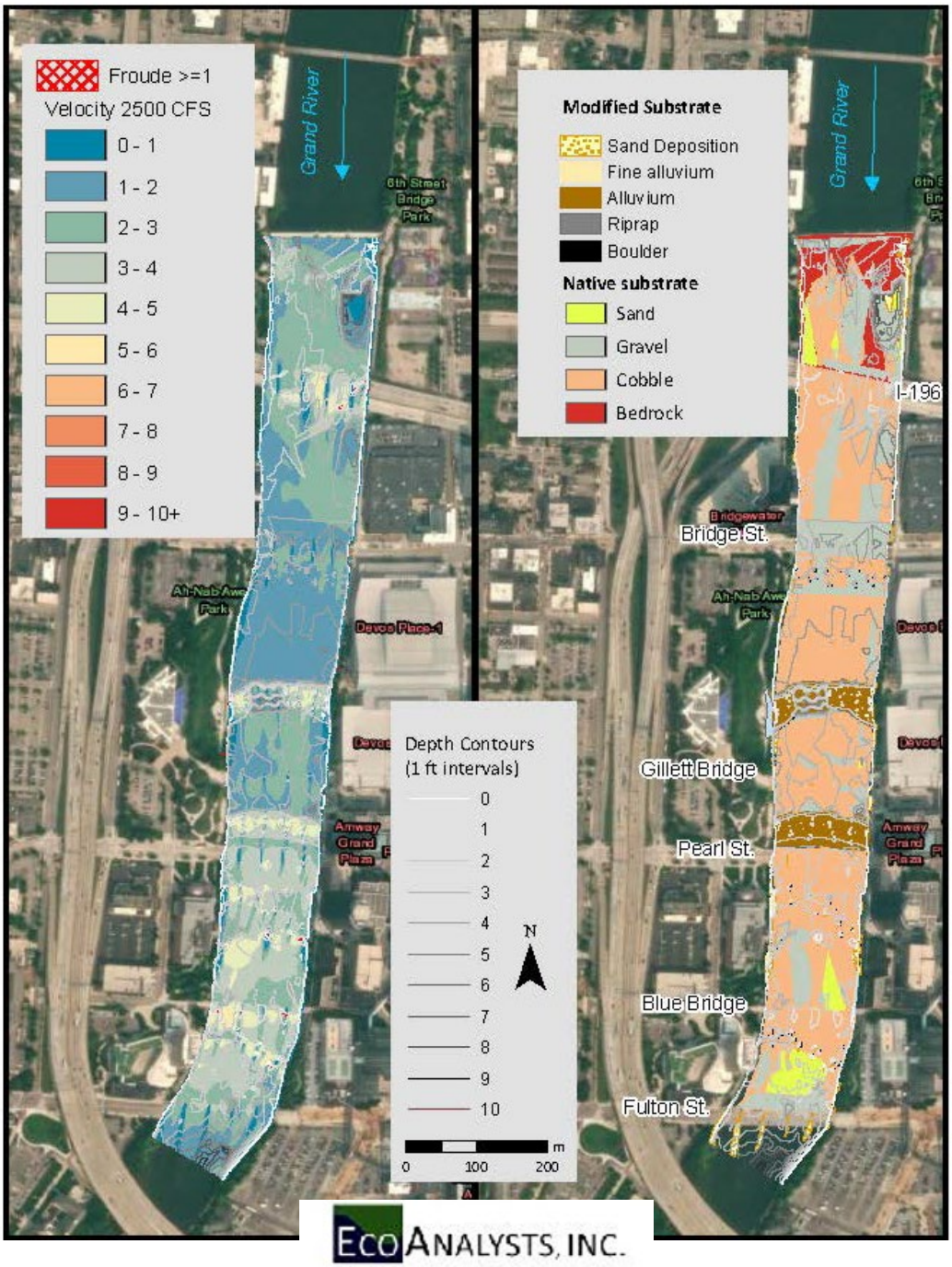
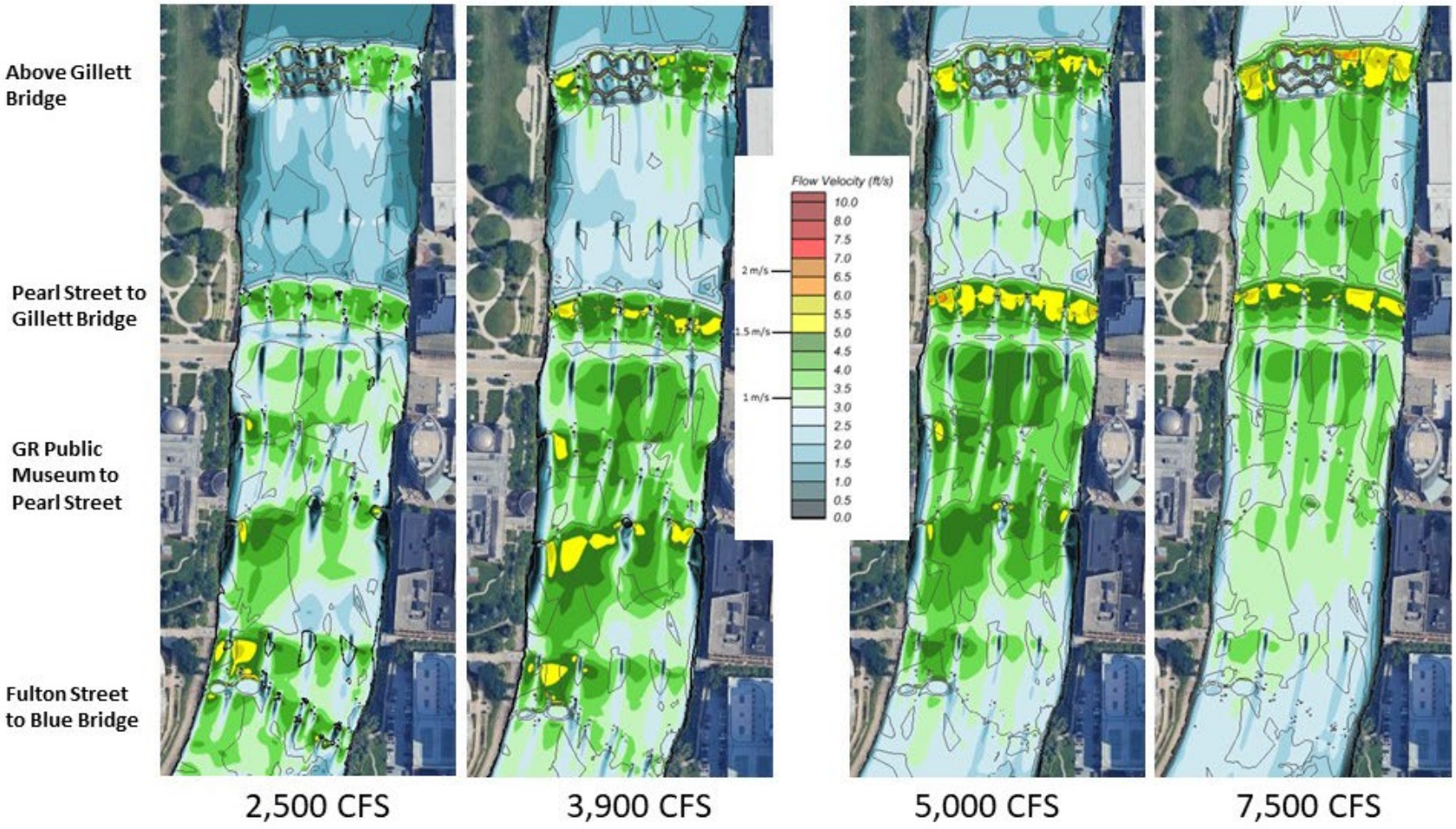
APPENDICES

Appendix A. Project area features, velocity, and substrate of the current design.

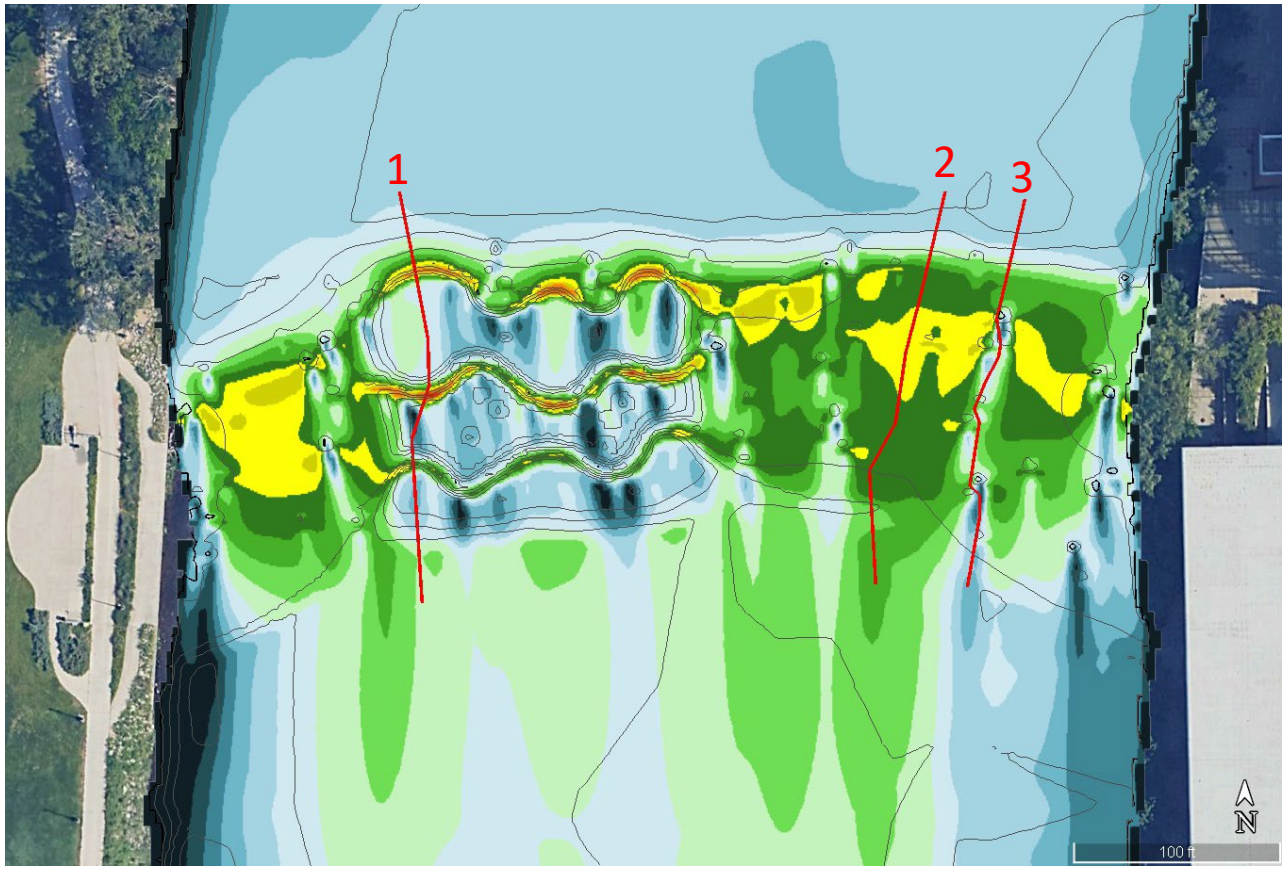


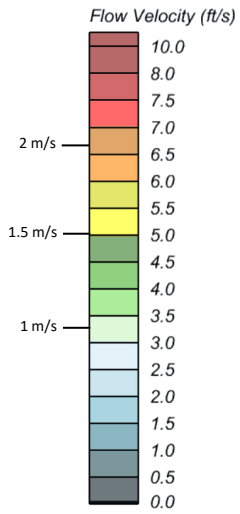
Appendix B. The project area with depth and depth-averaged velocity at 2500, 3900, 5000 and 7500 cfs.



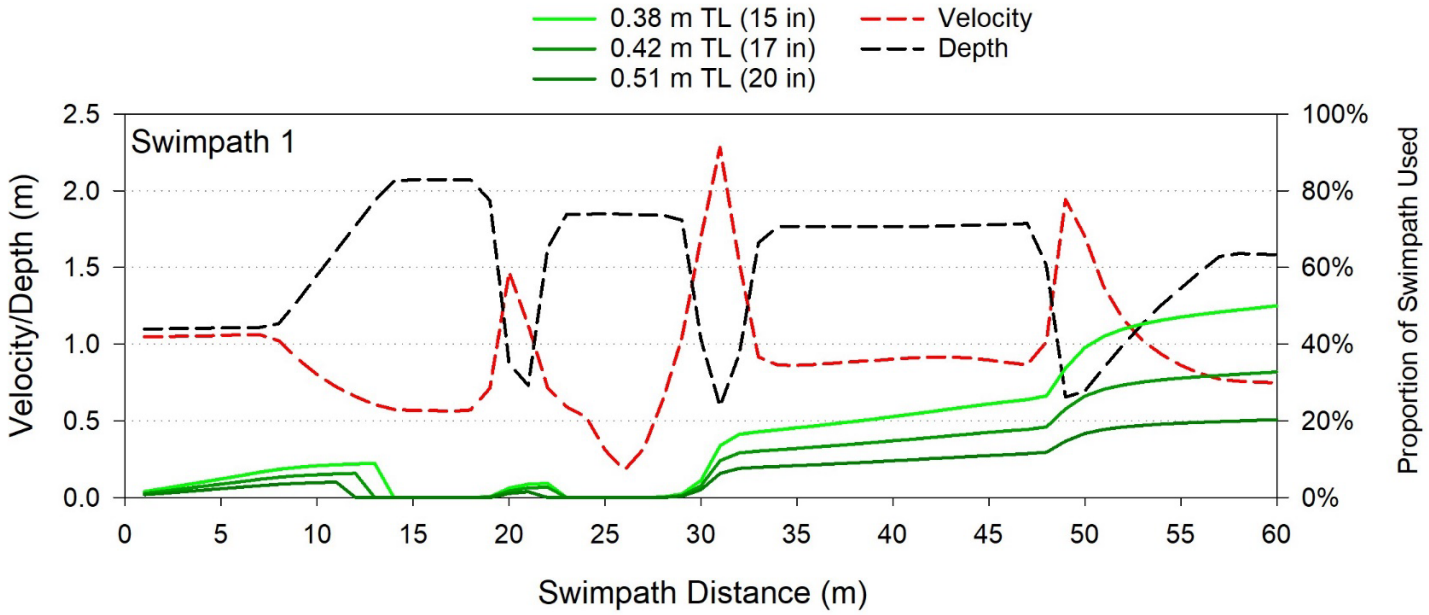
Appendix C. Depth and velocity heatmaps of project area during difficult hydraulic conditions depicting 15 swimpaths. Figures display the depth, velocity and percent of swimming distance expended for a fish traveling along each of the swimpaths.

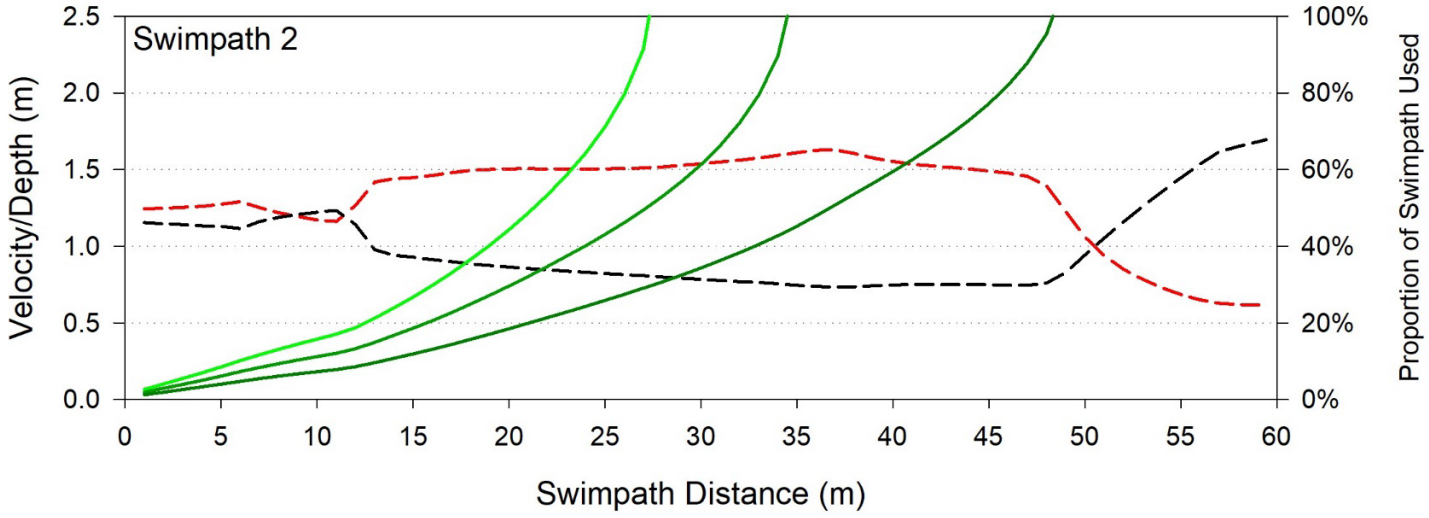
Above Gillett Bridge (W-Weir/Riffle/Boulder Cluster) 5,000 CFS

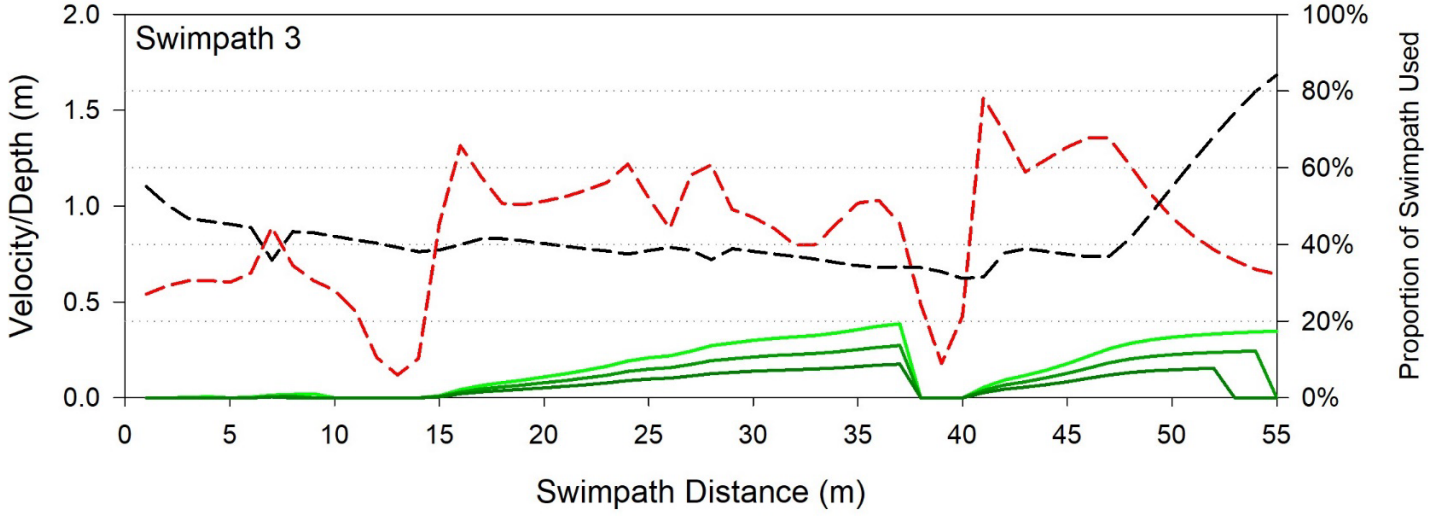




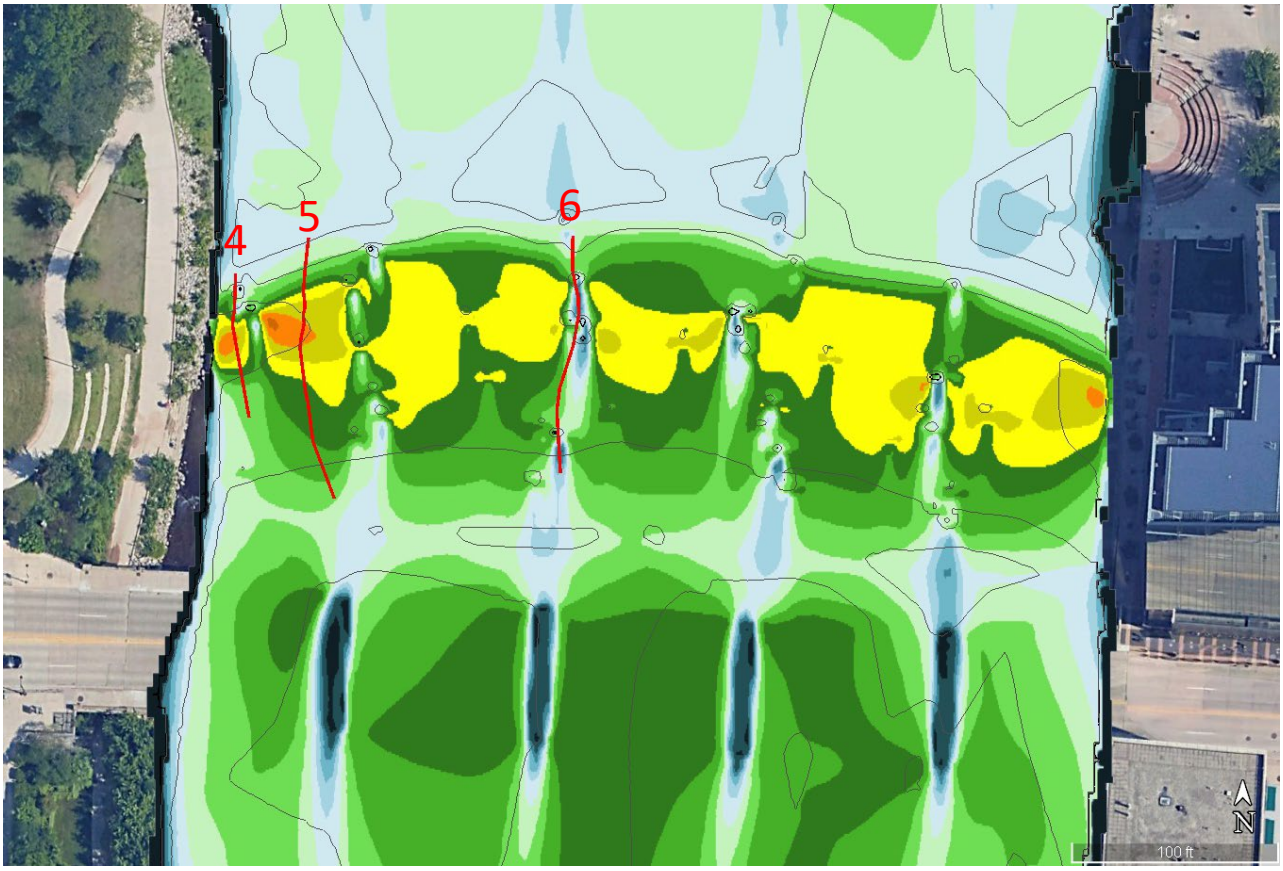
Swimpaths 1-3

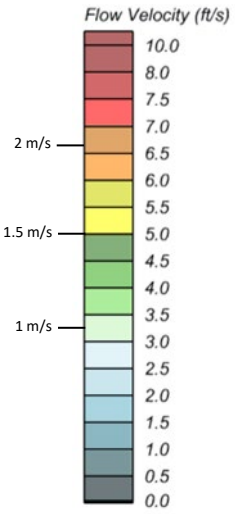




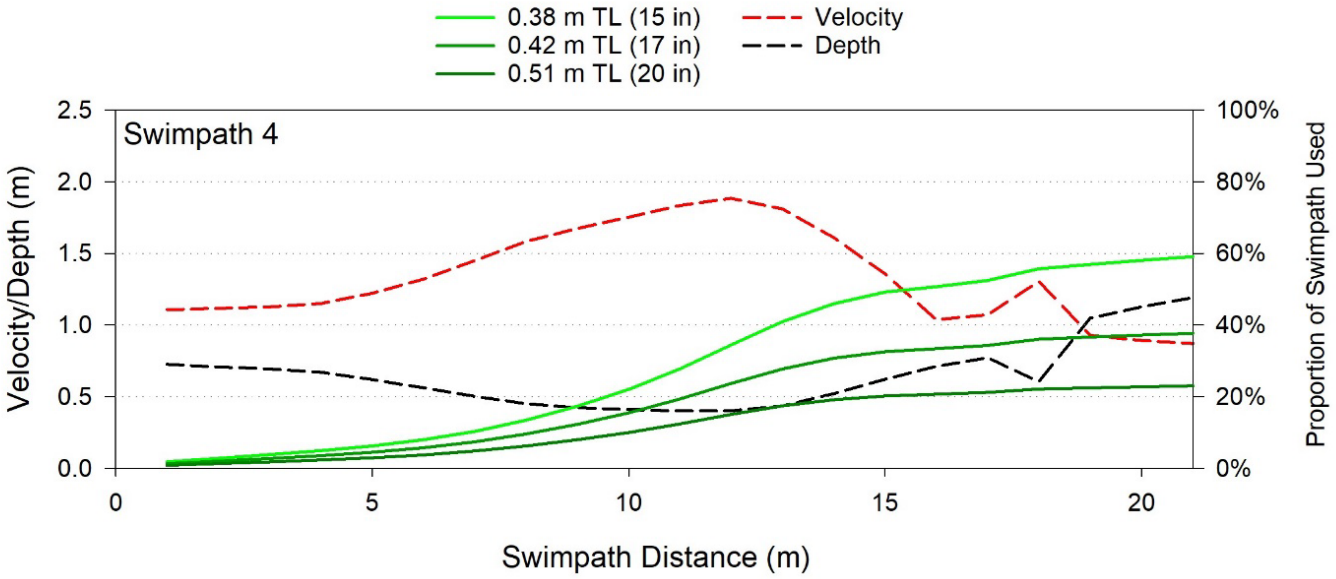


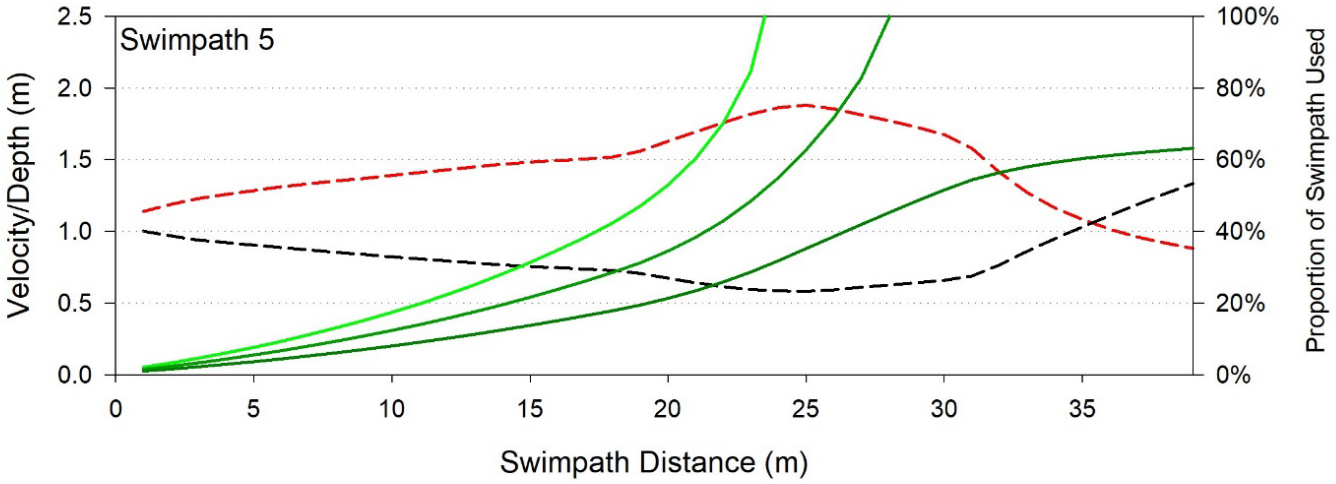
Pearl Street to Gillett Bridge (Riffle Structure/Boulder Cluster)
5,000 CFS

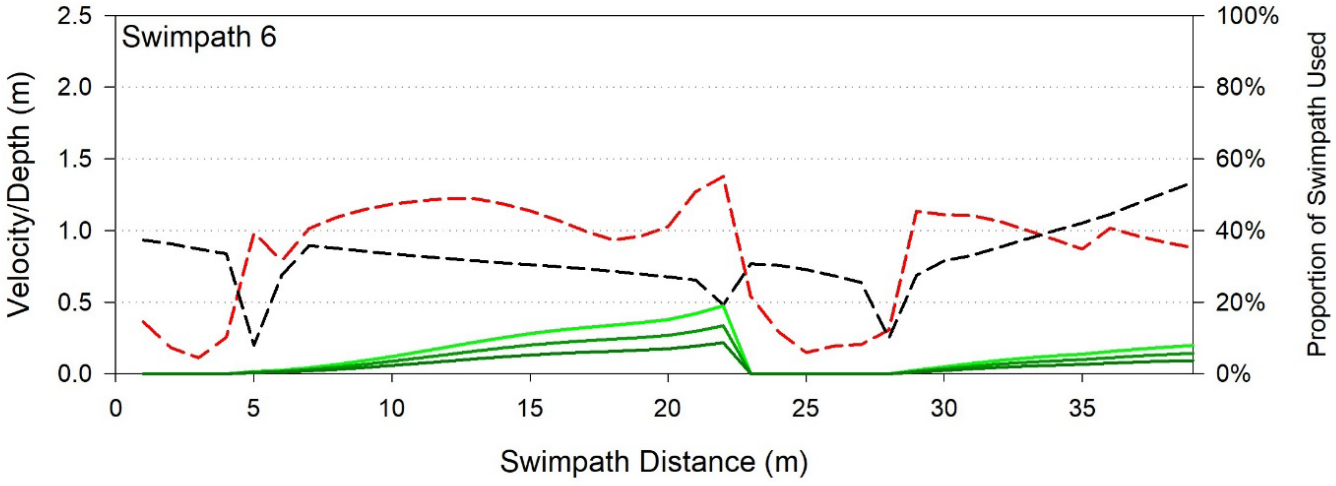




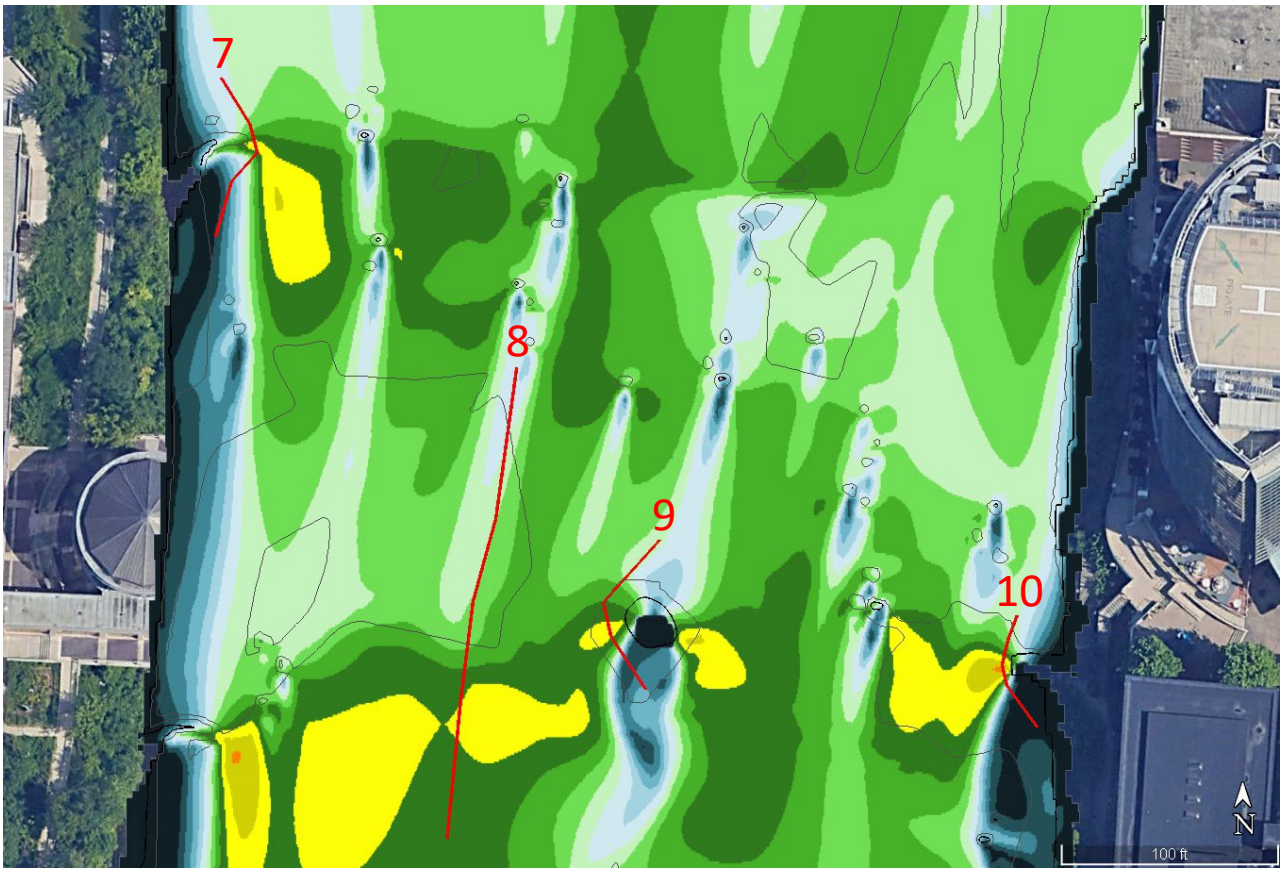
Swimpaths 4-6

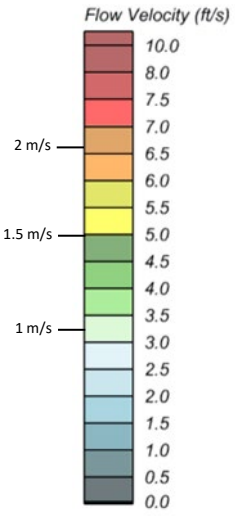




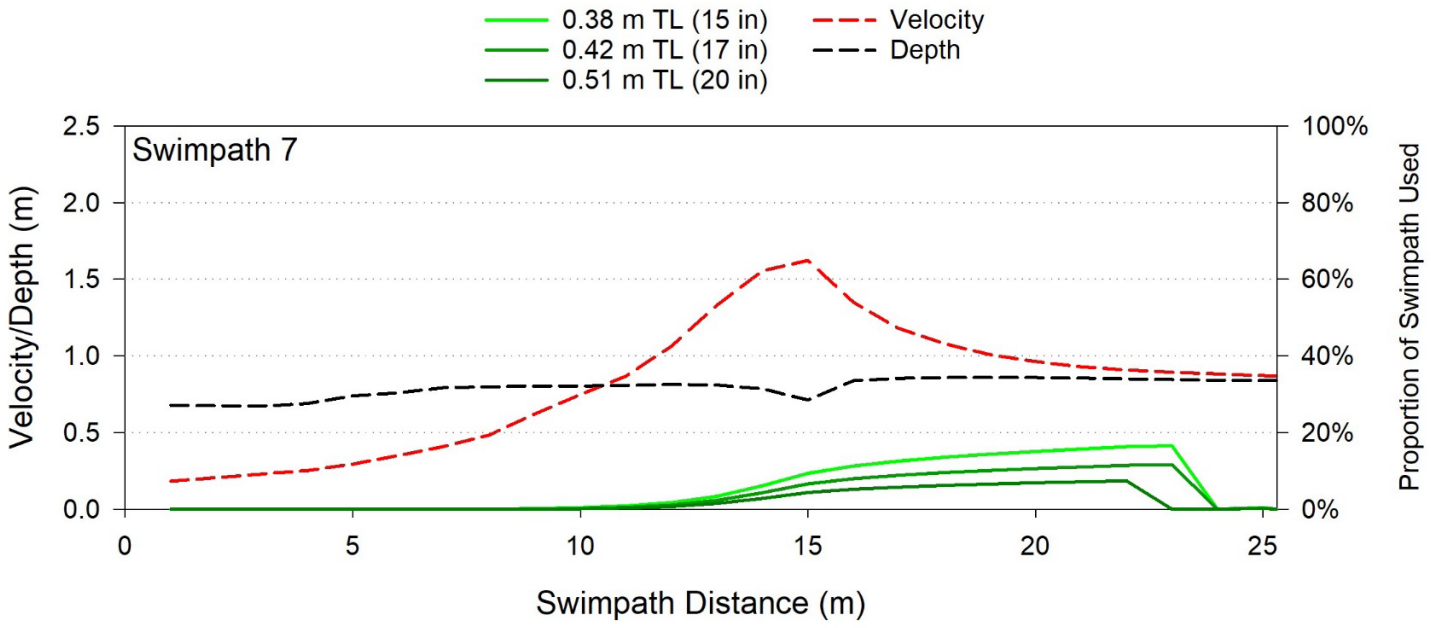


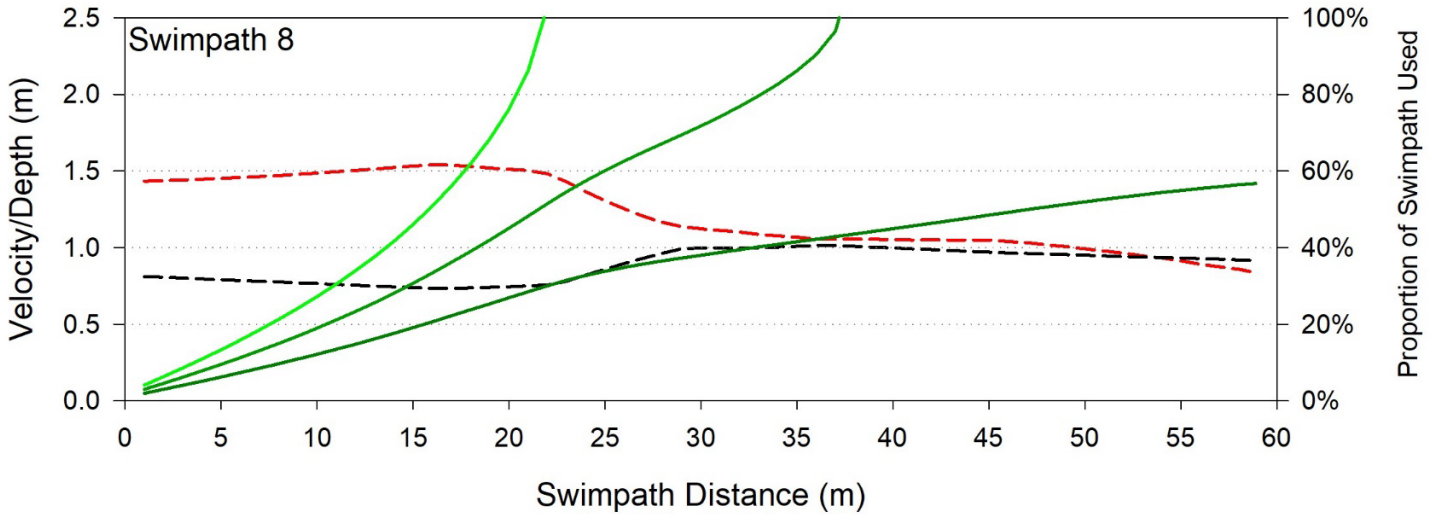
GR Public Museum to Pearl Street (J-hooks/Riffle)
3,900 CFS

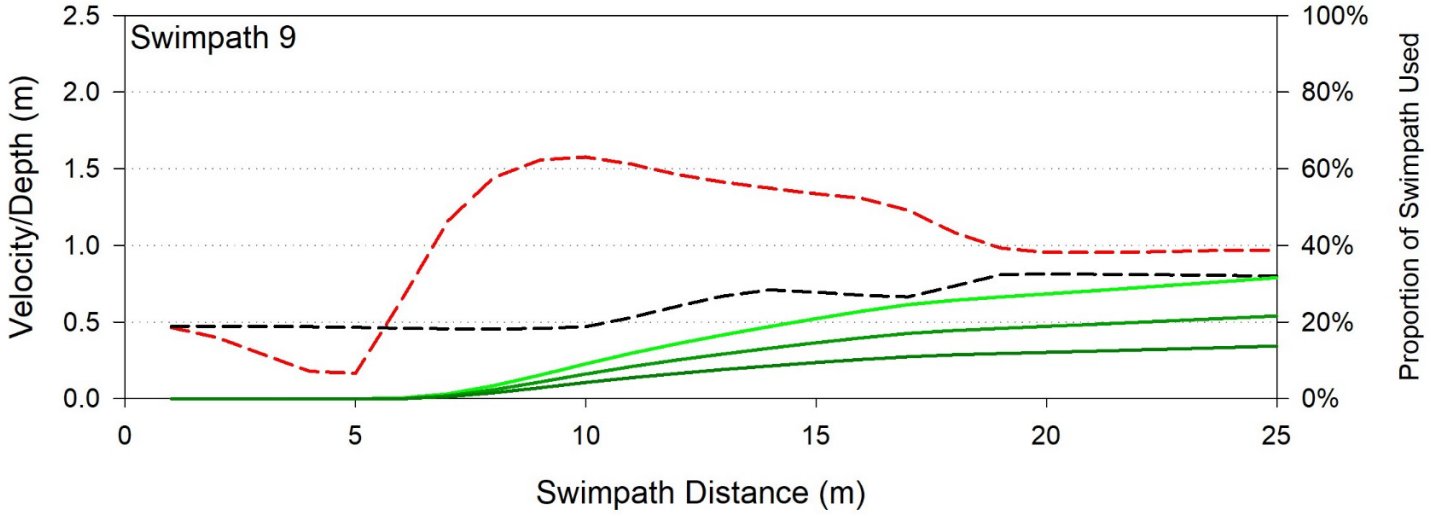




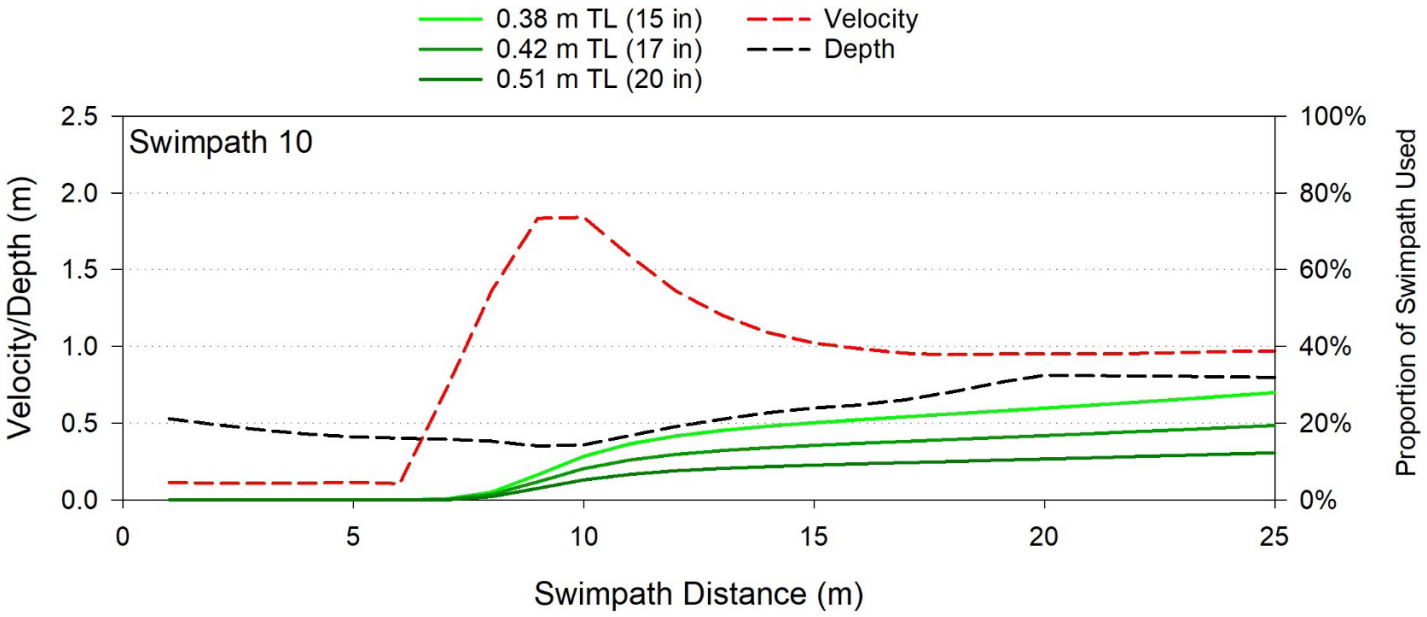
Swimpaths 7-9



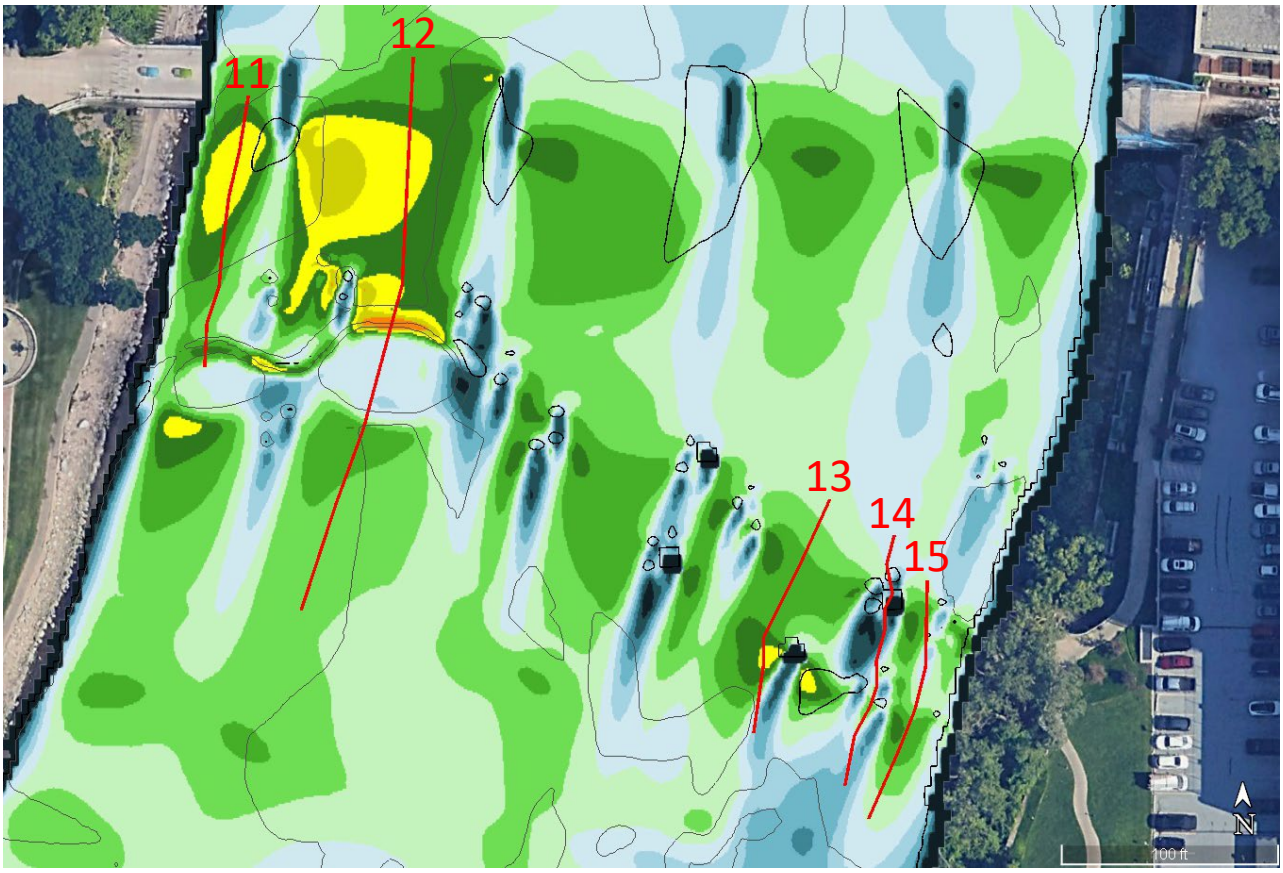


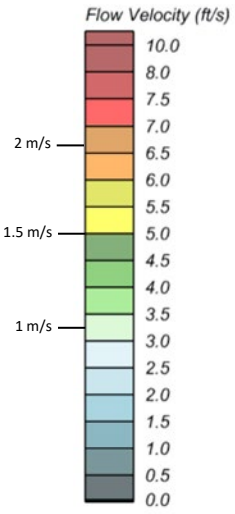


Swimpaths 10

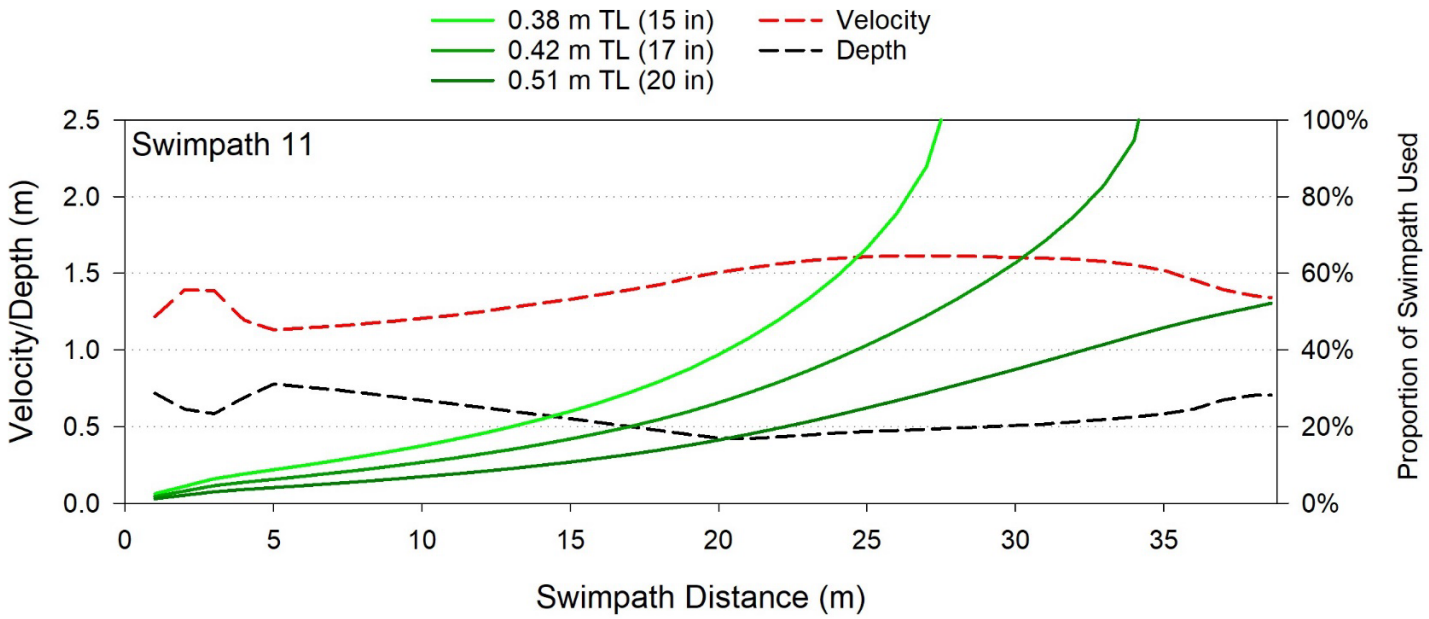


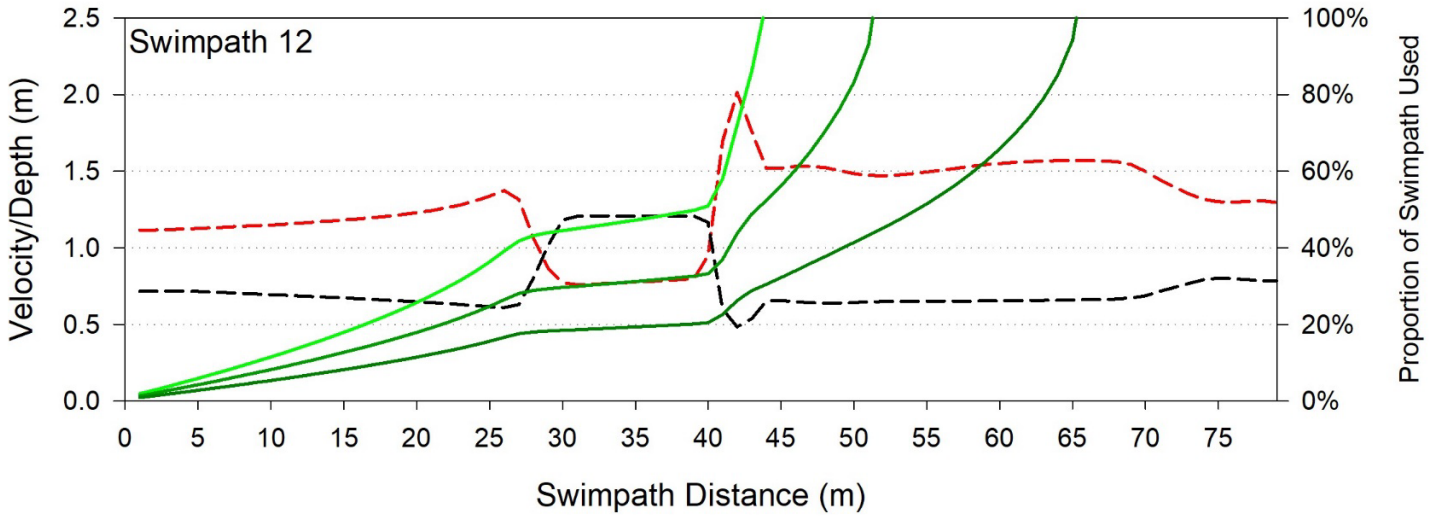
Downstream of Blue Bridge (Riffle/boulder clusters) 2,500 CFS

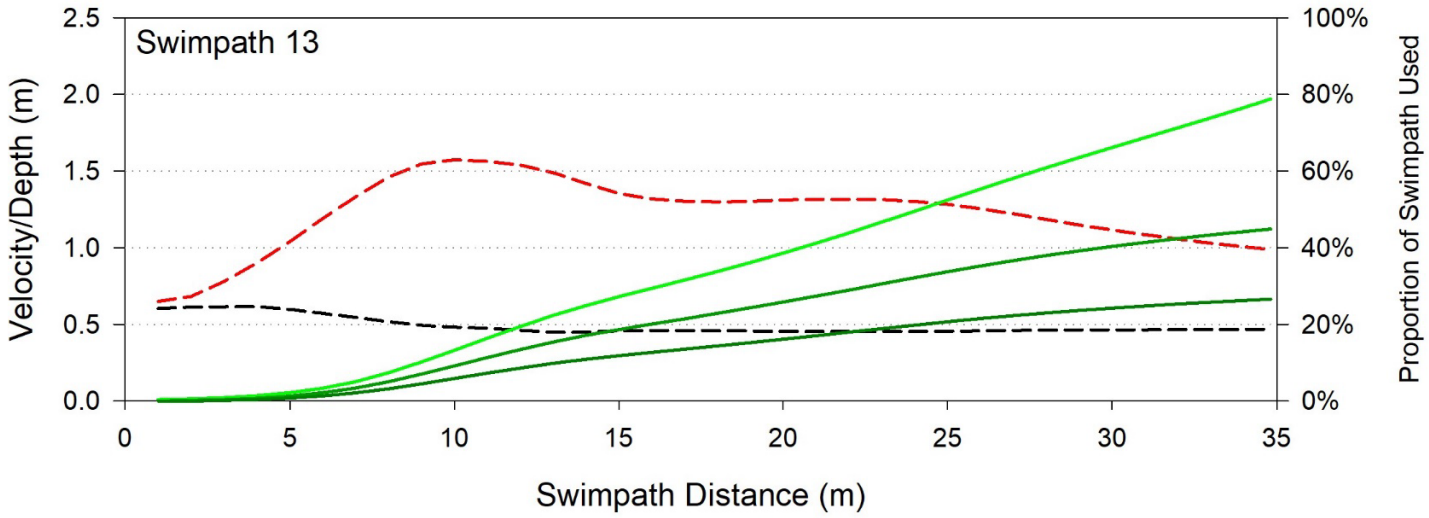




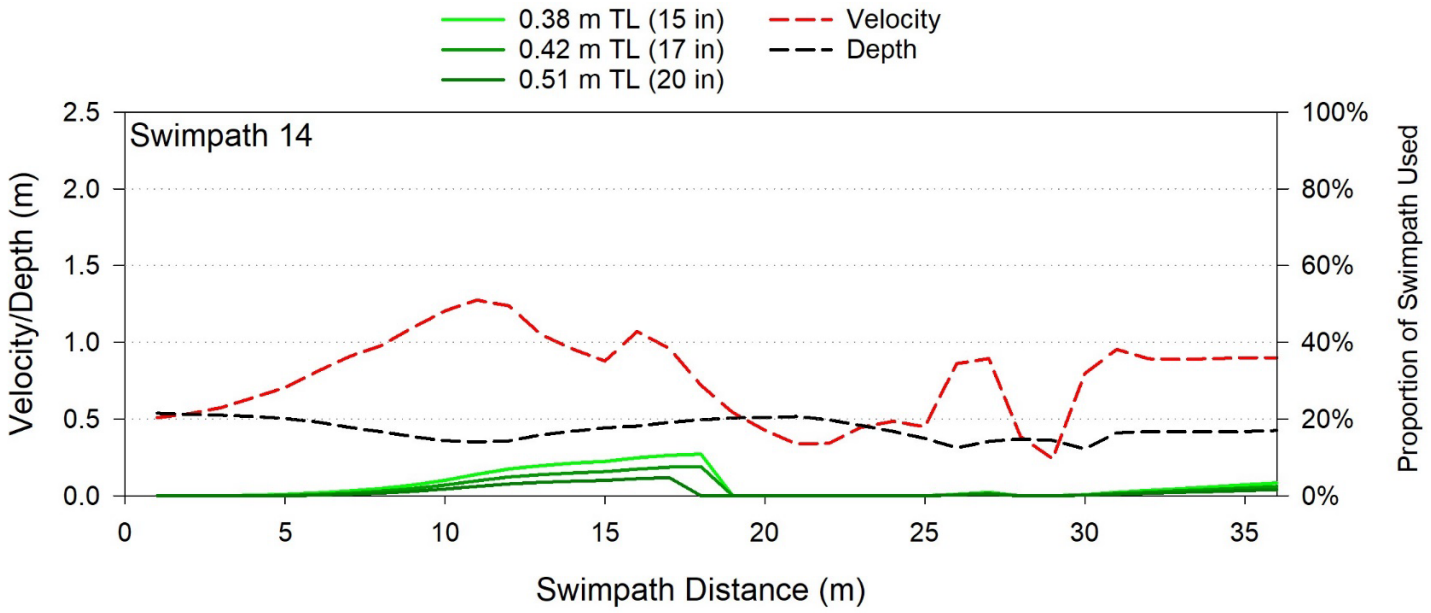
Swimpaths 11-13

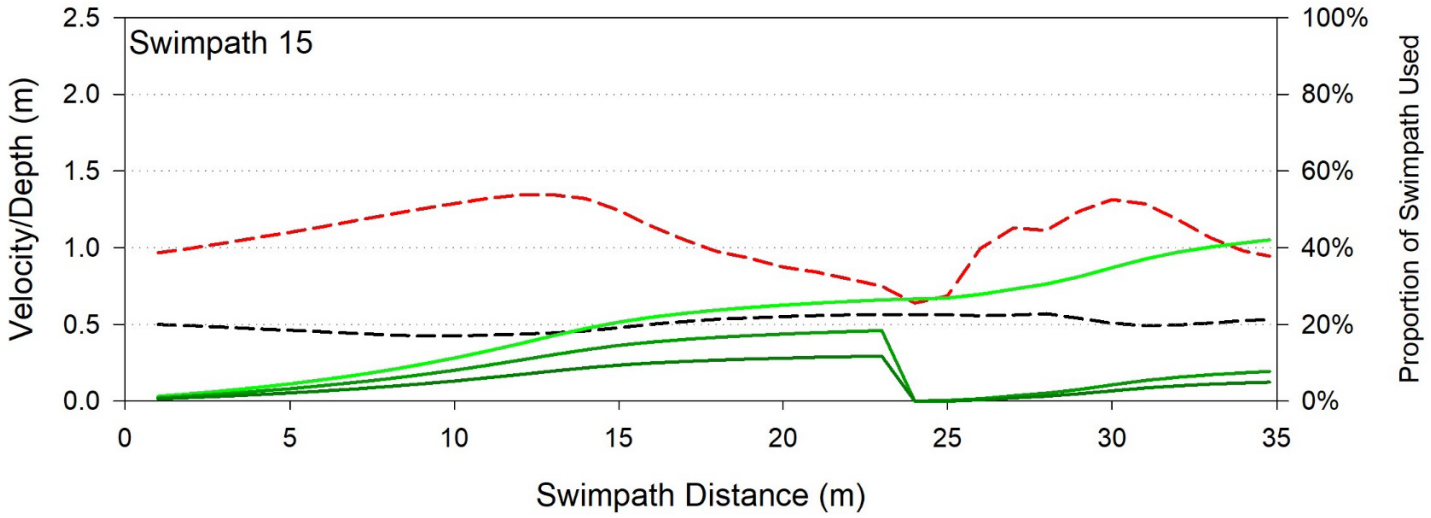




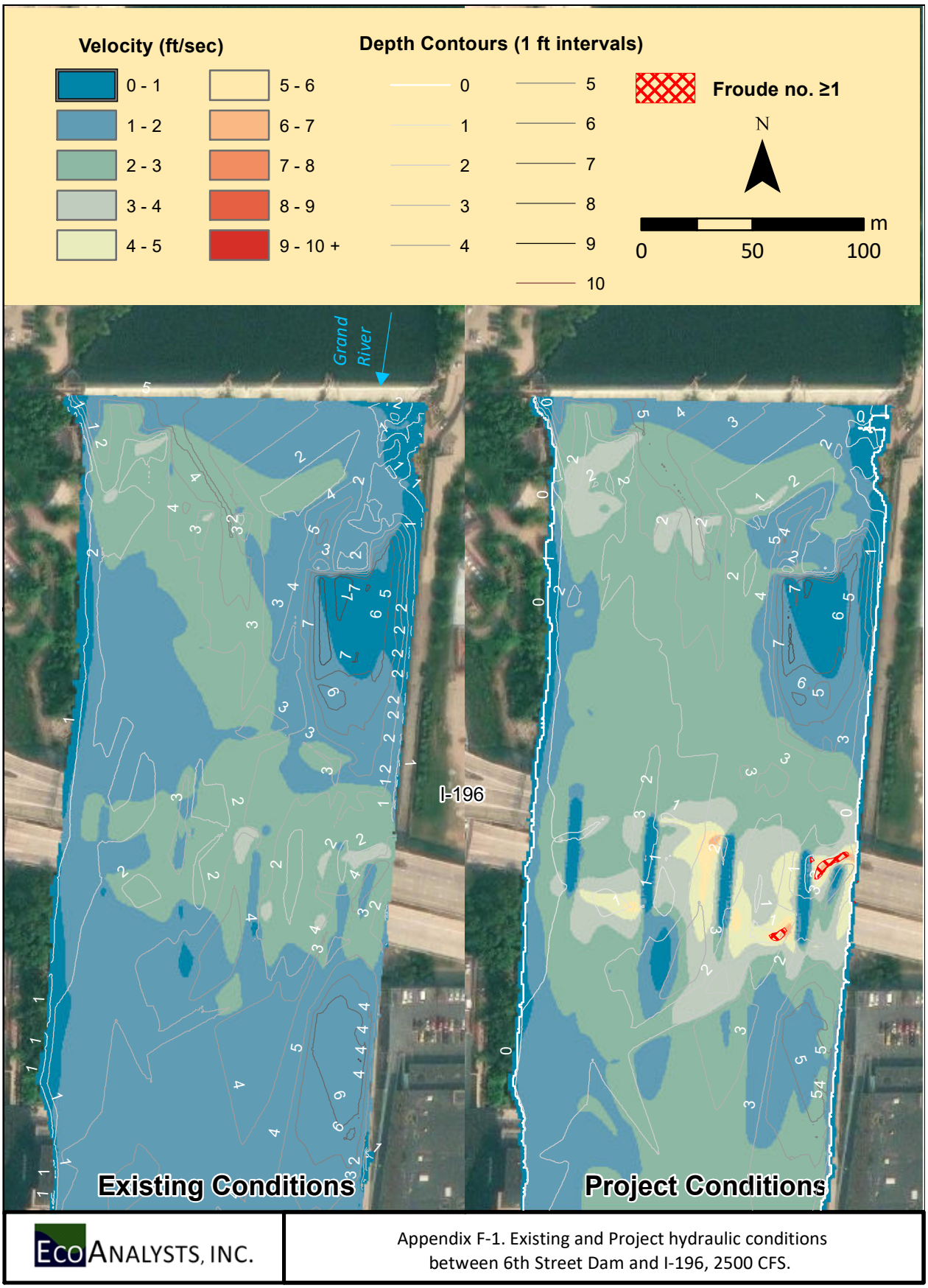


Swimpaths 14-15





Appendix F. Existing and Proposed hydraulic conditions, 2500 CFS, 3900 CFS and 7500 CFS



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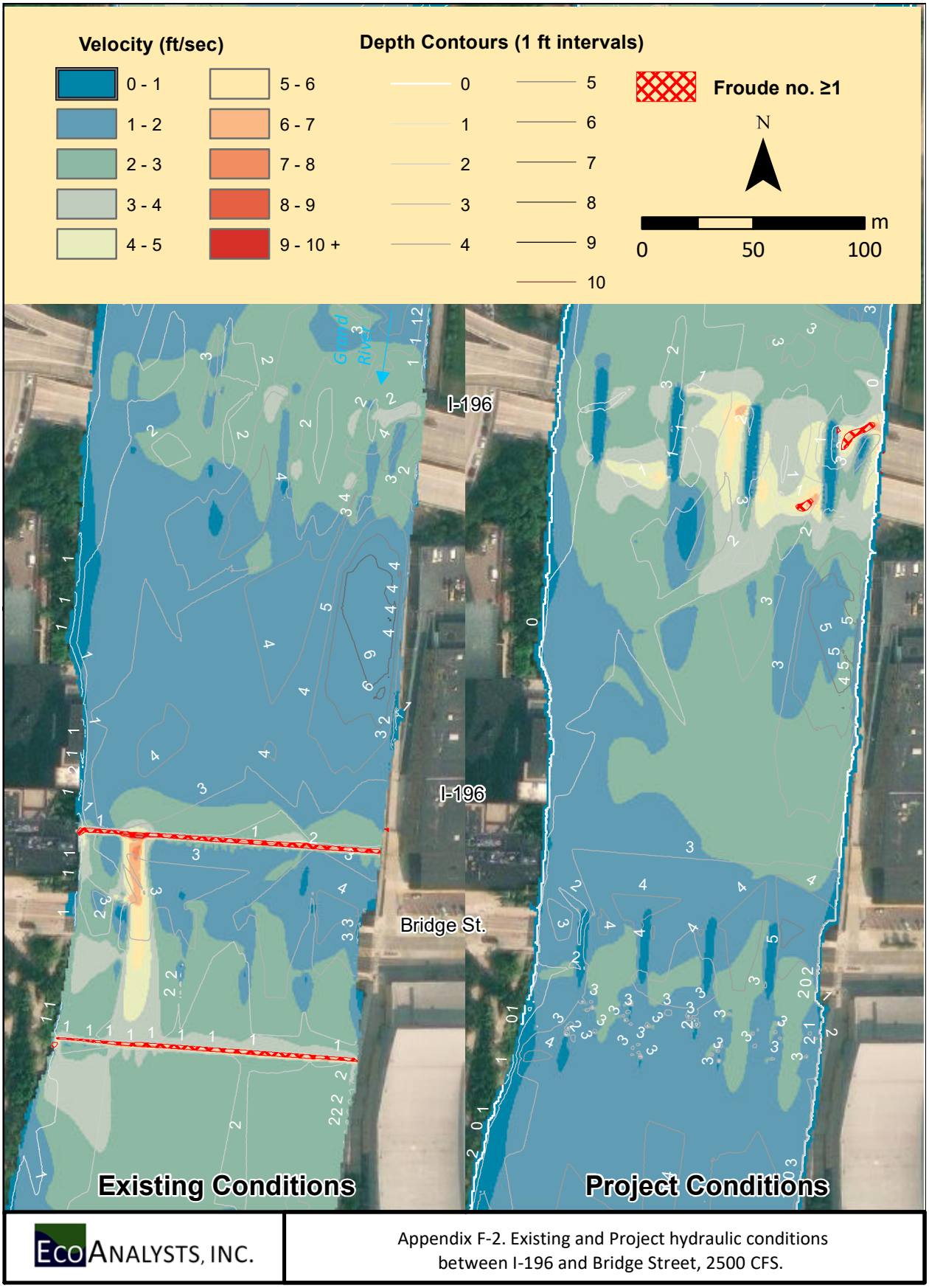
Appendix F-1. Existing and Project hydraulic conditions between 6th Street Dam and I-196, 2500 CFS.



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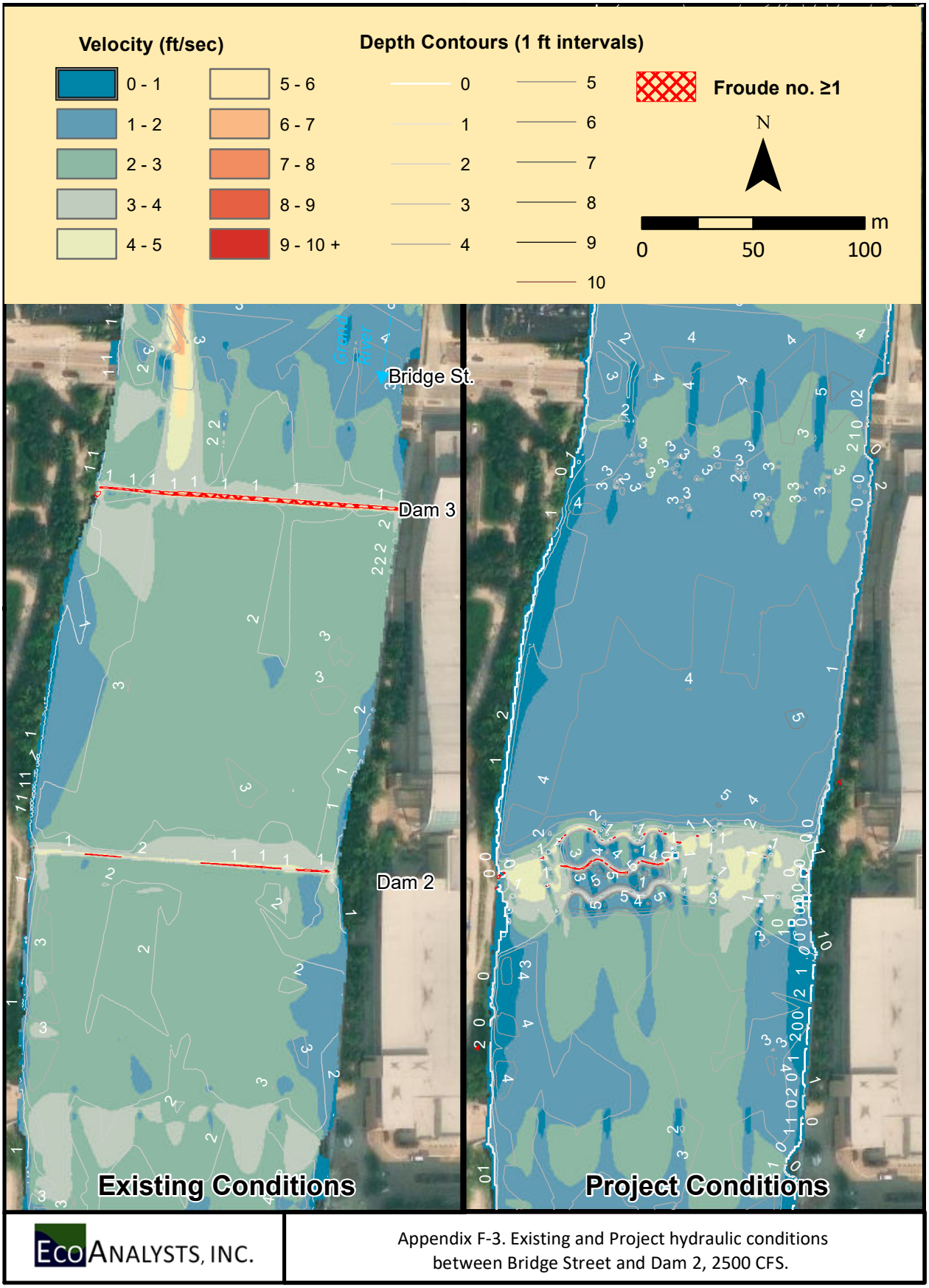
Appendix F-2. Existing and Project hydraulic conditions between I-196 and Bridge Street, 2500 CFS.



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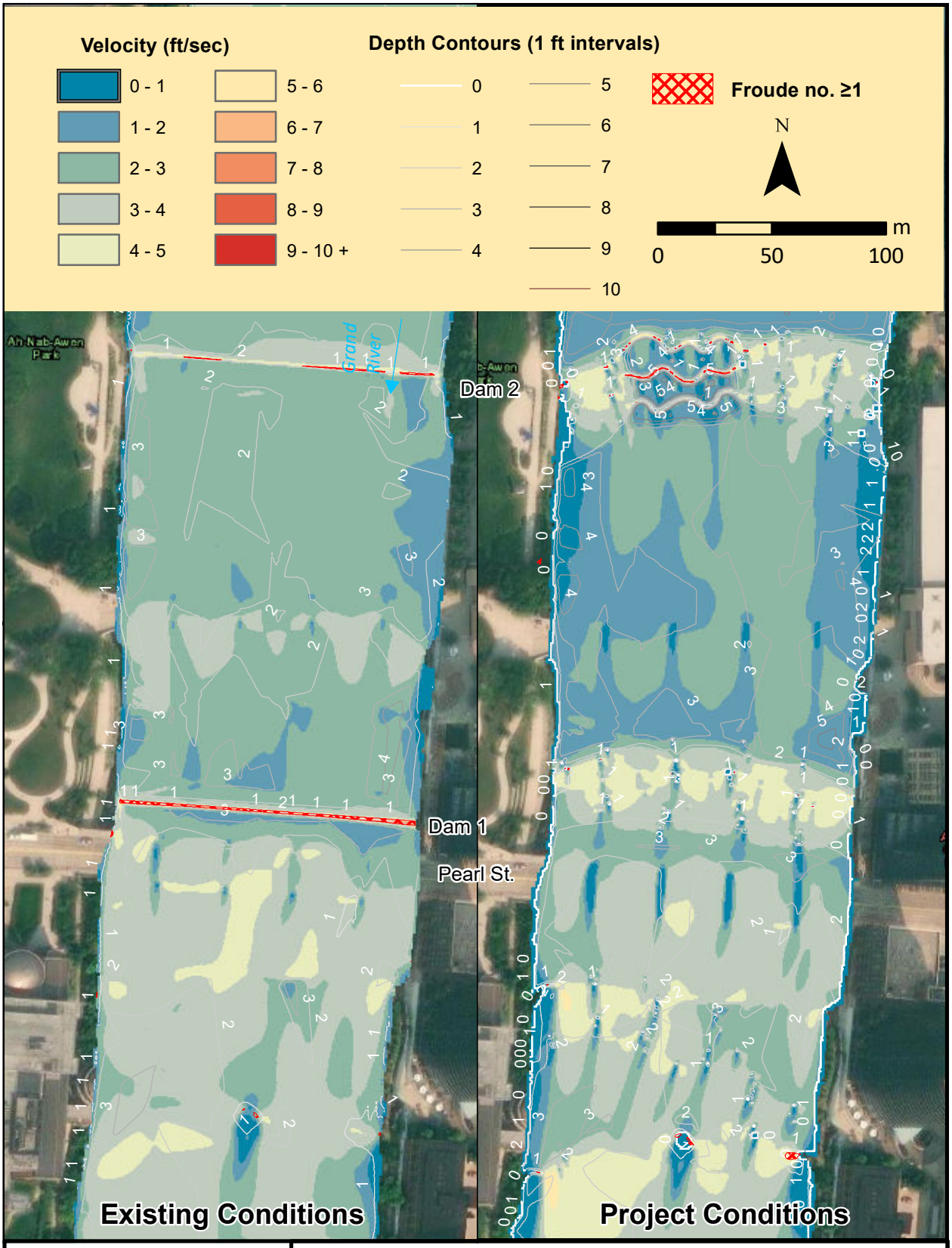
Appendix F-3. Existing and Project hydraulic conditions between Bridge Street and Dam 2, 2500 CFS.



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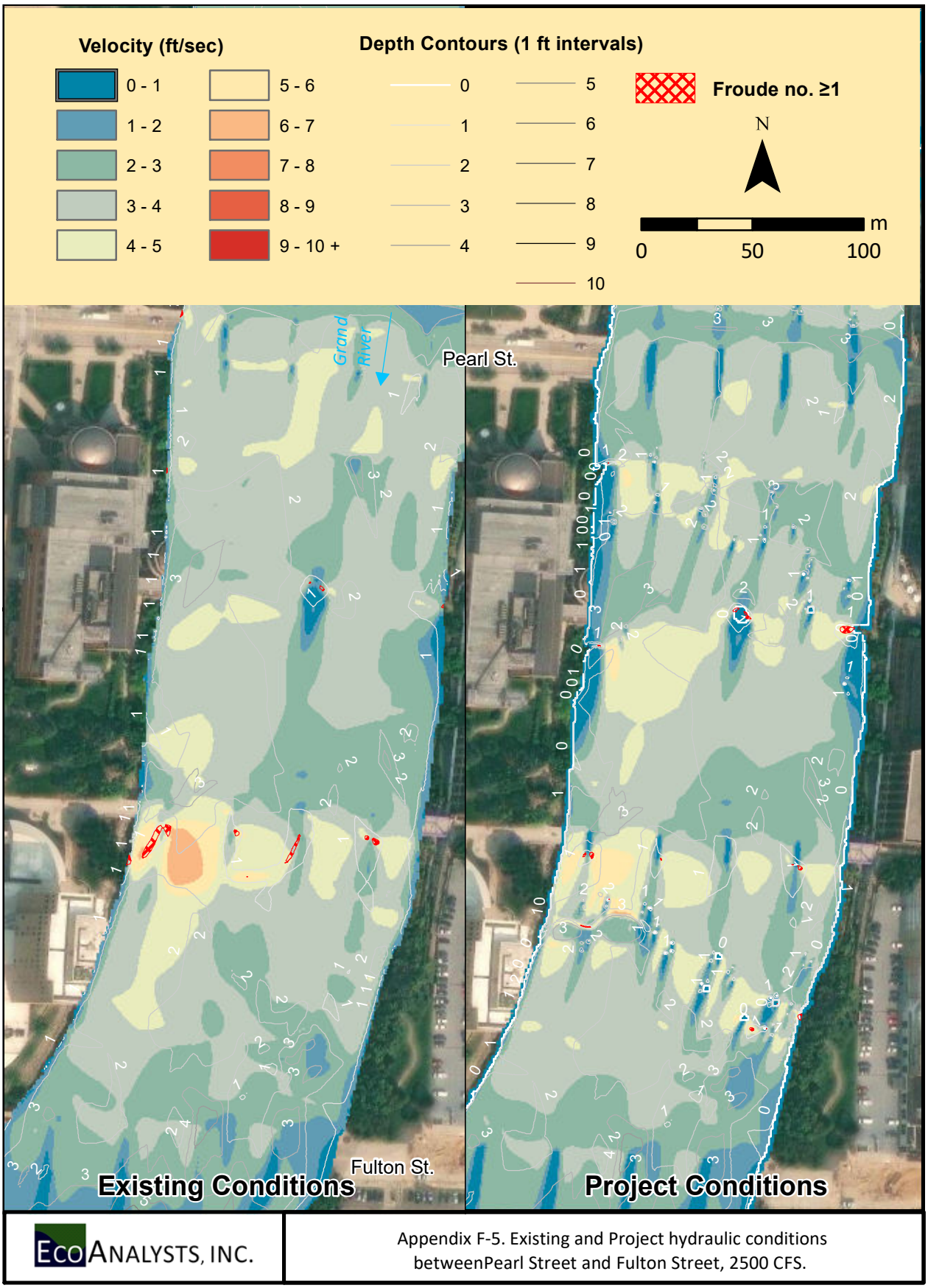
Appendix F-4. Existing and Project hydraulic conditions between Dam 2 and Pearl Street, 2500 CFS.



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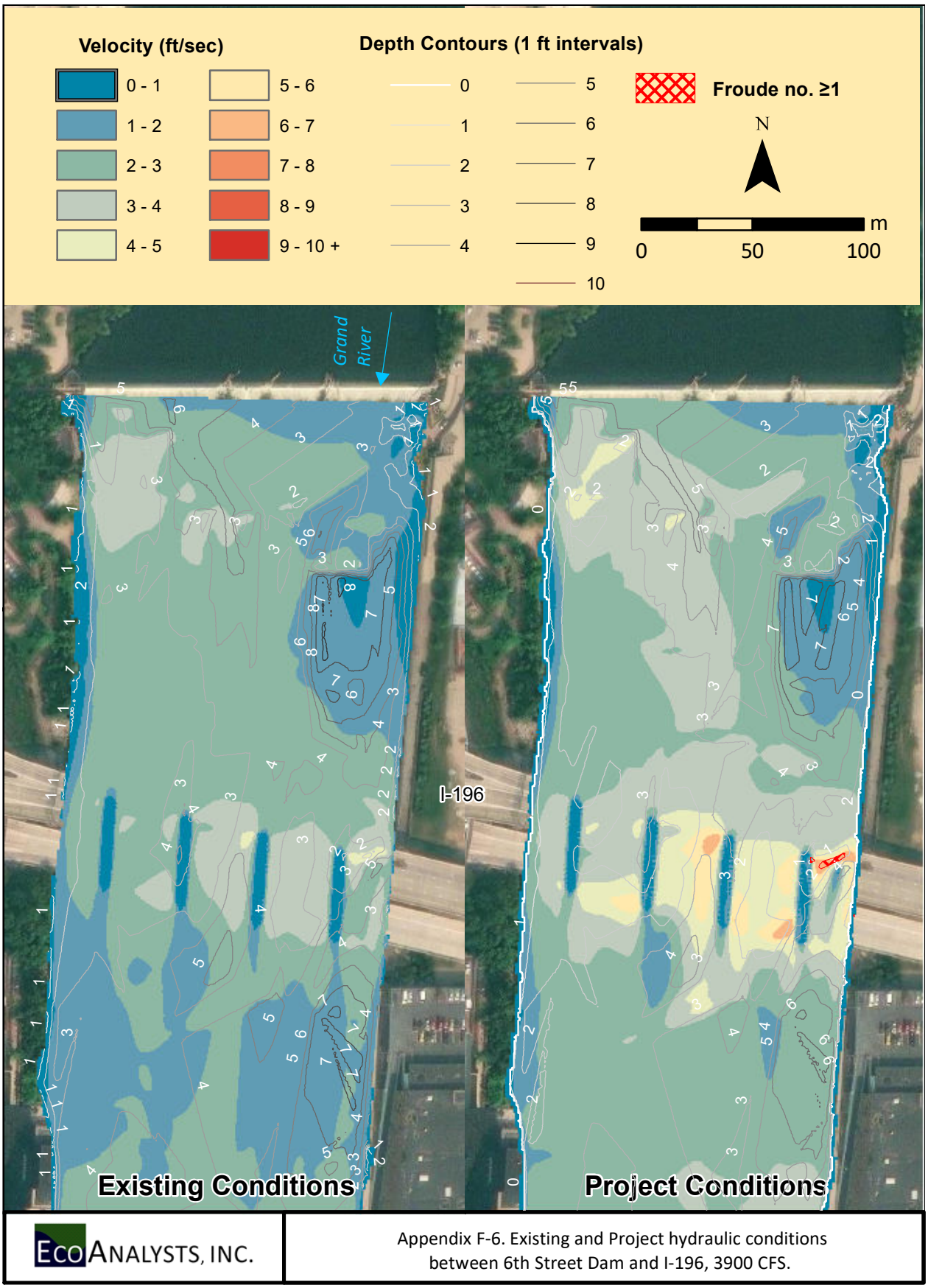
Appendix F-5. Existing and Project hydraulic conditions betweenPearl Street and Fulton Street, 2500 CFS.



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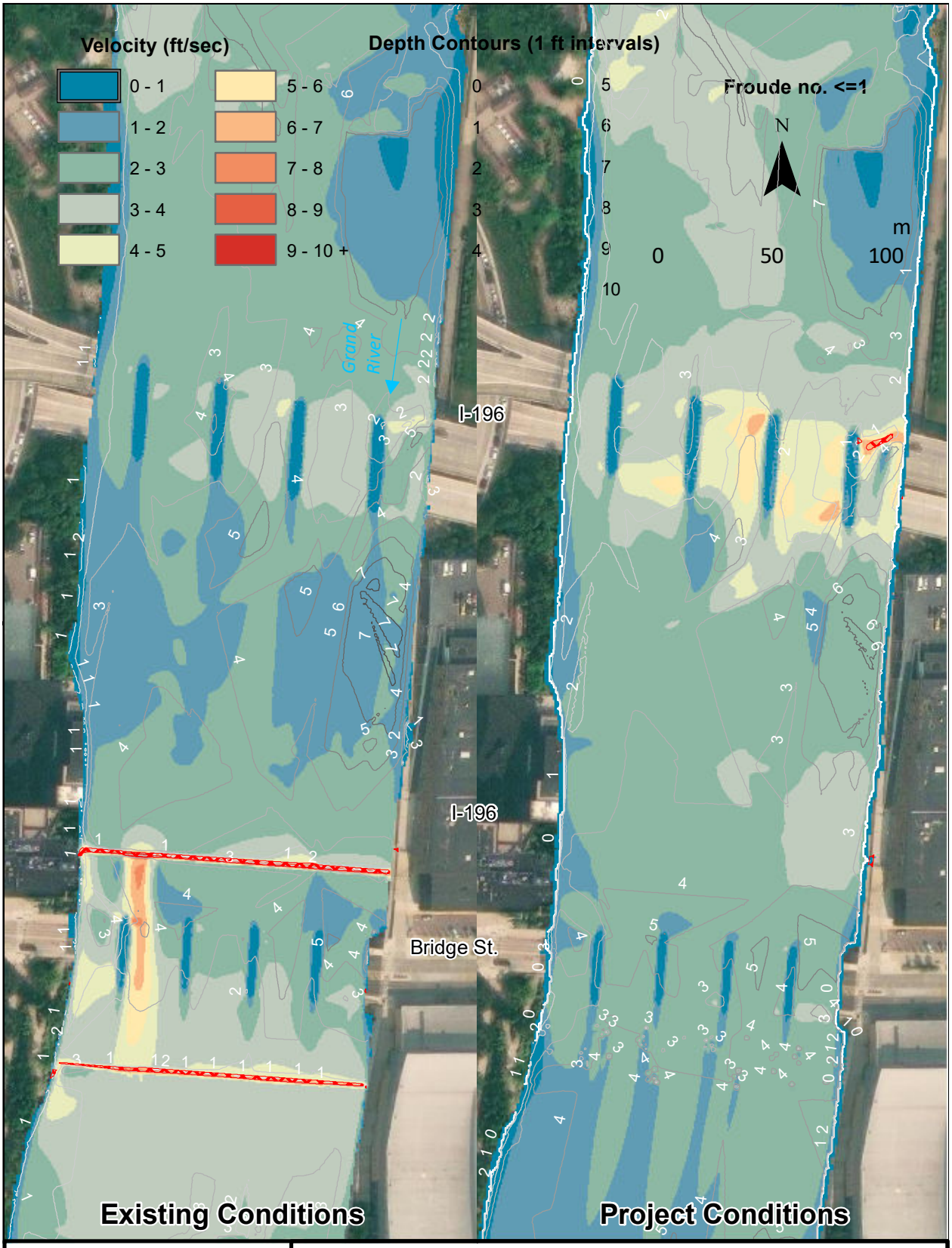
Appendix F-6. Existing and Project hydraulic conditions between 6th Street Dam and I-196, 3900 CFS.



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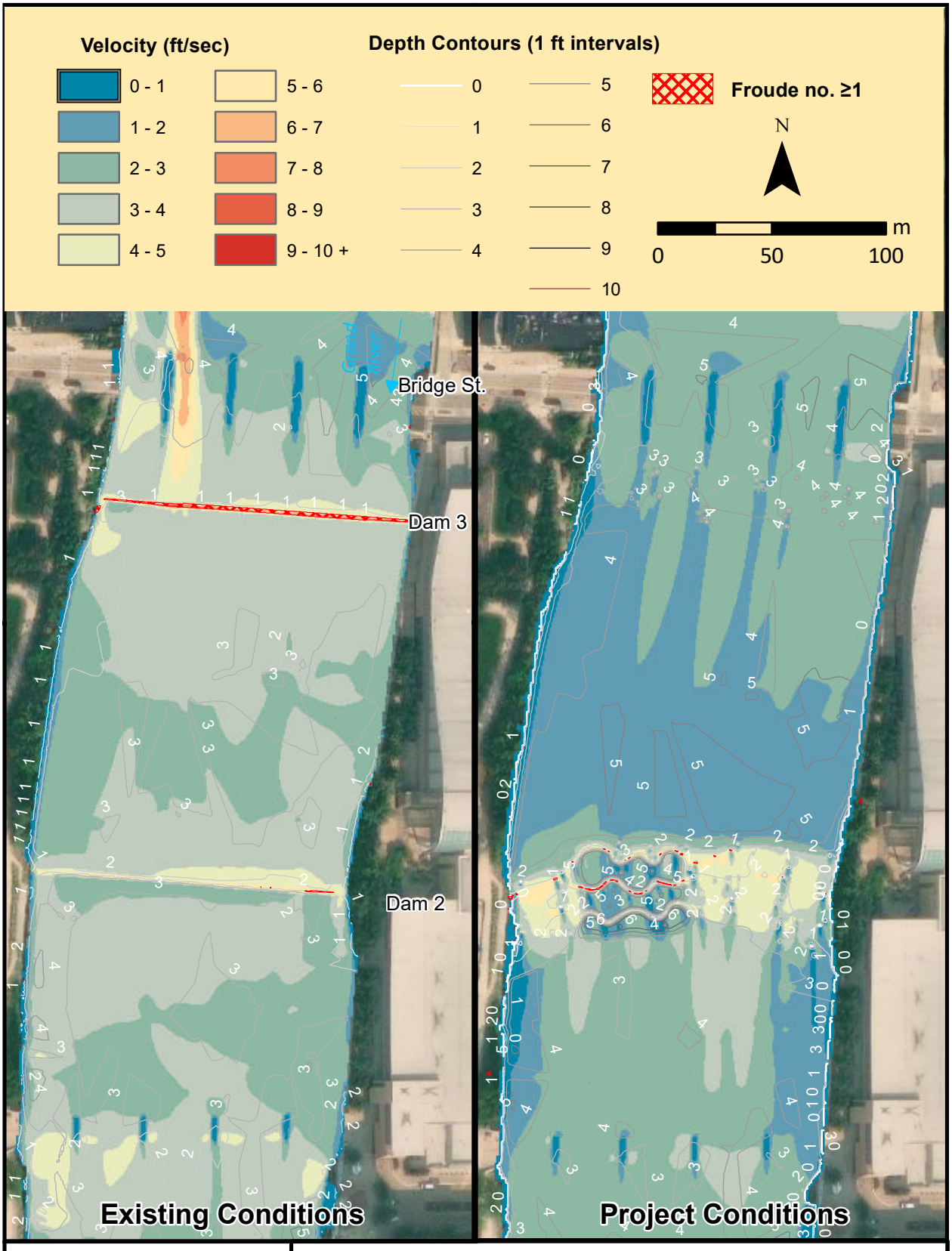
Appendix F-7. Existing and Project hydraulic conditions between I-196 and Bridge Street, 3900 CFS.



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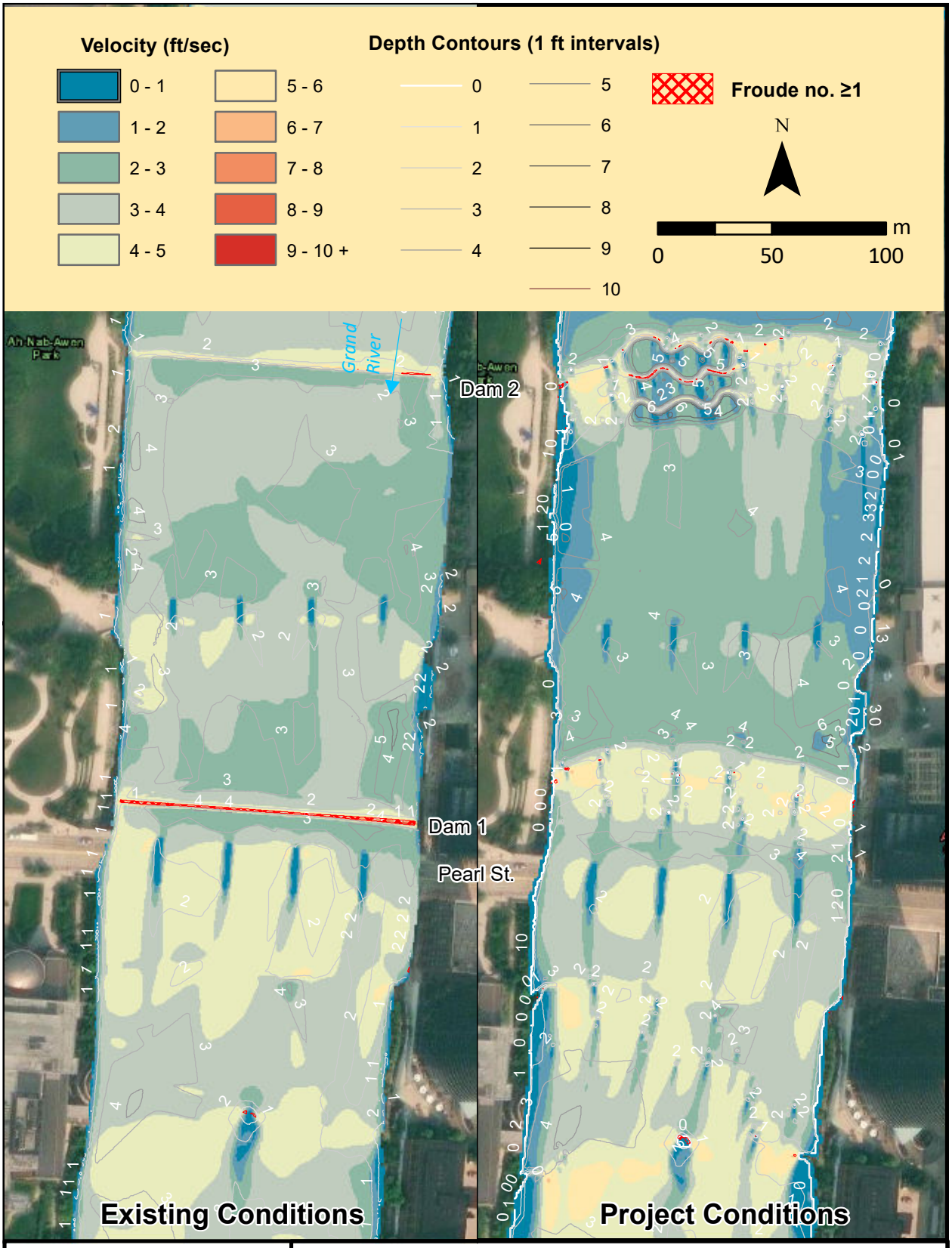
Appendix F-8. Existing and Project hydraulic conditions between Bridge Street and Dam 2, 3900 CFS.



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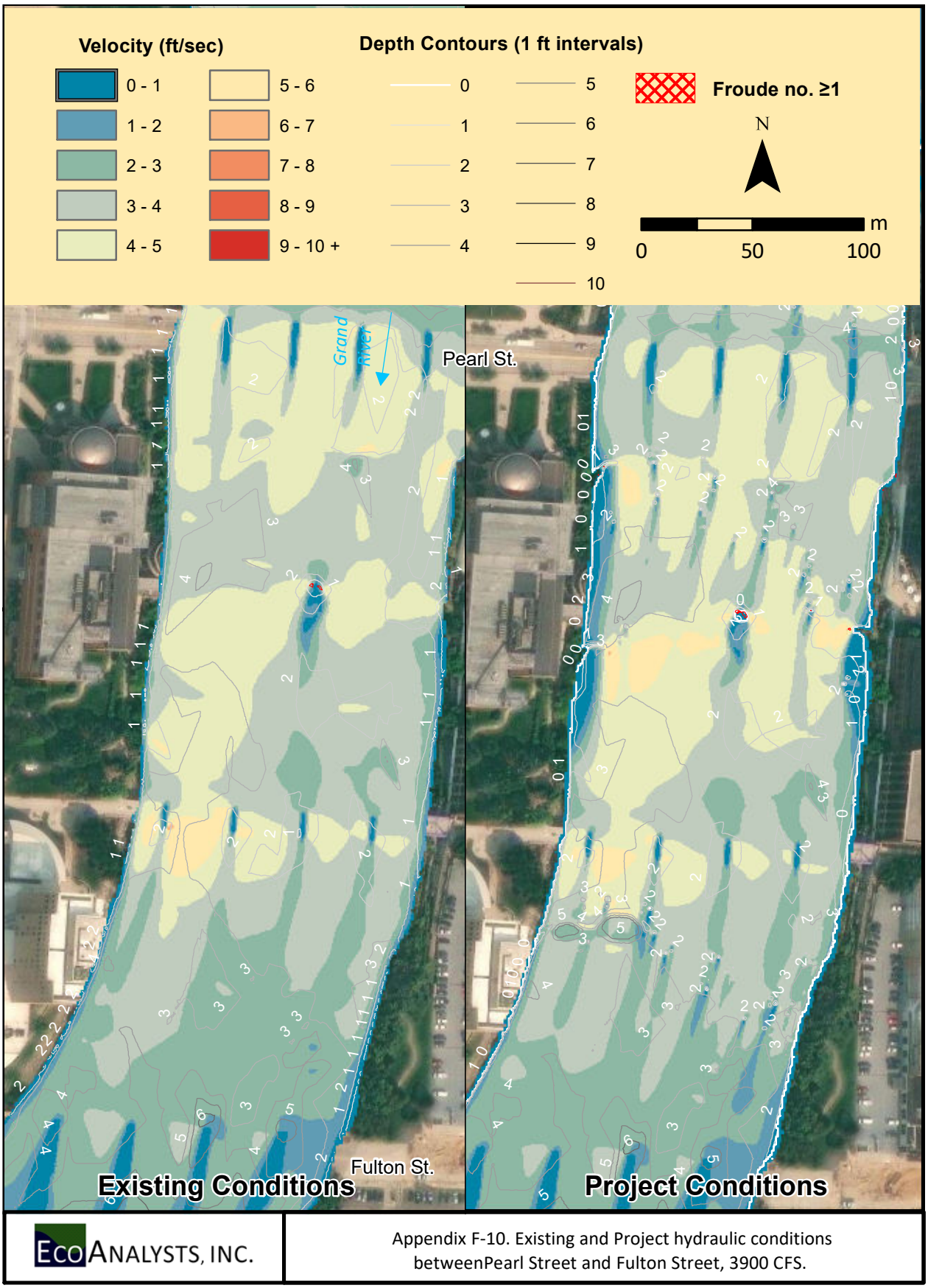
Appendix F-9. Existing and Project hydraulic conditions between Dam 2 and Pearl Street, 3900 CFS.



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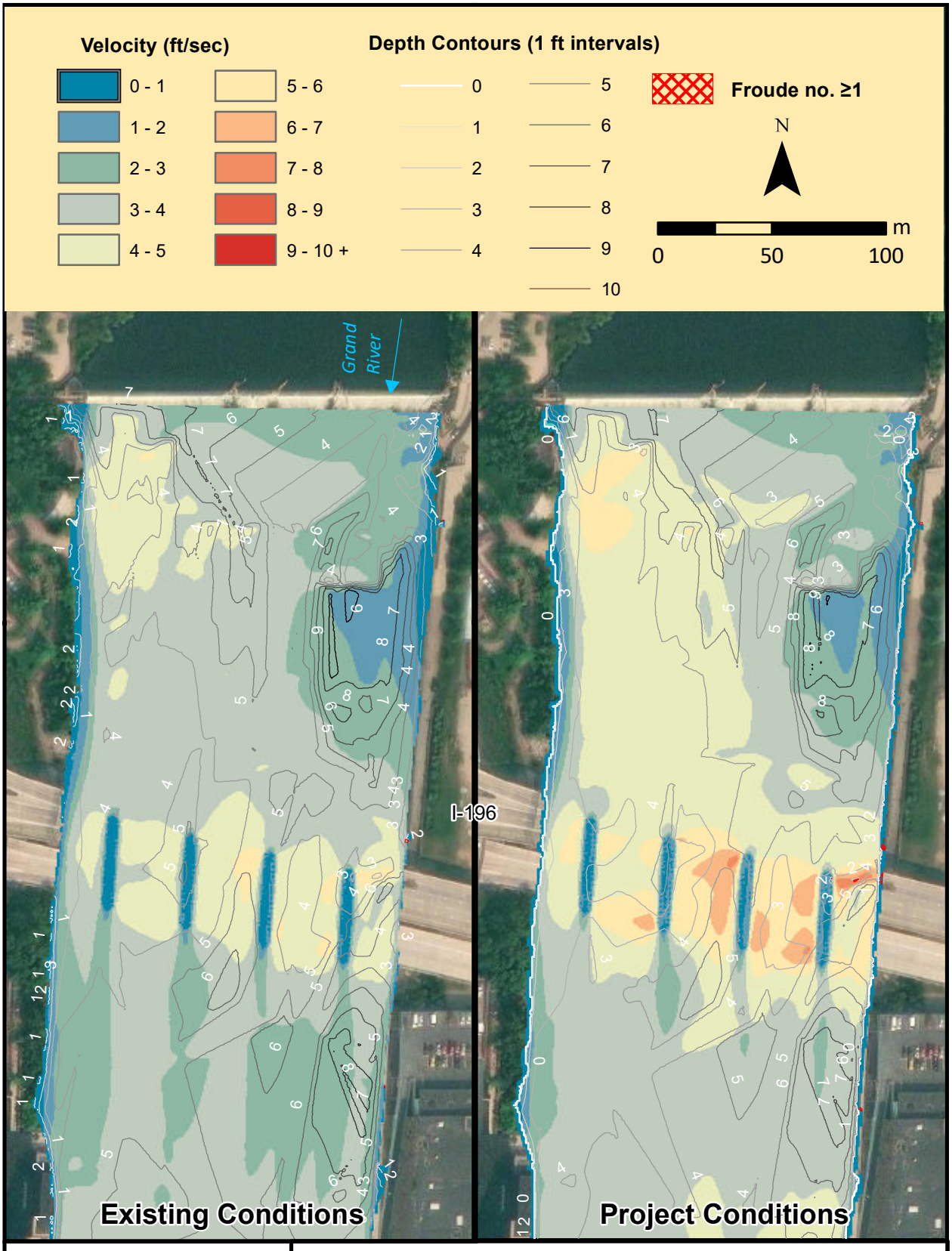
Appendix F-10. Existing and Project hydraulic conditions betweenPearl Street and Fulton Street, 3900 CFS.



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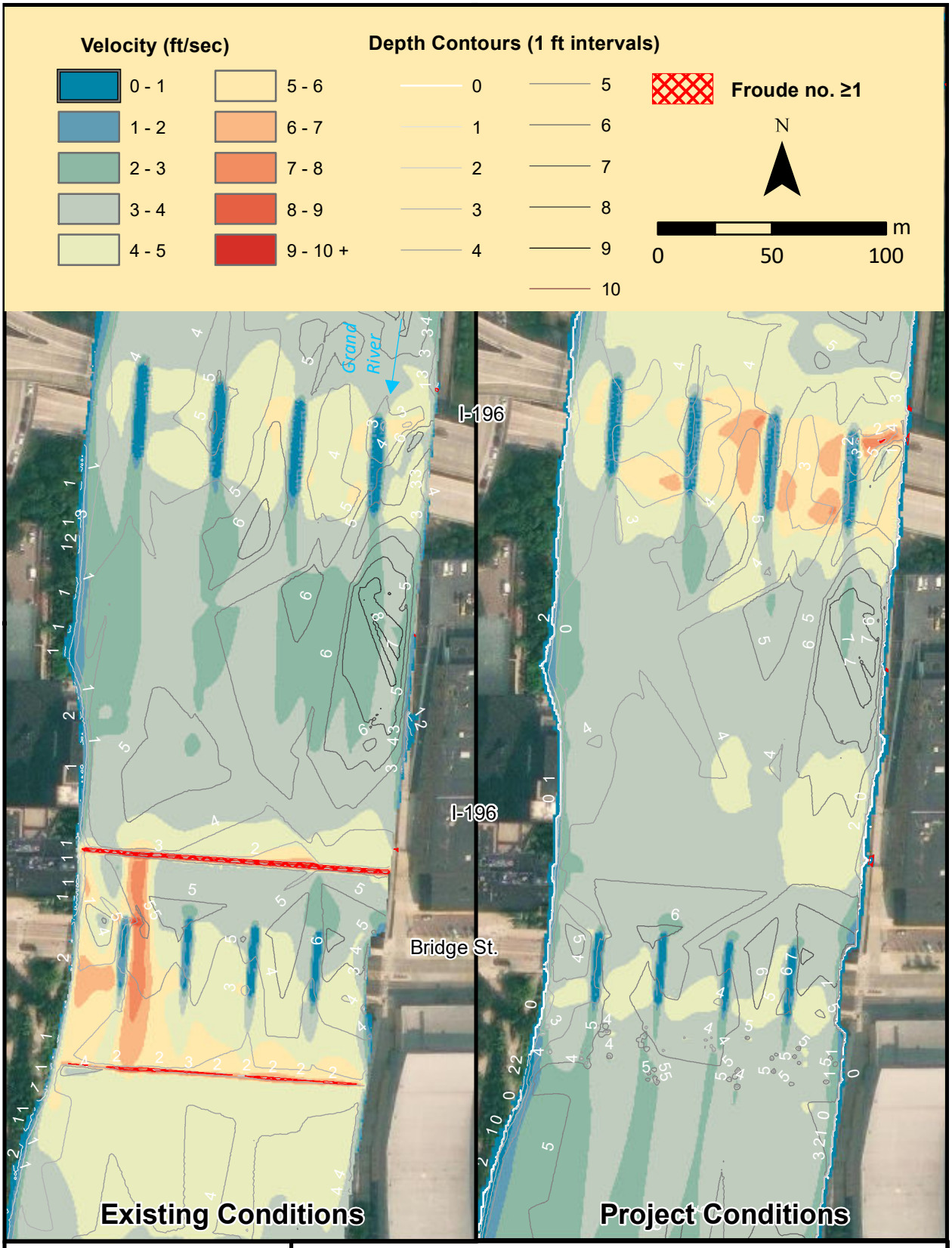
Appendix F-11. Existing and Project hydraulic conditions between 6th Street Dam and I-196, 7500 CFS.



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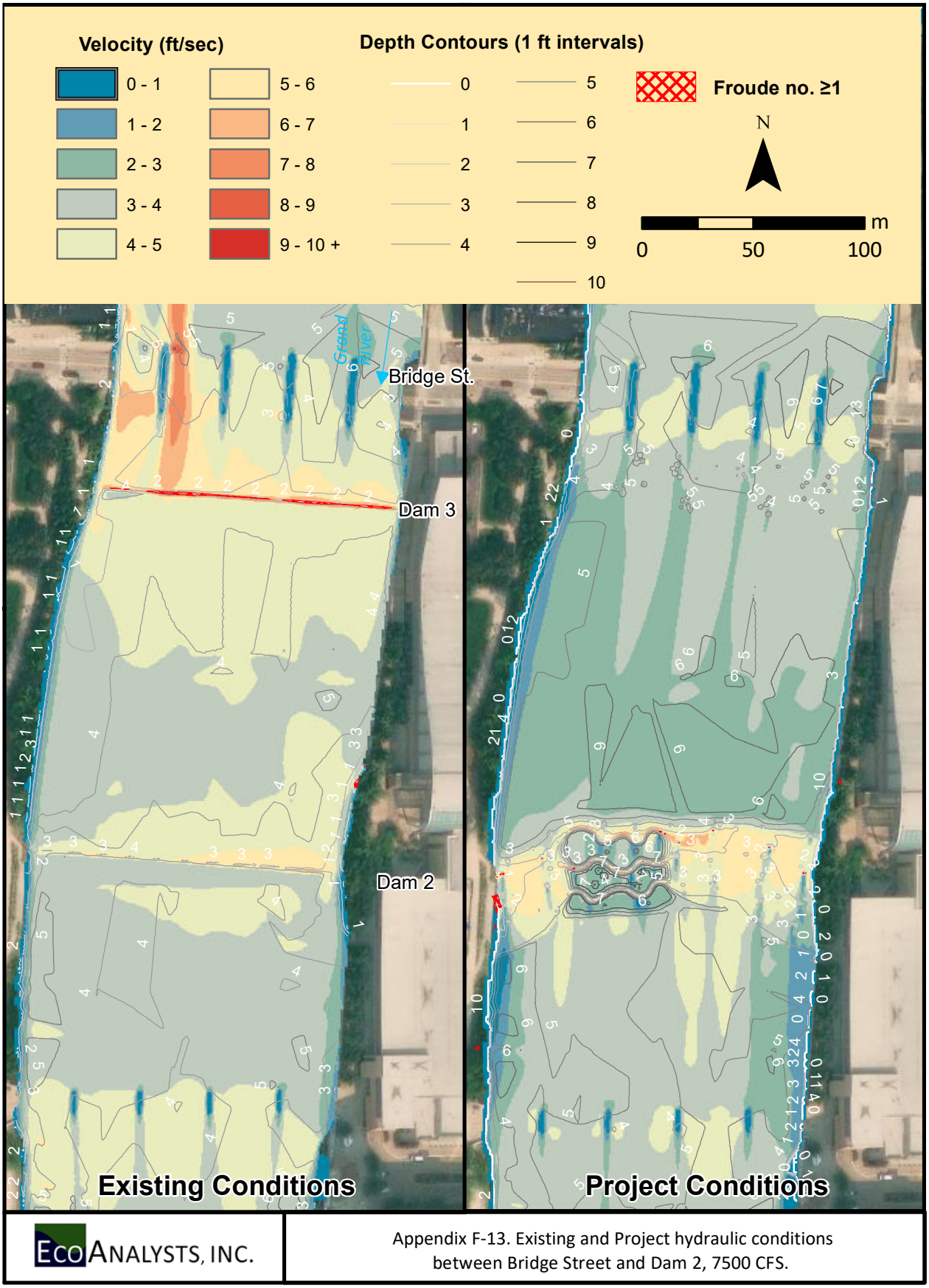
Appendix F-12. Existing and Project hydraulic conditions between I-196 and Bridge Street, 7500 CFS.



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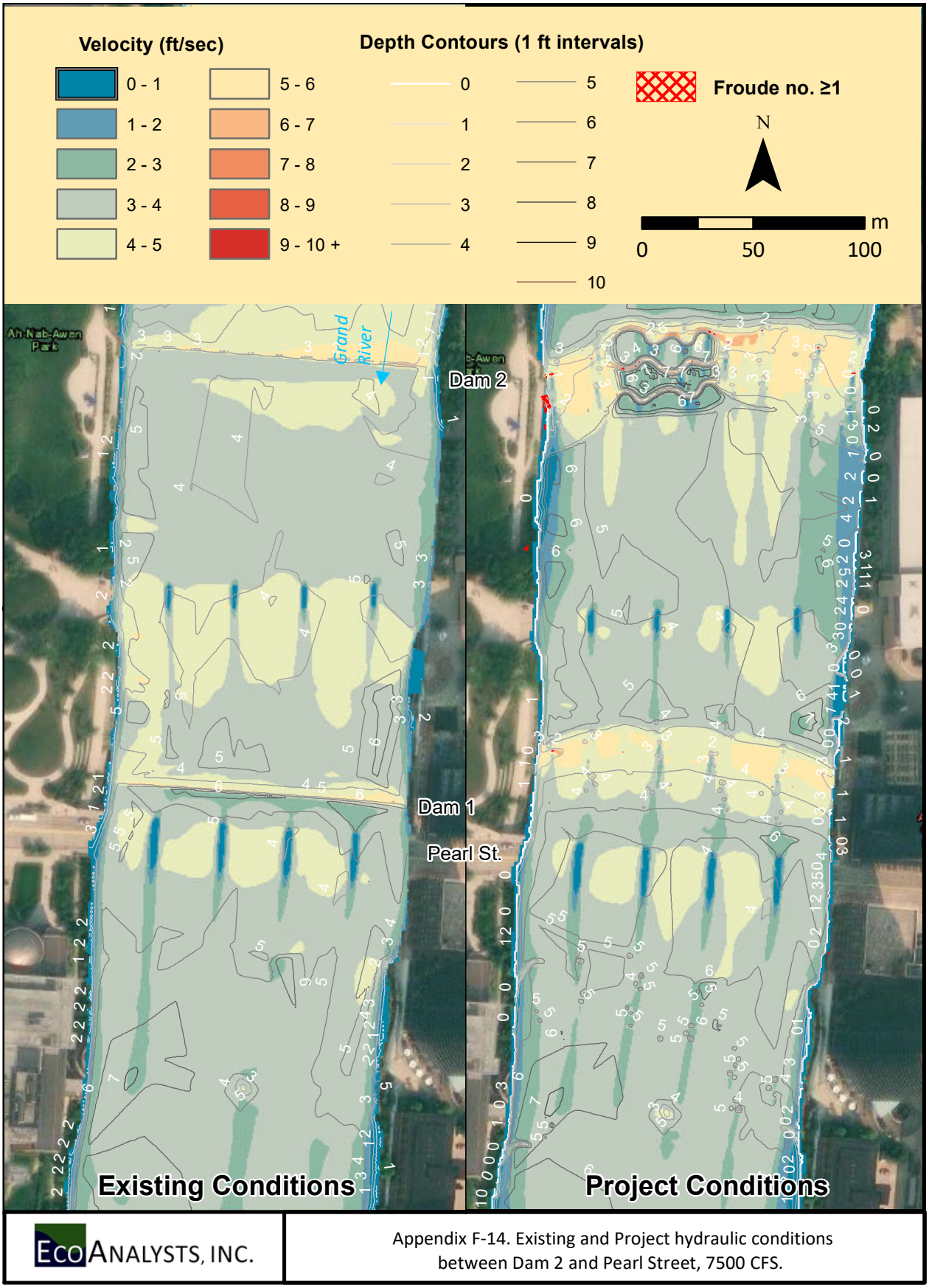
Appendix F-13. Existing and Project hydraulic conditions between Bridge Street and Dam 2, 7500 CFS.



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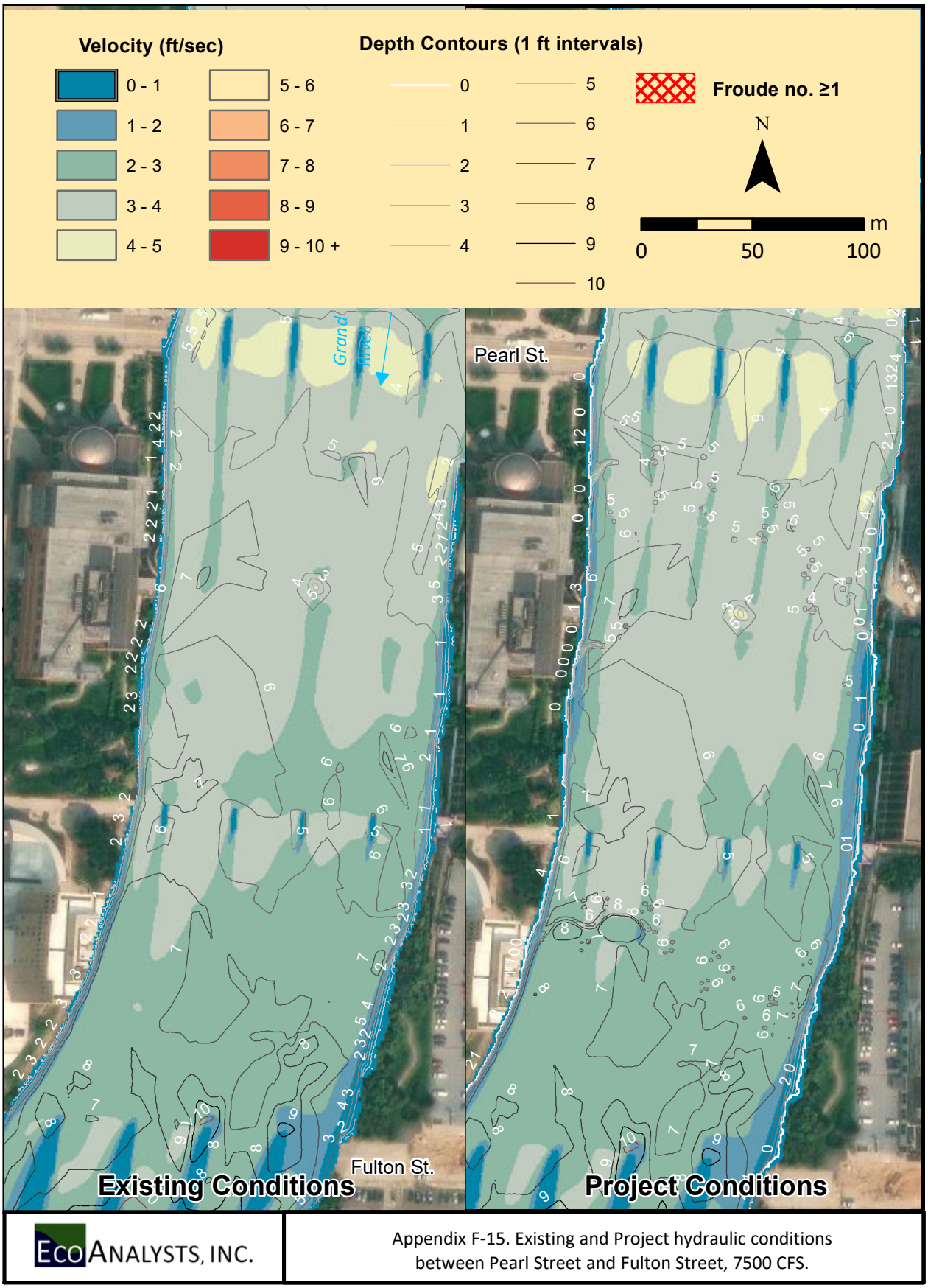
Appendix F-14. Existing and Project hydraulic conditions between Dam 2 and Pearl Street, 7500 CFS.



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Appendix F-15. Existing and Project hydraulic conditions between Pearl Street and Fulton Street, 7500 CFS.

Appendix G. Cumulative Impacts Analysis memo

OFFICE OF
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ENGINEER

CITY OF GRAND RAPIDS

March 7, 2024

To: Michigan Department of Environment, Great Lakes, and Energy

RE: Cumulative Impacts Analysis
City of Grand Rapids Projects along the Grand River

To whom it may concern:

At EGLE's request, in connection with its review of the City's application for permits under Parts 301, 303, and 31 of the Natural Resources and Environmental Protection Act ("NREPA") for the Grand River Revitalization Project (the "Project"), the City of Grand Rapids compiled a list of projects planned along the Grand River on City-owned property or where the City may be the State permit applicant. EGLE also specifically asked the City to include the River for All projects on this list. The City has included the River for All (RFA) projects, though these projects are only in the City's Parks and Recreation 2022 Strategic Master Plan, and the specific design and schedule for implementation for most of them are currently unknown. The narrative of the projects and impacts shown below for the River for All projects are based on conceptual graphics, and future projects may be significantly different. Some of these projects may not receive funding and would not be built.

The following changes have been made since the previous version was submitted on October 13, 2023:

1. 201 Market Ave from Fulton St. to Wealthy St. has been updated to match the permit application submission.
2. Canal Park Project and Leonard St. to Ann St. Trail – RFA #1 statuses were updated to be "Construction" after receiving permits in 2024.
3. Lower Reach status was updated to be "Active Design".
4. Other minor formatting and grammatical changes

Maps and Figures showing the location of the projects and approximate project extents are attached as Appendix A; a table of the projects and simplified activity information is attached as Appendix B; a narrative describing the projects and anticipated impacts from the projects is attached as Appendix C; and available design drawings are attached as Appendix D.

The projects on the list vary in status from purely conceptual renderings to permit-level design. Project status has been labeled as either "Master Plan only", "concept design", "active design" or "permitting". Definitions of each status are included in Appendix B. Only projects in the active design or permitting phases have progressed enough to be able to calculate any regulated activity. Impacts related to the Master Plan and concept design projects have been estimated based on current renderings or concept plans; these estimates are denoted in the green cells of Appendix B and are likely to change as design

progresses. For projects in the active design phase, the City has included the estimated work in wetlands, bottomlands, and floodplains, but these estimates are subject to change prior to submittal of the permit application. The projects in the permitting phase have the State's permit application number included in the table so those project files may be easily referenced. All other projects have a page number listed to indicate which page the drawing or set of drawings is in Appendix D.

Sincerely,



Tim Burkman, P.E.
City Engineer
City of Grand Rapids

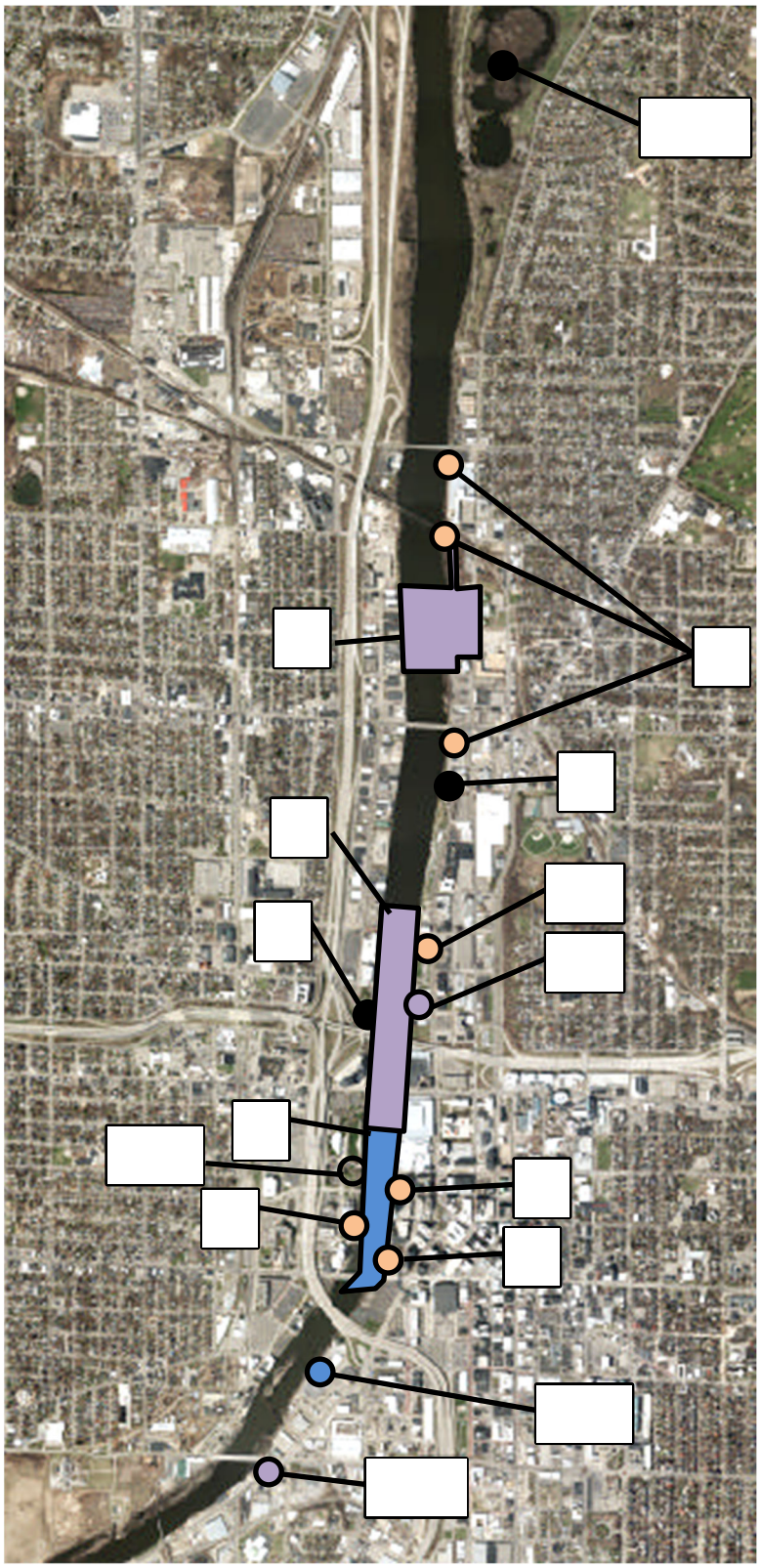
Encl.
Appendix A - City of Grand Rapids Projects on the Grand River Map
Appendix B – Table of Ancillary Grand River Projects
Appendix C – Narrative of Anticipated Impacts of Ancillary Grand River Projects
Appendix D – Drawings

Appendix A:
City of Grand Rapids' Projects on the Grand River Map

EGLE Permit Application
Date Revised: January 11, 2024

Site	Project Name
1	Lower Reach
2	Corps Project - including River for All (RFA) #2
3	Lyon Edge Project
4	East River Edge Sidewalk Project (Campau)
5	GRPM Riverfront – RFA #6
6	Leonard St. to Ann St. Trail - RFA #1
7	Coldbrook Water Pump Station -RFA #3
8	Fish Ladder Park RFA #5
9	Wealthy St Access
10	201 Market Ave
11	Canal Park
12	6th St. Park
13	Riverside Park
14	Ah-Nab-Awen Park - South

	Permitting Phase
	Active Design
	Concept Design
	Construction
	Master Plan Only



Appendix B
Table of Grand River projects

Appendix C
Narrative of Anticipated Impacts from Grand River projects

This document describes the cumulative impacts on regulated aquatic resources which may result from other projects in the vicinity of the Lower Reach Project. All impacts discussed or quantified herein are based on information currently available at the time of permit submission. Impacts for projects not at permitting level were estimated based on assumptions. Impacts have been identified which may occur from projects the City of Grand Rapids has in permitting, active design, concept design, or in the Master Plan only. Potential impacts to aquatic resources discussed here include:

- Impacts on the Public's right to Navigate, Fish, and Fowl on the Grand River;
- Impacts on Bed Mobility, Downstream Turbidity, and Sediment Transport;
- Impacts on Wildlife and Habitat, including Threatened and Endangered Species;
- Impacts to Wetlands;
- Impact on Stream Function;
- Impacts on Modeled Flood Risk;
- Temporary Construction Impacts

Summary Project Narratives

Lower Reach Project (Active Design):
This project is undergoing a refined concept design. The new design will result in improved aquatic habitat and enhanced recreational opportunities; removal of the safety risks caused by the four existing low-head dams; improved mussel habitat area; improved fish passage hydraulics over existing conditions; and enhanced public access to the river. Thus, once constructed, the Project will have positive impacts on regulated resources.

In terms of adverse impacts to a regulated resource, the Project has been designed to have limited, temporary impacts. Specifically, construction of the Project will necessitate the following temporary adverse impacts: (i) the public's ability to navigate and recreate on the Grand River will be temporarily limited in certain areas due to temporary restrictions on river access during construction; (ii) there may be a temporary increase in bed mobility and downstream turbidity and sediment transport during construction; and (iii) there will be temporary adverse impacts on aquatic wildlife.

Corps Project including RFA#2 (Concept Design):
The Great Lakes Fishery Commission has contracted with the U.S. Army Corps of Engineers (Corps) to conduct an Environmental Impact Statement (EIS) for the Corps project. Fourteen alternatives have been identified and will be considered for the project. Upon completion of the formal EIS process, the Great Lakes Fishery Commission will select the preferred alternative and issue a Record of Decision.

For the purpose of this analysis, the City and GRWW have analyzed the potential cumulative impacts for the City's preferred alternative, which is to remove the 6th Street Dam, construct an adjustable hydraulic structure (AHS), and install diversified hydraulic features in the Grand River.

The proposed AHS would incorporate a portage route connecting the upstream and downstream sides of the barrier for navigation. Similar to the Lower Reach Project, once constructed, the Corps Project alternative evaluated here is anticipated to have positive impacts on regulated resources.

The proposed site of the AHS, as evaluated for this application, is adjacent to the River for All (RFA) Site #2, the decommissioned Water Department Storage Yard. River for All Site #2 will be decommissioned as a storage yard for the City of Grand Rapids Water Department and is re-envisioned as a riverfront park. Currently, this site is being considered for access and staging for the construction of the proposed AHS. The existing site is primarily a compacted gravel parking lot/storage yard with ancillary structures for water main and storm water pumping stations. The former railroad bed serves as the top of the flood protection system, but the flood protection is envisioned to be relocated and increased as part of the project. When completed, river access will dramatically increase and transform this site into a regional recreation hub. Concept Design plans for RFA Site #2 call for:

1. An elevated canopy trail to connect pedestrians to the forested canopy above and protect wetland habitat below.
2. A lodge for year-round educational and cultural events.
3. Increase the flood protection system to 100-year base flood elevation plus 3 feet.
4. Potential repurposing of the water storage tank providing a unique space for large events and daily use.
5. A logjam inspired nature playground.
6. A dedicated drop-off area to accommodate large group access and circulating river traffic.
7. River terraces provide additional access to the water's edge
8. 600 lineal feet of new shared use trail.
9. Removal of railroad berm and terraced site to allow access into and out of the river as well as creating a naturalized edge and additional flood storage.
10. River landing provides a safe and accessible public river access space.
11. A large universally accessible walk provides river recreation opportunities to the north and south of the AHS.
12. Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project will include removal of stairs and amphitheater to create a passive and active recreational area, connection of existing routes, and pedestrian safety improvements related to vehicular traffic in Lyon Square.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
This river edge sidewalk has been undercut by river flows, and the area is not currently open to the public as it presents public health and safety concerns. This project will restore the stability and safety of the trail and improve safe access to the river edge from the proposed paved multi-use trail.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):

This project will remove existing sidewalk and install a new trail down to the river's edge to improve access. The project will also add a new access to the east side of the museum and will include a dual-purpose step/seating area and outdoor classroom. The improvements will allow unrestricted access for all people and add native vegetation to improve aesthetics, and create aquatic and wildlife habitat

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project has been refined to be an upper non-motorized pathway on the top of a flood protection berm. This project is proposing to provide freeboard to reach FEMA's NFIP accreditation levels above the 100-year base flood elevation.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
The project seeks to transform a property with mostly surface parking lots and storage buildings, which drain directly to the Grand River, into a prominent public recreation and outdoor education amenity. This existing site has a concrete floodwall limiting access to the river.

The new site layout will be an opportunity to provide education on the importance of best management practices related to stormwater and the positive changes happening along the Grand River and its tributaries. This site will be a critical hub for river and trail access. Envisioned improvements include the following:

1. Removal of approximately 150 lineal feet of concrete floodwall allowing access into and out of the river as well as creating a naturalized edge and additional flood storage.
2. Interpretation of Coldbrook Creek to demonstrate the channel's historic alignment and educate the public on the other hidden streams in the area.
3. Flexible plaza spaces adjacent to the building provide areas for outdoor learning, events, and cultural activities, such as canoe building with the Anishinaabe and programmed outdoor recreation activities could be pursued here.
4. Mixed use redevelopment above the 100-year floodplain is anticipated at the corner of Leonard Street and North Monroe Avenue with plazas oriented towards the river.
5. A large multipurpose lawn provides flexible space with an option for future bus drop off
6. ADA and small parking lot is located onsite.
7. An emergency access boat ramp.

Fish Ladder Park – RFA #5 (Master Plan only):
Fish Ladder Park has been identified as an important community gathering spot and the fish ladder structure is an iconic piece of functional art. The park would continue to serve these purposes and the project seeks to enhance and improve the site to function with any future changes to the river. If or when the 6th Street Dam is removed, the Fish Ladder structure would be modified to continue to provide fish passage, and improvements would be implemented within the surrounding park, which would continue to be a primary hub for fishing access. Envisioned improvements include the following:

1. Viewing deck located north of the Fish Ladder.
2. Existing fish ladder structure will remain for rapids viewing and fish observation.
3. Increase the flood protection system to 100-year base flood elevation plus 3 feet.
4. Changing room, restroom, and fish cleaning station.

5. Flexible plaza and adjacent parking area to accommodate small events.
6. Sloped event lawn next to new trees, planted on the high point of the existing berm to provide shade
7. Emergency access boat ramp.
8. Upper viewing perches on the embankment link to Scribner with Fish Ladder Park, provide small lounging pockets and expand spectator areas.
9. Approximately 800 lineal feet shared use trail.
10. Angling and wading access steps link the river trail to the bank.
11. Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.

Wealthy St. Access (Concept Design):
Wealthy St. Access is situated at the southern end of the downtown river corridor and a vital connector for residents within the Roosevelt Park and Black Hills Neighborhoods. The eastern edge is a City-owned parking lot with minimal use. The western edge is a small City-owned parking lot that is also minimally used, with dilapidated stairs that provide access about halfway down to the river. The stairs were originally installed for City workers to access an outfall that is now abandoned. The envisioned improvements will provide equitable river access in an area that currently consists of 15-foot tall concrete flood walls and a neglected river edge with some trees. Please note only one of the river edges is anticipated to be improved in this project, but both potential improvements are shown in the figure in Appendix D. At this time, it is unknown which side of the river the project would occur on. Envisioned improvements include the following:

1. Approximately 250 lineal feet of elevated boardwalk/ramps providing access from the existing parking lot to the river
2. Reconfiguration of the existing parking lot with improved drop-off location
3. Site amenities including pedestrian-scale lighting, benches, litter, and interpretive signage
4. Vegetated rip rap

201 Market Ave. (Permitting, HPZ-0BP4-6TQCH):
The existing river's edge on the east side of the Grand River between Fulton Street and Wealthy Street is approximately 2/3 of a mile. The current parcel contains buildings used to store the City's public works equipment. The river edge condition is a combination of cast in place concrete wall and steel sheet piling. Dependent upon the water level, portions of the river's edge include a sloped bank at the base of the walls. The entire length is populated with a combination of mature large trees and dense scrub-shrub underbrush providing screening of views for the current industrial and commercial uses.

The conceptual designs for the river's edge propose removal of the existing floodwall to provide better access to a more natural shoreline while adding freeboard to the flood control system in order to reach the 3 feet above the 100-year base flood elevation. Flood control will be maintained by utilizing a variety of design features rising to the flood control level with gentler slopes, naturally terraced dolomitic limestone and native plantings combined with walking running and biking trails paralleling the river and joining the properties along the Grand River. The proposed trail will be connected to river access points and public right of ways using universal design guidelines, creating universal access for all to enjoy the Grand River. This

development will coincide with changes in the adjacent parcels in the industrial use to commercial use, public green space, and potentially residential use.

Canal Park (Construction, WRP040025 V.1):
Project proposes to remove and replace approximately 3,810 LF of sidewalk and pathways in Canal Park. The new sidewalk and pathways will be 14-foot wide shared-use trail and raised to meet FEMA's NFIP accreditation requirements. A river terrace area and seat wall is proposed along river's edge. In addition, an event pavilion and plaza are also proposed. A river overlook decks is proposed to provide safe and unobstructed view of the river. A barrier-free floating kayak launch is also proposed. Proposed work activities have been designed to minimize impacts below the OHWM to the greatest extent possible. Furthermore, design meets the 100-year BFE plus required freeboard. Design to the 100-year flood plus required freeboard will provide sufficient flood protection within park area and protect infrastructure and park amenities. The barrier-free floatable kayak launch is the only proposed work past water's edge.

6th St. Park (Concept Design):
This park currently consists of a north/south linear trail, a restroom, fish cleaning station, small pavilion, public parking lot, and a concrete floodwall that spans the entire length of the park from I-196 to 6th Street with only one (1) point of access (which is not universally accessible) to the river located at the 6th Street Dam. Due to the concrete floodwall, there is minimal to no biodiversity along the river's edge. Additionally, there are several storm sewers that discharge into the river through the existing concrete floodwall. The southern half of the park consists of an electrical substation and remnant surface parking lots. The City acquired the parking lot parcels through a Michigan Natural Resources Trust Fund acquisition grant and has been temporarily activating the site. Permanent improvements will not proceed for several years as this is one of the anticipated staging and access sites for the Corps Project. This site will provide an opportunity to transform how the City and its citizens engage with its most valuable natural resource in one of its most prominent downtown locations. Envisioned improvements include the following:

1. 1,800 lineal feet of new shared use trail.
2. Increase the flood protection system to 100-year base flood elevation plus 3 feet.
3. Removal of approximately 740 lineal feet of concrete floodwall allowing access into and out of the river as well as creating a naturalized edge and additional flood storage.
4. River landing providing a safe and accessible public river access space.
5. A large universally accessible walk for river access.
6. Daylighted stormwater outfall and stormwater marsh provide resilient, natural stormwater treatment and re-establish a healthy river edge.
7. Stepped seating terraces at the river edge to provide an expanded, resilient rapids viewing area.
8. A shaded seating edge expands park access, even during high water events.
9. An event pavilion to accommodate concessions, restrooms, and services to support recreation.
10. An event lawn sized for markets, concerts, and a number of other uses.
11. Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.
12. A flexible mid-level terrace can host seasonal events and recreation.
13. A skate park in the area near I-196.

14. Non-motorized watercraft takeout point

Riverside Park (Master Plan only):
Riverside Park is Grand Rapid's largest and most prominent park for active and passive recreation users. The 182-acre park with approximately 2,000 lineal feet of river frontage lies almost entirely within the 100-year flood limit with a few exceptions along Monroe Avenue. The river edge is primarily naturalized with the exception of some armored locations and 3 public boat launch facilities. The park also has an interior lagoon with two heavily vegetated islands. Numerous smaller improvements have been made within the park over the last 20 years, but the last major investments were implemented in the late 1990's. Due to the park's popularity, use, and location within a highly fluctuating floodplain, most of the built assets are nearing the end of their functional life cycle. Roads, bridges, trails, and other structures are in need of repair, replacement. or removal. Additionally, over 100 acres of the park consists of maintained turf. This practice, along with the surface runoff from interior roads and parking, and siltation from seasonal flooding have contributed to poor water quality within the park's lagoon. The park is also situated at the downstream end of several large storm outfall pipes. These pipes collect stormwater from an approximately 1,800-acre watershed to the east and discharge directly into the Grand River. The City's master plan contains a broad list of ambitious and exciting changes for the park that focus on the following community priorities:

1. Remove, replace, and expand non-motorized trails network within the park
2. Daylight existing stormwater low-flow and route through new bio-swales, rain gardens, constructed wetlands to collect, cleanse and infiltrate water prior to reaching the lagoon and/or Grand River.
3. Reduce road and parking impervious surfaces
4. Increase native wetland, wet meadow, and upland plantings, especially along areas receiving surface runoff.
5. Renovate existing restrooms and maintenance facility.
6. Provide multi-purpose community waterfront center with restrooms, concessions, large event area, accessible watercraft launch, and river amphitheater.
7. Improve existing active recreation programs including sport fields, cross country course and disc golf.
8. Improve accessibility to the lagoon and river's edge as well as increase edge resiliency through use of bio-engineering techniques.
9. New dog park dedicated as off-leash area
10. Improve all 3 existing boat launches
11. Renovate existing play areas and incorporate nature-based play elements

Ah-Nab-Awen Park - South (Active Design)
Ah-Nab-Awen Park is on the west side of the Grand River between Pearl and Bridge Streets and a vital outdoor event space, trail connector, and cultural site for guests and residents in the heart of downtown. The proposed design for the south end of the park between Gillett Bridge and Pearl Street includes removal of the representative burial mounds, aging restroom and improvements to sidewalks that are not ADA compliant, and cultural interpretation. Special attention was also given to transform the "Fake Mounds", as they are referred to by the Grand River Band of Ottawa Indians who helped shape the proposed improvements from an under-utilized and misrepresented historical area to a space for healing, celebration, and a welcoming environment for both tribal members and the general public.

Impacts on the Public's right to Navigate, Fish, and Fowl on the Grand River

Lower Reach Project (Active Design):
Removal of the four low-head dams is anticipated to make the Grand River in this reach more accessible, and therefore, improve the public's right to navigate, fish, and fowl.

Corps Project including RFA#2 (Concept Design):
Due to the proposed portage route around the AHS structure that currently does not exist, this project is expected to have a significant positive impact on the public's right to navigate, fish, and fowl on the Grand River. The site improvements related to RFA #2 will also improve access to and from the river, also positively impacting the public's right to navigate, fish, and fowl on the Grand River.

During construction of the project, it may be necessary to temporarily restrict or prohibit use of a portion of the river for public safety.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project is expected to have a positive impact on the public's right to navigate, fish, and fowl on the Grand River by enhancing the riverfront to provide a gathering space for the public along the river's edge. The stairs down to the river in this area will be removed, but two access points to the river are nearby along the Devos Place Convention Center and across Pearl St. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
The East River Edge sidewalk improvements will have a positive impact on the Public's right to navigate, fish, and fowl on the Grand River by rehabilitating and improving access along the river. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project. This public walkway is currently closed due to a public safety hazard and will not reopen until this project occurs. Severe erosion has substantially undercut the sidewalk creating a public safety hazard.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The Grand Rapids Public Museum is reimagining their riverfront and are proposing to remove the large riprap and scrub-shrub vegetation and install a concrete sidewalk with foundation along a portion of their property. This change is expected to have a positive impact on the Public's right to navigate, fish, and fowl as it is creating two access points with universal access design principles to the river's edge that do not currently exist. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
The walkway will provide better access along the river's edge. No adverse impacts are anticipated on the Public's right to fish and fowl the Grand River from this project either.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This site is anticipated to have a positive impact on the Public's right to navigate, fish, and fowl on the Grand River. By removing approximately 150 lineal feet of concrete floodwall to allow access into and out of the river and adding a naturalized river edge with universal design concepts, access to the river will improve allowing anyone to fish or fowl on the Grand River. With improved access, this will positively impact the public's river to navigate the river. There are no anticipated improvements that would adversely affect the public's right to navigate, fish, or fowl on the Grand River.

Fish Ladder Park – RFA #5 (Master Plan only):
This project is anticipated to have positive impacts on the public's right to fish, fowl, and navigate the Grand River. One of the main goals of this project is to provide universal access to the riverfront for all people to enjoy. The proposed improvements of adding more access and associated support facilities (i.e., changing rooms, restrooms, fish cleaning stations) are all added to support the public's use of the river. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project.

Wealthy St. Access (Concept Design):
This project is anticipated to have positive impacts on the public's right to fish, fowl, and navigate the Grand River. This project would add access to a site where minimal facilities currently exist to improve the public's right to fish, fowl, and navigate the Grand River. There are no anticipated adverse impacts on the public's right to fish, fowl, and navigate the Grand River.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
One of the main goals of this potential project is to provide universal access to the riverfront for all people to enjoy. The proposed amenities, including the river edge and bridges, will be designed to add access to aid in the Public's abilities to fish, fowl, and navigate the river. Therefore, this project would have a positive impact on the Public's right to fish, fowl, and navigate the Grand River.

Canal Park (Construction, WRP040025 V.1):
One of the main goals of this potential project is to provide universal access to the riverfront for all people to enjoy. With the removal of the concrete retaining wall, and the addition of a large universally accessible walk, this will positively impact the public's right to fish, fowl, and navigate the Grand River. There are no anticipated adverse impacts to the public's right to fish, fowl, and navigate the Grand Rapids associated with this project.

6th St. Park (Concept Design):
One of the main goals of this potential project is to provide universal access to the riverfront for all people to enjoy. The current river access is limited in its ability to provide sufficient access to all people. With the removal of the concrete retaining wall, and the addition of a large universally accessible walk and stepped terrace seating, this will positively impact the public's right to fish, fowl, and navigate the Grand River by creating more universally accessible space at the edge of the Grand River. There are no anticipated adverse impacts to the public's right to fish, fowl, and navigate the Grand Rapids associated with this project.

Riverside Park (Master Plan only):

Riverside Park currently offers a wide variety of options for people to access the Grand River. With this project, the options would be to further enhance those to provide universal access and boating access or to renew the current assets. Therefore, positive impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated. No adverse impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated.

Ah-Nab-Awen Park - South (Active Design)
Ah-Nab-Awen Park currently offers for people to access the Grand River. With this project, the options would be to further enhance those to provide universally accessible walks to the existing main path leading down to the river. Therefore, positive impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated. No adverse impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated.

Impacts on the Bed Mobility, Downstream Turbidity, and Sediment Transport

Lower Reach Project (Active Design):
This project is not anticipated to have any adverse permanent impacts on bed mobility, downstream turbidity, and sediment transport. Temporary increases in downstream turbidity may occur during construction, but proper best management practices will be utilized to minimize impacts.

Corps Project including RFA#2 (Concept Design):

The Corps Project, as being analyzed in this document, is not expected to have adverse impacts on bed mobility, turbidity, or sediment transport. The hydraulic gradient over the dam would be distributed over the proposed AHS and several hydraulic features, each designed with a 2x factor of safety against mobility. In this way, the hydraulic features and AHS would function to maintain grade control throughout the reach. Additionally, modeling and design of features would verify that any increases in the scour potential over existing riverbed would not exceed threshold mobility for existing substrate. Similar to the Lower Reach Project, care will be taken through design and modeling to verify that ongoing accumulation of fine sediment within the project reach is avoided and minimized.

Temporary turbidity during construction would be managed with industry standards and assumed to be performed in a similar fashion to means and methods proposed in the Lower Reach Project.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
The Lyon Edge project is not expected to have any impacts to bed mobility, sediment transport, or downstream turbidity as all project work is occurring above the ordinary high water mark (OHWM) or behind the floodwall.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
The East River Edge sidewalk improvements is anticipated to have a positive impact to bed mobility, downstream turbidity, and sediment transport. Since 1990, the project area has experienced lateral erosion of 1.7 to 2.8 feet of material along the 439-foot length of river edge that has been transported downstream. This demonstrates the project area has eroding and transporting to downstream areas in the past and may be continuing to this day. The project will stabilize the river edge using slabbed pieces of dolomitic limestone and vegetative plugs, resulting in reduced downstream turbidity and substrate mobility. Temporary turbidity during construction would be managed utilizing appropriate best management practices.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The Grand Rapids Public Museum Riverfront Improvements is expected to have no net adverse impact on the bed mobility, downstream turbidity, or sediment transport. Minimal work would be conducted within the flowing channel and any temporary turbidity during construction would be managed with appropriate best management practices.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project is not expected to adversely impact bed mobility, downstream turbidity, and sediment transport as the work is above the OHWM.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This site is anticipated to have no adverse impact on the bed mobility, downstream turbidity, and sediment transport. There is no in-river work planned with this project. The intent of the design is to soften some of the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport.

Some temporary impacts to turbidity may occur during construction, but appropriate best management practices will be taken and/or installed during construction.

Fish Ladder Park – RFA #5 (Master Plan only):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport as the proposed work is not significantly changing the cross-section at this park and the material will be designed to be stable. There may be temporary adverse impacts during construction, but these will be managed by appropriate best management practices.

Wealthy St. Access (Concept Design):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport as any change in the cross-section or any protrusions into the flow that increase shear stresses will be minimal. There may be a slight positive impact on these aspects as an increase in native vegetation may help reduce turbidity in the river. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport. The intent of the design is to soften the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport. There may be a marginal positive impact in downstream turbidity for higher flow events given the additional space in the floodplain. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

Canal Park (Construction, WRP040025 V.1):
There are no anticipated adverse impacts on bed mobility, downstream turbidity, and sediment transport as the intent of the design is to soften the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport. There may be a slight positive impact on these aspects as an increase in native vegetation may help reduce turbidity in the river. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

6th St. Park (Concept Design):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport. The intent of the design is to soften the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

Riverside Park (Master Plan only):
With the intent of project to improve the stormwater management, water quality of the stormwater, and the lagoons in the park, work below the OHWM is expected, but it would likely be within the park itself, not on the river edge. Given that the intent of the system is to improve water quality, it is anticipated there will be no adverse impacts to the Grand River related to bed mobility, downstream turbidity, and sediment transport. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

Ah-Nab-Awen Park - South (Active Design)
This project is not expected to adversely impact bed mobility, downstream turbidity, and sediment transport as the work is above the OHWM.

Impacts on Wildlife and Habitat, including Threatened and Endangered Species

Threatened and Endangered Mussel impact was calculated using an estimated polygon of work area compared to extents of the Grand River at 890 cfs. This 890 cfs line is the low water level (7Q10) used to assess changes in the wetted area available for aquatic organisms under low flow conditions as detailed in the [TOC 26] Revised Biological Assessment. Where the areas overlapped was assumed to be possible area of mussel impact for the sake of this exercise.

The density of the mussel habitat in the Grand River in the City of Grand Rapids varies based on reach. Based on quantitative samples, in 2013, 2015, and 2016, an average mussel density has been assumed for the following reaches. Impacts to mussels have been estimated based on these densities.

Reach	*Mussel Density (unionids/m^2)*
Proposed AHS to 6th St. bridge	*3.0*
6th St. bridge to 6th St. dam	*1.7*
6th St dam to Fulton St.	*0.3*
Fulton St. to Plaster Creek	*0.1*

It is important to note that these are approximate estimations, based on 30% preliminary design for the in-channel improvements, and include conservative assumptions for construction means and methods which have yet to be determined.

Lower Reach Project (Active Design):
This project is anticipated to pursue a Biological Opinion from the United State Fish and Wildlife Service. All impacts to mussels will be avoided and minimized.

Corps Project including RFA#2 (Concept Design):
The Corps Project is expected to have a positive impact on wildlife and habitat. Aquatic wildlife would have a more diverse range of habitat types which are more representative of a naturally functioning river. Added habitat types would include pools, riffles, runs, and glides, all of which are not as prevalent under existing conditions. The macroinvertebrate community is categorized as poor in the Lower Grand River because “stable habitat necessary for a diverse macroinvertebrate community” is lacking and riffle habitat has not formed (DEQ 2016b). The macroinvertebrate community is anticipated to benefit and respond with a higher species richness and diversity after construction. The addition of coarse substrate riffle habitat is expected to provide an important habitat type for aquatic macroinvertebrates and produce benefits to the habitat of the reach as a whole (Vinson and Hawkins 1998).

While there will be temporary impacts associated with the proposed removal of 6th Street Dam and construction of the proposed AHS and hydraulic features, the project is expected to provide access to approximately 80 acres of aquatic habitat for non-jumping fish species, including Lake Sturgeon spawning habitat currently blocked by the 6th Street Dam. The project, with the 16 acres of permanent streambed change as analyzed in this document, is also expected to create 240% more preferred hydrophysical habitat for mussels than existing conditions. There may be

temporary impacts on the aquatic wildlife, but the project team will continue to consult with the United State Fish and Wildlife Service (USFWS) and Michigan Department of Natural Resources (MDNR) on ways to avoid, minimize, and mitigate any potential impacts.

Construction access to the proposed AHS site will be most likely through the Water Dept. Storage Yard and access to 6th Street Dam most likely through Fish Ladder Park and 6th Street Park. For this reason, these river edge improvements would likely be constructed following the in-river work for the Corps Project. Since all projects are still in concept design phase and any timeline for construction at the time of this submittal is unknown, the mussels impact from projects were shown separately to provide a conservative estimate.

The species discussed below could experience some potential impacts from the Corps project. These impacts can likely be further mitigated during the design/development process and using best management practices during construction.

Unionids (Mussels):
Construction of the AHS will affect approximately 18,500 m^2 of riverbed. Unionid density in this area is approximately 3.0 unionids/m^2. Approximately 150 *E. triquetra*, 5,300 Michigan TES species, and 51,000 other unionids could be affected by construction of the AHS. However, approximately 80% of those unionids could be translocated before construction: 120 *E. triquetra*, 4,200 Michigan TES species, and 41,000 other unionids. Unionids that would not be translocated include approximately 30 *E. triquetra*, 1,100 Michigan TES species, and 10,200 other unionids.

The area between the 6th Street Bridge and the 6th Street Dam would also be directly impacted during construction, approximately 42,000 m^2. Unionid density in this area averaged 1.7 unionids/m^2, A total of approximately 200 *E. triquetra*, 6,800 Michigan TES species, and 66,000 other unionids could occur in this area. Collecting and translocating unionids from this area would be limited to those within work isolation areas due to the dangerous diving conditions this close to the 6th Street dam. For the purposes of this assessment, unionids were assumed to be collected from one third of the area, as some of the area may require work in wet and some of the area may be covered with isolation measures before unionids can be collected. An estimated 80% of the unionids in one third of the area could be translocated under isolated conditions; 50 *E. triquetra*, 1,800 Michigan TES species, and 17,600 other unionids. Unionids that would not be translocated and affected by the Upstream Project above the dam include 144 *E. triquetra*, 5,000 Michigan TES species, and 48,400 other unionids.

Most of the area between the 6th Street Dam and the Lower Reach project will also be directly impacted by construction below the dam; 107,400 m^2. Freshwater mussels occur at a low density (0.3/m^2) between the 6th Street Dam and the Lower Reach project. Approximately 290 *E. triquetra*, 4,300 Michigan TES species, and 27,700 other unionid species may reside in this direct impact area. Diving conditions below the dam are also dangerous due to the high current velocities. Conservatively, unionids could be collected from within work isolation areas, approximately one third of the area. Approximately 80% of the unionids within the cofferdams would be translocated; 80 *E. triquetra*, 1,150 Michigan TES species, and 7,400 other unionids. Unionids that would not be translocated and assumed to be directly impacted by the Upstream Project below the 6th Street Dam include 215 *E. triquetra*, 3,150 Michigan TES species, and 20,300 other unionids.

The total number of unionids affected after translocation in all 3 areas is approximately 400 *E. triquetra*, 9,200 Michigan TES species, and 79,000 other unionids.

Hydraulic changes to flow depths and velocities would occur between the AHS and channel reconfiguration areas (indirect affect areas). The indirect affects area is approximately 232,000 m^2, with a mussel density of 1.7/m^2. Approximately 400,000 mussels may be indirectly affected, including 1,100 *E. triquetra* and 37,000 other Michigan TES species.

Measures that could be used to mitigate impacts include translocating mussels from the AHS construction area to a suitable recipient site. Collection and translocation of unionids directly affected by the project may be limited to slower flowing areas near the banks and within cofferdams.

The loss of mussels could also be mitigated by the improvement in habitat conditions within the Corps Project area. The area above the 6th Street Dam is now a slow flowing pool. An increased velocity with the removal of the 6th Street Dam should improve habitat conditions for unionid mussels and their host fish. A preliminary Preferred Hydraulic Habitat (PHH) model was developed based on hydraulic conditions within the highest density areas within the sampled area between the AHS and the 6th Street Dam. The model included an index of substrate stability (shear stress/critical shear stress) ≤1.2 under high flow conditions (stable substrate under high flow), velocity under low flow conditions between 0.15 m/sec and 0.036 m/sec (low enough velocity to allow juvenile settlement but some flow during low flow conditions), and areas with ≤10% bed slope. Bedrock areas and areas that would not be inundated under 7Q10 (low flow conditions) were excluded from the model. Under existing conditions, approximately 32,700 m^2 of PHH occurs above the 6th Street Dam and 2,800 m^2 of PHH occurs between the 6th Street Dam and Dam 2. This should increase to approximately 86,000 m^2 of PHH or a 240% increase after the project is completed.

Myotis septentrionalis (Northern Long-eared Bat)

Northern long-eared bats could be affected if they used any of the trees in the area for roosting if roost trees were removed as part of construction activities. However, few *M. septentrionalis* appear to spend the summer in the southern portion of Michigan. Additionally, the Project is within an urban setting, not likely to harbor this species of bat. A few trees would likely need to be removed from construction/staging areas for the proposed AHS on the east bank but none of these trees appear to be suitable roost trees. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats. Northern long-eared bats are unlikely to be affected by this Project.

Myotis sodalis (Indiana bat)

Although summering *M. sodalis* occur throughout the southern portion of Michigan, including Kent County, it is not likely to be affected by the Project. Impacts to bats would primarily include removal of roost trees as part of construction activities. A few trees would likely need to be removed from construction/staging areas for the AHS (Upstream Reach) on the east bank. This area is already heavily urbanized and trees that are to be removed are unlikely to be roost trees. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. Indiana bats are unlikely to be affected by this Project.

Lycaeides melissa samuelis (Karner blue butterfly)
This species primarily occurs in oak savannas and pine barrens with sandy soil. It is dependent upon wild lupine (*Lupinus perennis*), as larvae feed exclusively on this plant species. Although *L. m. samuelis* is known to occur in Kent County, no suitable habitat exists in the Project Area. This species would not be affected by the Project.

Acipenser fulvescens (Lake Sturgeon) - Threatened
A small *A. fulvescens* population is known to occur in the mainstem of the lower Grand River and the mouth of the Grand River, but within the project area**,** it has not been found upstream of the 6th Street Dam (Figure 3-8, Hanshue and Harrington, 2011). The 6th Street Dam is a barrier to spawning grounds of several Lake Michigan fish species, including *A. fulvescens* (Hanshue and Harrington, 2011). As a result, *A. fulvescens* populations are restricted to the Grand River downstream of this structure. Annual spawning numbers of *A. fulvescens* are believed to be between 66 and 130 fish of primarily older adults (Hanshue and Harrington, 2011). Juvenile Lake Sturgeon have not been documented in the project area. Allowing Lake Sturgeon upstream of the 6th Street Dam and diversifying habitat in the Downstream Reach would improve conditions for A. fulvescens in the Grand River.

Moxostoma carinatum (river redhorse) – Threatened
Adults spawn each year, at temperatures between 18˚C and 24˚C (Mongeau et al., 1992; Jenkins and Burkhead, 1993), which occurs between mid-May through July in the Grand River.
Moxostoma carinatum occurs throughout the entire lower segment of the Grand River, from downstream of the Maple River near Lyons to Grand Haven near the mouth of Lake Michigan (Hanshue and Harrington, 2011). Small numbers of River Redhorse have been found in the project area during summer electrofishing surveys (Holtgren, personal communication). River Redhorse are known to occupy areas with deep runs, swift currents, and larger substrates during Winter and Spring months and then shift to lower velocities and finer substrates during Summer and Fall months. The diversity of habitat, with coarser substrate and a wider variability of localized flow velocities, will increase and subsequently provide a habitat mosaic with improved conditions for River Redhorse.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project is not anticipated to have any impacts on wildlife and habitat. All project work is occurring above the ordinary high water mark (OHWM) or behind the floodwall. No work or construction access will occur within the Grand River and a debris net will be installed under work area to prevent debris from adversely impacting aquatic wildlife, including aquatic macroinvertebrate habitat, fish passage, or fish habitat. USFWS Consistency letter dated May 4, 2022 indicates “no effect” for federally protected Snuffbox Mussel *(Epioblasma triquetra).*

Review of Michigan Natural Features Inventory (MNFI) notes the following state protected aquatic wildlife exist within 1.5 miles of the project area: Snuff box *(Epioblasma triquetra),* Purple wartyback *(Cyclonaias)*, River redhorse *(Moxostoma carinatum)*, Slippershell *(Alasmidonta viridis)*, Black sandshell *(Ligumia recta)*, Fawnsfoot *(Truncilla donaciformis)*. Proposed work activities will not impact these species as no work is proposed within the Grand River.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
The East River Edge sidewalk improvement project is expected to have a positive impact on wildlife. The project is proposed to install slabs of dolomitic limestone and native vegetative plugs along the river edge to reduce streambank erosion and create streamside habitat foraging, resting, and breeding areas. The project will reduce streambank erosion which will also benefit the aquatic wildlife downstream of the project area. Proposed work extends 2.75 feet waterward of the OHWM and will be conducted entirely from upland area using a turbidity curtain.

Review of Michigan Natural Features Inventory (MNFI) notes the following state protected aquatic wildlife exist within 1.5 miles of the project area: Snuff box *(Epioblasma triquetra),* Purple wartyback *(Cyclonaias)*, River redhorse *(Moxostoma carinatum)*, Slippershell *(Alasmidonta viridis)*, Black sandshell *(Ligumia recta)*, Fawnsfoot *(Truncilla donaciformis)*. It is anticipated that work activities will likely not impact these species as their presence was not identified in the 2020 mussel survey conducted by EcoAnalysts. USFWS Consistency letter dated April 8, 2021 indicates “no effect” for federally protected Snuffbox Mussel.

USFWS has also indicated the 2020 mussel survey conducted by EcoAnalysts would be acceptable for this project and was submitted with the permit application. EcoAnalysts confirmed that common mussels were found in the project area (email correspondence attached). Early coordination with MDNR Biologist notes 2 state protected mussels (Snuffbox and Black sandshell) species may be in the project reach. As requested by EGLE, further coordination with MDNR and the City to address potential impacts to protected aquatic species has been requested, has not occurred, and will be handled during permit review process.

This project is not anticipated to have an adverse impact on fish passage. The dolomitic limestone and native vegetative plugs will provide a stable natural river edge which will have a positive impact on macroinvertebrates and fish habitat due to reduced sediment load from erosion. Streamside vegetation will provide safe harbor areas and cooler water temperatures for aquatic species, including macroinvertebrates and larval and juvenile fish species. Furthermore, the proposed work is not installing structures that would typically interfere with fish passage (e.g., weir, dam, etc.)

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The Grand Rapids Public Museum riverfront project is expected to have no adverse impacts on wildlife. The current large riprap offers little habitat value. Replacing the existing riprap with either natural field stone or dolomitic limestone would not change that habitat value, and the disturbance on the stream bottom is 0.01 acre.

Native plantings along channel banks will work to improve streamside foraging, resting, and breeding areas for terrestrial wildlife. Work will be conducted from upland areas and steel sheeting cofferdam will be used to protect existing undergrade structures during the construction process, so no tracking in the river is currently proposed. Work is anticipated to extend approximately 0.5-1.0 feet past the water’s edge but would not extend into the limits of the 890 cfs line. Therefore, this project would result in no impacts to mussel habitat areas. The dolomitic limestone and native vegetative plugs will provide a stable natural river edge that will have a positive impact on macroinvertebrates and fish habitat due to reduced sediment load from erosion. Streamside vegetation will provide resting areas and refugia, and cooler water

temperatures which will benefit aquatic species. Furthermore, proposed work is not installing structures that would significantly modify conditions that would interfere with fish passage (e.g., weir, dam, etc.)

USFWS Consistency letter dated November 16, 2021 (attached) indicates “no effect” for federally protected Snuffbox Mussel). Review of Michigan Natural Features Inventory (MNFI) (attached) notes the following state protected aquatic wildlife exist within 1.5 miles of the project area: Snuff box *(Epioblasma triquetra),* Purple wartyback *(Cyclonaias)*, River redhorse *(Moxostoma carinatum)*, Slippershell *(Alasmidonta viridis)*, Black sandshell *(Ligumia recta)*, Fawnsfoot *(Truncilla donaciformis)*. Impacts from proposed work activities will be negligible given work extends minimally (1 foot) into the water.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
Inquiry to MNFI (attached) notes 3 state Threatened Species (Purple Wartyback, Slippershell and River Red Horse), and 2 state Endangered Species (Black Sand Shell and Peregrine Falcon), may exist within 1 mile of the project area. No adverse impact to Peregrine Falcon or River Red Horse is expected to occur as a result of proposed activities. Peregrine Falcon preferred habitat (inland or coastal cliffs, open woodlands near water, and potentially high city buildings) generally does not exist in the project area. River Red Horse habitat is associated with long deep runs (1-10 feet) in rivers, and proposed work activities will not extend into these areas of the Grand River. Mussels and/or their habitat will not be impacted as proposed activities do not impact the channel bed.

Evaluation of federally protected species was conducted using USFWS IPaC determination key for the following species: Whooping Crane, Snuffbox Mussel, Karner Blue and Monarch Butterfly, Eastern Massasauga, and Indiana, Northern Long Eared and Tricolored bats. Based on absence of suitable habitat, urbanized area, and existing site conditions, it was determined no impacts to these species would occur as a result of proposed work activities. There is reasonable assumption no impact to mussels will occur as all work will occur from upland area and no activities will impact the riverbed.

Furthermore, all work activities will occur outside the 890 CFS line and not impact mussels or their habitat. Mussel studies for the Grand River note the 890 CFS is the breakpoint line for where mussels live and thrive, therefore no adverse impact to either federal or state protected mussels is anticipated to occur.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This site is currently a parking lot and storage buildings with a concrete floodwall along the river edge. No threatened and endangered species would be anticipated in the upland portion of this project. Threatened and endangered mussels could possibly be in the river near this area.

There is an assumed possible 0.03 acre of permanent streambed impact for the emergency access boat ramp. This would reduce the potential habitat for mussels in the river. A temporary streambed impact of 0.06 acres (243 m^2) was assumed to be needed for construction, including the 0.03 acre area mentioned above. The anticipated population of mussel in this area, assuming a mussel density of 1.7/m^2, would be approximately 420 mussels in this area. Assuming approximately 80% of the unionids would be translocated; the estimated take for this project is

85 mussels based on the current concept design. Measures that would be used to mitigate impacts include translocating mussels from the construction area to a suitable recipient site.

Fish Ladder Park – RFA #5 (Master Plan only):
This site is currently a park along the river edge. No threatened and endangered species would be anticipated in the upland portion of this project. Threatened and endangered mussels could possibly be in the river near this area.

This park may be one access point for the Corps project. Any river edge work included in this plan may be in conjunction with that project. This project is estimated to have up to 0.45 acre (1820 m^2) in areas of the river that could be occupied by mussels. Total permanent streambed impact area is estimated to be 0.08 acres. Assuming the higher 1.7/m^2 density of mussels upstream of 6th St. dam (rather than 0.3/m^2 downstream of the dam) in order to be conservative, the streambed impacts could include approximately 3,100 mussels. Therefore, assuming 80% of the mussels can be translocated, the take is assumed to be 620 mussels. The total impact to the mussels may be duplicated since both the Corps Project and the Fish Ladder Park project may account for the same riverbed area in the impact assessment.

There are some trees in this park, which could potentially be bat habitat, although it is unlikely as the area is already heavily urbanized. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. No threatened and endangered species would be anticipated in the upland portion of this project.

Wealthy St. Access (Concept Design):
The parcels along the river edge are currently underutilized parking areas with minimal facilities to the river. There are some trees in the area, but any potential impacts to threatened or endangered bats would be avoided or minimized. No threatened and endangered species would be anticipated in the upland portion of this project.

Threatened and endangered mussels could possibly be in the river near this area. A mussel survey has not been completed for this area. Within the 0.30 acre (1215 m^2) of temporary streambed impact and no permanent streambed impact area, the anticipated population of mussels, using mussel density of 0.1/m^2, there would be approximately 120 mussels in this area. Approximately 80% of the unionids within the cofferdams would be translocated; therefore, take estimates for mussels associated with his project have been calculated to be approximately 25 mussels.

Measures that would be used to mitigate impacts include translocating mussels from the construction area to a suitable recipient site.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
The June 6, 2023 inquiry to MNFI for the Canal Park and Ah-Nab-Awen projects was determined appropriate to use for this project, given the project site is within close proximity to the two other sites and has similar work activities being proposed. MNFI notes 3 state Threatened Species (Purple Wartyback, Slippershell and River Red Horse), and 2 state Endangered Species (Black Sand Shell and Peregrine Falcon), may exist within 1 mile of the project area. No adverse impact to Peregrine Falcon is expected to occur as a result of proposed activities. Peregrine Falcon

preferred habitat (inland or coastal cliffs, open woodlands near water, and potentially high city buildings) generally does not exist in the project area. River Red Horse habitat is associated with long deep runs (1-10 feet) in rivers, and proposed work activities will not extend into these areas of the Grand River. Lastly, protected mussels and/or their habitat will not be impacted as proposed activities do not impact the channel bed, and work will be conducted from upland area.

Evaluation of federally protected species was conducted using USFWS IPaC determination key for the following species: Whooping Crane, Snuffbox Mussel, Karner Blue and Monarch Butterfly, Eastern Massasauga (EMR), and Indiana, Northern Long Eared (NLB) and Tricolored bats. USFWS Consistency letter dated November 20, 2023 notes no effect for all species except EMR and NLB, which have a not likely to adversely affect (NLAA) designation. Based on absence of suitable habitat, urbanized area, existing site conditions, and construction methodology, it was determined no adverse impacts to these species would occur as a result of proposed work activities.

Furthermore, all work activities will occur outside the 890 CFS line and not impact mussels or their habitat. Mussel studies for the Grand River Revitalization project (HNV-A018-7X9N3) note the 890 CFS is the breakpoint line for where mussels live and thrive, therefore no adverse impact to either federal or state protected mussels is anticipated to occur. Tree removals will occur during the migrating season (October to March 30) to ensure no adverse impact to federally protected bats.

Fishbeck has determined there is reasonable certainty of no take for Snuffbox or Northern Long Eared bat for the following reasons:

- All work will occur from upland area and no equipment will enter the water.
- All work will occur outside the 890 CFS lines, which is breakpoint line for where mussels live and thrive.
- Turbidity curtain will be used in areas where work occurs below the OHWM to prevent off-site siltation to the greatest extent possible. Curtains will be installed from upland area or by wading out into the river.
- Silt fence or coir logs will be used to prevent off-site siltation in work areas above the OHWM.
- All SESC measures will be inspected and maintained daily throughout construction and any deficiencies observed will be repaired prior to commencement of daily activities.
- No work will impact the river bed.
- Tree removals will occur during the migratory season.

Canal Park (Construction, WRP040025 V.1):
Inquiry to MNFI (attached) notes 3 state Threatened Species (Purple Wartyback, Slippershell and River Red Horse), and 2 state Endangered Species (Black Sand Shell and Peregrine Falcon), may exist within 1 mile of the project area. No adverse impact to Peregrine Falcon or River Red Horse is expected to occur as a result of proposed activities. Peregrine Falcon preferred habitat (inland or coastal cliffs, open woodlands near water, and potentially high city buildings) generally does not exist in the project area. River Red Horse habitat is associated with long deep runs (1-10 feet) in rivers, and proposed work activities will not extend into these

areas of the Grand River. Mussels and/or their habitat will not be impacted as proposed activities do not impact the channel bed.

Evaluation of federally protected species was conducted using USFWS IPaC determination key for the following species: Whooping Crane, Snuffbox Mussel, Karner Blue and Monarch Butterfly, Eastern Massasauga, and Indiana, Northern Long Eared and Tricolored bats. Based on absence of suitable habitat, urbanized area, and existing site conditions, it was determined no impacts to these species would occur as a result of proposed work activities. There is reasonable assumption no impact to mussels will occur as all work will occur from upland area and no activities will impact the riverbed.

Furthermore, all work activities will occur outside the 890 CFS line and not impact mussels or their habitat. Mussel studies for the Grand River note the 890 CFS is the breakpoint line for where mussels live and thrive, therefore no adverse impact to either federal or state protected mussels is anticipated to occur.

6th St. Park (Concept Design):
This project is anticipated to not adversely impact wildlife and habitat. This park may be one of the access points for the Corps project. Any river edge work included in this plan may be in conjunction with that project. This project is estimated to have up to 1 acre (4046 m^2) in streambed impacts, which would include approximately 7,000 mussels assuming a 1.7/m^2 density, but the mussels could be translocated. Assuming 80% of the mussels would be translocated, the take is estimated to be 1,400 mussels. The total impact to the mussels in this assessment may be duplicated since the Corps project include the same riverbed area in the impact assessment.

Since the park as it exists today is a dilapidated parking lot, and the proposed improvements will include increased vegetation, it is anticipated to have positive impacts on wildlife and habitat.

There are some trees in this park, which could potentially be bat habitat, although it is unlikely as the area is already heavily urbanized. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. No threatened and endangered species would be anticipated in the upland portion of this project.

Riverside Park (Master Plan only):
This park provides a variety of habitat for wildlife, including some common aquatic wildlife. Envisioned work will be assumed to improve water quality of the lagoons and stormwater runoff and increase wetlands, wet meadows, and upland plantings. For the purpose of this assessment, it was assumed there would be 1.0 acres (4046 m^2) of temporary riverbed impact area that impacted mussels, including 0.5 acres of permanent streambed impact. Assuming a 3.0/m^2 density, this project would impact approximately 12,200 mussels. The mussels would be translocated. Assuming 80% of the mussels would be translocated, the take is estimated to be 2,440 mussels.

Habitat assessments for the northern long-eared bat, Indiana bat, and the karner blue butterfly may be necessary at the time design starts. As a precaution, trees should be removed from

construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. No threatened and endangered species would be anticipated in the upland portion of this project.

Given the current wide variety and habitat, and the goal of adding other natural features, it is anticipated that any impacts to wildlife will be temporary from construction, and the long term impacts is anticipated to be positive. No permanent adverse impacts are anticipated.

Ah-Nab-Awen Park - South (Active Design)
There are no impacts on wildlife and habitat, including threatened and endangered species.

Impacts on Wetlands

Lower Reach Project (Active Design):
The Lower Reach Project may have direct impact on wetlands, but the impacts are likely to be temporary and minimal. In 2019, approximately 0.25 acres of wetlands were delineated in this reach.

Corps Project including RFA#2 (Concept Design):
The Corps project may have a direct impact on 0.21 acres of wetlands, as determined from the 2014 Golder Wetland Delineation [TOC No. 23], which identified a total of 3.09 acres of wetlands along the Grand River from approximately Ann St. to Fulton St. This area of wetland impact includes the area of the elevated boardwalk included in RFA #2, the Water Department Storage Yard. More recent delineation data from the 2019 Fishbeck report [TOC No. 24] was also referenced but does not extend upstream of 6th Street Dam. Wetland impact associated with the Corps project could potentially be reduced based on updated wetlands delineation, further discussion on construction methodology, and/or further design development from the 30% design state.

The changes in water levels relative to existing conditions are expected to have indirect impacts to existing wetlands and other riparian areas within the project reach. Water levels in areas downstream of 6th Street Dam would increase, while water levels in areas between the dam and the AHS would decrease. These changes in water levels would alter the frequency of inundation of existing wetlands and are anticipated to result in some changes to long-term wetland boundaries. Much of the vegetation within the delineated wetlands are well-established non-emergent species [TOC No. 23]; these portions of wetlands would continue to be periodically inundated and remain vegetated similar to existing conditions. Since non-emergent species of wetland vegetation do not rely as much on specific water levels in the river, much of the existing vegetation is expected to survive and/or adjust to the new water level. Specific estimation of indirect impacts to wetlands resulting from the proposed changes to water levels are unable to be approximated at this time. Based on [TOC No. 23], there appears to be some emergent wetland vegetation within the 1.7 acre delineated wetland on the east bank directly upstream of Leonard Street. These emergent species of vegetation are anticipated to be impacted by lower water levels; however, the new inundation patterns of post-project conditions would likely establish new, and potentially expanded areas of emergent wetlands.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
There are no anticipated wetlands impacts for the Lyon Edge Project. All work is upland above the OHWM.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
There are no anticipated wetland impacts for the East River Edge sidewalk improvement project. There are no wetlands in this project area.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
There are no anticipated wetland impacts from the Grand Rapids Public Museum Riverfront project. There are no wetlands in this project area.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
No wetlands are anticipated to be impacted by this project.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
There are no known adverse impacts to wetlands in this project. This area was not included in any of the project wetland delineations, and the State's online wetland mapper shows no wetland in this area. River for All conceptual plans for the Coldbrook Decommissioned Water Pumping Station Site imagines a stormwater outfall water quality treatment area, which could be beneficial to wetlands.

Fish Ladder Park – RFA #5 (Master Plan only):
River for All plans for the Fish Ladder Park redevelopment could result in temporary disturbance of portions of the 0.25 acres of wetland along the RDB between the 6th Street Dam and I-196 as identified in [TOC No. 23] 2014 Golder wetland delineation report. Permanent impacts are not anticipated based on this delineation. The wetlands delineations would be updated prior to any future design, and any impacts would be avoided, minimized, or mitigated to the extent possible.

Wealthy St. Access (Concept Design):
We are not currently aware of any detailed wetland delineation on this site, so the State of Michigan's online wetland mapper was utilized. From this mapper, it appears a forested wetland up to approximately 0.15 acres is on the eastern river edge site. A wetland delineation would have to be performed on this concept prior to future design. Any impacts to the wetland would be avoided, minimized, or mitigated.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
A wetlands delineation was performed in July 2023. The wetland in the project area consisted of ten segments with an approximate total area of 0.95-acre. Diminimus impacts to wetlands area, totaling 0.09 acres, will result from the proposed work. This project will result in improved ecological resources along the river's edge due to the naturalization of the shoreline. Proposed native vegetation will improve water quality and facilitate streamside aquatic habitat and foraging areas to do not currently exist.

Canal Park (Construction, WRP040025 V.1):
There are no anticipated wetlands impacts for the Canal Park Project. There are no wetlands in this project area.

6th St. Park (Concept Design): From the [TOC No. 23] 2014 Golder Wetland Delineation, there was 0.05 acres of wetland just north of 6th St. dam. These wetlands may be temporarily impacted by construction, but proper best management practices to protect, avoid, or minimize the impacts would be utilized. River for All conceptual plans for portions of this site along the left descending bank just north of the I-196 westbound bridge include the creation of two small marsh-type wetland features, which would lead to a beneficial impact.

Riverside Park (Master Plan only):
A wetland delineation has not yet been performed for this site. Based on the State's online wetland mapper, there could be 50-60 acres of wetland in the park, including the area of the lagoons. The goals of the project include to improve the lagoons, wetlands, wet meadows, and upland plantings. To achieve this goal, it may be necessary to impact wetlands in the park, but

these adverse impacts are assumed to be temporary, and permanent impacts would be positive. No permanent adverse impacts to the wetlands are anticipated. A wetland delineation will be performed prior to finalizing design. Temporary impacts due to construction may occur, but proper best management practices may be installed.

Ah-Nab-Awen Park - South (Active Design)
There are no anticipated wetlands impacts for this project. There are no wetlands in this project area.

Impacts on Stream Function

Lower Reach Project (Active Design):
This project proposes to remove four low-head dams from the reach, so changes to the existing stream function can be expected.

Corps Project including RFA#2 (Concept Design):
Similar to the Lower Reach Project, the Corps project proposes significant changes to the existing stream function of the Grand River through the project reach. The proposed removal of 6th Street Dam and installation of the proposed in-river features seeks to replace a very uniformly flowing and hydraulically disconnected reach with a more dynamic and diverse hydraulic environment that more-closely emulates a natural river The stream gradient distributed at the dam would be spread-out over the project reach, both over the proposed features and over the existing channel bed. Average flow velocities throughout the reach would generally increase. Water levels would increase, when compared to existing conditions, downstream of the dam and decrease between the dam and the proposed AHS, establishing a more-gradual hydraulic gradient throughout the reach. More diversity in flow depths and velocities, as well as substrate, would result from the project and riffles, glides, pools, and runs would exist that do not under existing conditions.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
This project is not anticipated to have discernable impacts to the stream function of the Grand River

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project is not anticipated to have discernable adverse impacts to the stream function of the Grand River.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Fish Ladder Park – RFA #5 (Master Plan only):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Wealthy St. Access (Concept Design):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Canal Park (Construction, WRP040025 V.1):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

6th St. Park (Concept Design):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Riverside Park (Master Plan only):
If the lagoons are improved and wetlands are improved or added, there could be a positive impact on the stream function of the Grand River. None of the other improvements to this project would have discernable impacts to the stream function of the Grand River.

Ah-Nab-Awen Park - South (Active Design)
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Impacts on Modeled Flood Risk

Lower Reach Project (Active Design):
This project will be hydraulically modelled and will be required to maintain the City's freeboard deficient certification from FEMA. Localized increases in flood stages may occur, but no harmful interference is expected to result.

Corps Project including RFA#2 (Concept Design):
The Corps Project has been added to the cumulative impacts model for the Lower Reach Project as requested by EGLE. The model calculates a no-rise condition during the 100-yr flood based on the 30% design of the proposed improvements. Localized increases in flood stages are modeled to occur at some locations within the project reach; however, all increases would be contained within the flood protections system and would not result in harmful interference. The HEC-RAS model has been included as [TOC No. 11 Revised July 2022]. Refer to the Hydraulics Report [TOC No. 12 Revised July 2022] for further discussion.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
Per the request from EGLE prior to Correction Request #3, all ancillary bank projects have been added to the HEC-RAS model for the Lower Reach Project; this includes the addition of the Lyon Edge Project. Model results indicate that no increases in modeled flood levels would occur from adding this project to the HEC-RAS model for the Project. The HEC-RAS model has been included as [TOC No. 11 Revised July 2022]. Refer to the Hydraulics Report [TOC No. 12 Revised July 2022] for further discussion.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
Per the request from EGLE prior to Correction Request #3, all ancillary bank projects have been added to the HEC-RAS model for the Lower Reach Project; this includes the addition of the East River Edge Project. Model results indicate that no increases in modeled flood levels would occur from adding this project to the HEC-RAS model for the Project. The HEC-RAS model has been included as [TOC No. 11 Revised July 2022]. Refer to the Hydraulics Report [TOC No. 12 Revised July 2022] for further discussion.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
Per the request from EGLE prior to Correction Request #3, all ancillary bank projects have been added to the HEC-RAS model for the Lower Reach Project; this includes the addition of the Grand Rapids Public Museum Riverfront Improvements Project. Model results indicate that no increases in modeled flood levels would occur from adding this project to the HEC-RAS model for the Project. The HEC-RAS model has been included as [TOC No. 11 Revised August 2022]. Refer to the Hydraulics Report [TOC No. 12 Revised August 2022] for further discussion.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project has a net fill of 100 CY in the floodplain with no fill proposed to be under the OHWM. No changes to the modelled flood risk are anticipated.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Based

on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut within the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

Fish Ladder Park – RFA #5 (Master Plan only):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut below the OHWM and in the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

Wealthy St. Access (Concept Design):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Portions of this project may be designed to be within a conveyance shadow of the Wealthy St. bridge abutment and would be designed to have no impact on the base flood elevation. No adverse impacts to modelled flood risk are anticipated.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
A hydraulic model for this project was created in HEC-RAS version 4.1. The project result in a slight decrease in Energy Grade Line or Hydraulic Grade Line throughout the project reach. Therefore, it is concluded the proposed project does not result in harmful interference.

Canal Park (Construction, WRP040025 V.1):
Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut below the OHWM and in the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

6th St. Park (Concept Design):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut below the OHWM and in the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

Riverside Park (Master Plan only):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. The task of the design team is to build the project without causing an increase in the modeled flood levels.

Ah-Nab-Awen Park - South (Active Design)
This project has a dredge of 56 CY and fill of 128 CY which results in a net fill of 72 CY in the floodplain with no fill proposed to be under the OHWM. No changes to the modelled flood risk are anticipated.

Temporary Construction Impacts

Lower Reach Project (Active Design):
This project will evaluate construction means and methods to avoid and minimize construction impact to the environment. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee from the nearshore area. However, it is anticipated species will return when construction is complete. Temporary turbidity during construction would be managed with industry standards and assumed to be performed.

Corps Project including RFA#2 (Concept Design):
Similar to the discussion of construction means and methods for the Lower Reach Project, included in Section 9.7 of the revised Basis of Design Report [TOC No. 6 Revised July 2022], temporary impacts during construction for this project would also evaluate alternative means and methods for construction to minimize and avoid impacts to aquatic resources. A discussion of temporary construction impacts to aquatic wildlife and threatened and endangered species for the Corps project has been included in the earlier section on Impacts to Wildlife and Habitat. Assumed construction impact was included in the assessments of the mussels. Temporary construction impacts to fish passage are minimal and would be similar to that of the Lower Reach project (Section 9.7.1 of Basis of Design [TOC No. 6 Revised July 2022]). It is worth noting that because the 6th St dam is currently a barrier to many species of fish in the Grand River, temporary adverse impacts to fish passage (relative to existing conditions) would be minimal. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee from the nearshore area. However, it is anticipated species will return when construction is complete. Temporary turbidity during construction would be managed with industry standards and assumed to be performed in a similar fashion to means and methods proposed in the Lower Reach Project.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
There are no construction impacts to the riverbed, shoreline or other water features as no work is proposed within the river and floodwall exists throughout entire project area. All work will occur from upland areas and no equipment will enter the river. Approximately 200 lineal feet of temporary construction debris net will be stretched under the work platform to ensure no construction debris enters the river. It is not anticipated that shade from the debris net will adversely impact aquatic resources. Proposed work activities will permanently reduce cover over bottom land by 367 square feet. It is anticipated that aquatic biota and insects will not be adversely impacted by temporary construction netting or increased sunlight. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee from the nearshore area. However, it is anticipated species will return when construction is complete.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
All construction activities will occur from upland area and no heavy equipment will enter the water. A turbidity curtain will be placed sufficient to cover the entire project area during construction. Construction activities will permanently impact 360 lineal feet of shoreline. Approximately 288 square feet of riverbed will be impacted. Riverbed impacts will extend no greater than 2.75 lineal feet into water from edge of shoreline. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee

from the nearshore area. However, it is anticipated species will return when construction is complete.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The majority of construction activities will occur from upland areas and no heavy equipment will enter the water. 500 lineal feet of temporary sheet piling will be installed approximately +/-1 foot east of water's edge at 3500 CFS. Approximately 500 square feet of riverbed will be impacted. Temporary sheeting is necessary to protect existing channel bank and undergrade structures during the construction process. Impacts to the riverbed, aquatic wildlife and organisms during construction will be negligible. Disturbances from construction equipment (noise, equipment, traffic, vibration, etc.) may temporarily cause aquatic wildlife to flee from the nearshore area, however, it is anticipated species will return when construction is complete.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
Temporary construction impacts are anticipated to be minimal. All work will occur upland and will not be performed during high flow events. Disturbances from construction equipment (noise, equipment, traffic, vibration, etc.) may temporarily cause wildlife to flee from the area, however, it is anticipated species will return when construction is complete.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

Fish Ladder Park – RFA #5 (Master Plan only):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

Wealthy St. Access (Concept Design):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed temporary impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
Most of the construction of this project will take place in upland areas. Some work below the OHWM is needed in order to construction the base of the retaining wall or sea wall as well as to remove existing debris and plant vegetation. Prior to any work occurring, appropriate best management practices such as a turbidity curtain would be installed to limit any potential turbidity that arose from the project. The project will also schedule the work under the OHWM during periods of typical low flows on the Grand River.

Canal Park (Construction, WRP040025 V.1):
The construction is assumed to take place from the river edge and no work will occur from the riverbed. Appropriate best management practices such as turbidity curtain would be installed to limit any potential turbidity that arose from the project.

6th St. Park (Concept Design):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

Riverside Park (Master Plan only):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

Any work along the river edge would take place from land. Appropriate best management practices such as turbidity curtain would be installed to limit any potential turbidity that arose from the project.

Ah-Nab-Awen Park - South (Active Design)
There are no construction impacts to the riverbed, shoreline or other water features as no work is proposed within the river or below the OHWM. All work will occur from upland areas and will not be any closer than 80' from the river's edge. Between the proposed work and river includes existing lawn and landscape beds. A silt fence barrier will be placed and maintained throughout the duration of construction to prevent any silt from entering the river.

APPENDIX D
Drawings

APPENDIX E

Other Supporting Information

Amendment to Biological Assessment June 2024

Biological Assessment 2024: Impacts to federal and state threatened and endangered species from rehabilitation of the Grand River between Bridge and Fulton Streets in Grand Rapids, Kent County, Michigan
Revision 1- *Amendment June 13, 2024*

RE: addition of temporary scour protection around Gillett Bridge piers during period of Dam 2 removal and construction isolation.

This increases the Direct Impact Area by 1,970 m^2 (170 m^2<=2 ft/sec; 1,800 >2ft/sec), decreases to Construction Indirect Impact Area by 1,970 m^2, and increases the number of mussels impacted by 592 animals. This includes:
5 E. triquetra
3 P. sintoxia
17 C. tuberculata
17 L. recta
3 P. alatus
10 T. truncata
4 A. marginata
24 L. costata

Temporary scour protection was verified by modeling to have no impact on modeled tailwater elevations

Modifications to the BA.
Executive Summary- Increase construction area from 45,445 m^2 to 47,415 m^2 Direct Impacts
Change from 11 Acres to 11.7 acres

1.0 Introduction
1.2.1 NRCS Action

Page 3, paragraph 3, change 45,445 m2 and 11 acres to 47,415 m2 and 11.7 acres

Informal consultation with U.S. Fish and Wildlife Service (USFWS) was initiated in October 2023 (Table 1-1). A series of meeting between NRCS, GRWW, City, USFWS, MDNR, and EGLE have been held to discuss the design and to further avoid, minimize, and mitigate impacts to the river, fish, and unionid mussels. Of the 127,600 m^2 (31.5 acres) Construction Area, 47,415 m^2 (11.7 acres) would be directly impacted during construction (direct impact area) of this project. This is approximately a 50% reduction in impact area from the previous design, 89,195 m^2 (22 acres).

Figure 1-1 modified to add the Gillett pier access and scour protection to the direct impact area.

2.0 Project description
2.1.1 Project location

Page 7, last paragraph, change area to 47,415 m^2 and 11.7 acres (direct impact area) and indirect construction impact area from 82,155 to 80,185 ,m^2 and 19.8 acres.

The Construction Area is within the wetted channel of the Grand River between Bridge and Fulton Street bridges in Grand Rapids, Kent County, Michigan. Of the 127,600 m^2 (31.5

acres) Construction Area, 47,415 m^2 (11.7 acres) would be directly impacted during construction (direct impact area) (Table 2-1). This is approximately a 50% reduction in construction impact area from the previous design, 89,195 m^2 (22 acres). The river bottom would not be physically modified in approximately 80,185 m^2 (19.8 acres) of the Construction Area (construction indirect impact area), but could be affected by turbidity and changes in local hydraulic conditions. Staging and access areas would primarily be from Ah-Nab-Awen Park (park).

2.1.2 Evaluation metrics

Page 8, second paragraph. Add to the definition of direct impact areas-

Area affected by construction (direct impact areas) considered all areas that would be impacted by causeways constructed to access and work in construction areas in the dam removal and riffle construction areas, and tracking in the river needed for placement of emergent habitat boulder fields, diversified boulder arches, and rock pile vanes downstream of Pearl Street. The direct impact area also includes the area needed to access and place temporary scour protection around the Gillett Bridge piers.

Modified construction sheets are attached.

Page 8, third paragraph-

Permanent impact area includes a sum of all structures that would not be available to freshwater mussels post-construction. This includes boulders and rock used for riffles, diversified boulder arches, emergent habitat boulder fields, rock vanes, and transient sand. Scour protection would be removed when the Dam 2 construction area is no longer isolated. This area is not considered a permanent impact area.

2.1.4 NRCS project

Page 14, first paragraph add scour protection-

Limiting construction to lower flows allows construction to occur in the wet, negating the need for most of the isolation measures previously proposed. Causeways of imported clean coarse aggregate would be installed along the west bank to access the Dam 1, 3, and 4 construction areas, as well as the bank vane structures and the emergent habitat boulder fields downstream of Pearl Street. The Dam 2 construction area would be accessed directly from the staging area. A low causeway (<0.6 m) may also be needed to access Gillett Bridge piers. However, if river levels permit, piers could be accessed by tracking on the river bottom. Construction equipment would be equipped with Global Positioning Systems (GPS) to ensure all construction and in river tracking is within the direct impact areas outlined in this BA.

Page 14, paragraph 4 add paragraph between paragraphs 3 and 4

Flow velocity may increase when the Dam 2 cofferdam is in place, potentially increasing scour around the Gillett Bridge piers. Therefore, a low causeway (<0.6 m) may be installed to access these piers to place temporary scour protection. The causeway would extend from the causeway along the west bank. Scour protection would extend around the three eastern most piers to twice the pier width (4.4 m; 14.4 ft). Scour protection would be installed before the Dam 2 area is isolated in July/August (after *P. marinus* spawning season). The temporary causeway and scour protection would be removed before the end of the construction season at the latest (not left in over winter). The additional material

in the river has been modeled to have no impact on tailwater elevation at 6th Street Dam and would not be in the river during *P. marinus* spawning season.

2.1.5 NRCS Project Impacts

Page 17- second paragraph in this section- Add temporary scour protection to the second sentence.

Project elements that could directly affect TES mussels include any actions that would affect freshwater unionid mussels and/or their habitat. TES would be harmed (killed or injured) by construction of temporary causeways, temporary scour protection, a cofferdam structure, substrate placement, grading, and equipment tracking within the river channel.

Page 17-Fourth paragraph in this section- Change 45,445 m^2 (11 acres) to 47,415 m^2 and 11.7 acres. Also add scour protection and update species numbers.

The area that would be affected by project construction includes the area from 91 m (300 ft) upstream of Bridge Street to the upstream face of Fulton Street, an area of 127,600 m^2 (31.5 acres) (Table 2-1). Of this, 47,415 m^2 (11.7 acres) would be directly impacted during dam removal, temporary scour protection placement, and causeway and feature creation. If unionid mussels are evenly scattered throughout the direct impact areas, approximately 128 *E. triquetra*, 1,878 additional Michigan TES, and 12,219 other unionid species could be impacted during construction (Table 2-1 updated). Unionids not relocated from direct impact areas could be crushed by construction activities. As many unionids as practicable would be translocated from direct impact areas before construction to minimize these impacts. However, unsafe diving/collection conditions may prevent some unionids from being removed (see Grand Rapids/GRWW relocation project, Section 2.2). Those not relocated would be considered Take and mitigated through a mitigation fund (see Section 2.3).

Updated Table 2-1

Page 18- top of the page- change area and animal numbers

The area of indirect impact within the construction area is approximately 80,185 m^2 (19.8 acres). Approximately 216 *E. triquetra*, 3,175 additional Michigan TES , and 20,664 other unionids could be affected by increases in turbidity and slight changes in local hydraulics (Table 2-1).

2.1.6 Conservation Measures

Page 20, first bullet point- update areas

The project has changed from most of the Project Area being isolated and impacted directly (89,195 m^2 direct impact Area; EcoAnalysts, 2020) to direct impact area of only 47,415 m^2, a 50% reduction in area affected by the project. Rather than the river being constrained by isolation measures during construction, construction would occur in the flowing river. Only a small area (3,285 m^2) at Dam 2 would be isolated during construction (Table 2-9), and the area would not be isolated during *P. marinus* migration season.

2.2 Grand Rapids/GRWW Relocation Project

Page 22, update areas and no. of animals

The Grand Rapids/GRWW Relocation Project would consist of collecting as many mussels as possible from the NRCS Project direct impact areas with USFWS assistance (Figure 1-1) and translocating them to three recipient sites (Figure 1-4). The area that would be affected by project construction includes the area from 91 m (300 ft) upstream of Bridge

Street to the upstream face of Fulton Street, an area of 127,600 m^2 (31.5 acres) (Table 2-1). Of this, 47,415 m^2 (11.7 acres) would be directly impacted during dam removal, and scour protection, causeway and feature creation. If unionid mussels are evenly scattered throughout the direct impact areas, approximately 128 *E. triquetra*, 1,878 other Michigan TES, and 12,219 other unionid species could be impacted during construction (Table 2-1). Unionids not relocated from direct impact areas could be crushed by construction activities. As many unionids as practicable would be translocated from direct impact areas before construction in 2024 to minimize these impacts. However, unsafe diving/collection conditions may prevent some unionids from being removed.

2.2.1 Recipient sites

Page 22, first paragraph, change no. of animals

A survey was conducted in 2015 to identify suitable recipient sites for mussels that would be translocated from NRCS Project impact areas (ESI, 2016). Five potential sites were identified; Ionia, Saranac, Chief Hazy Cloud, Ada, and Site 7. Of these, Ada is the largest (23,480 m^2 [5.8 acres]) site, and most of the TES were found at this site (Tables 2-7 and 2-8). The best habitat within the Ada bed is 3,400 m^2 (0.8 acres) mid channel (Figure 2-5). As many 10 m x 10 m areas as needed to accommodate TES would be established using corner markers driven into the substrate and either PVC pipe or ropes between the corner markers within this section of the site for the placement of TES. TES would be hand placed 1 unionid/m^2 into the 10 x 10 areas. A PVC grid with 1 m^2 cells would be used to delineate positions within the 10 x 10 area. The remainder of the site would be used to place common species. Density within this site averaged 2.8 unionids/m^2. If density is increased no more than 50%, the site can accommodate 4,760 TES individuals and 21,000 common individuals (Table 2-8). If mussels could be collected from all of the direct impact areas with no mortality, approximately 128 *E. triquetra*, 1,878 other Michigan TES, and 12,218 common individuals could be moved (Table 2-9). Landowners near the site would be contacted before any work is conducted.

Table 2-9 updated

2.2.2 Collection and Translocation Safety Limitations and Timing

Update Figure 2-8

2.2.3 Collection and Translocation Methods

No changes to text

Updated Table 2-11 and 2-12

2.2.4 Monitoring

No changes

2.3 Mitigation Fund

As many mussels as possible would be collected from direct impact areas and translocated to one of the three recipient sites under the Grand Rapids/GRWW project (see Section 2.2). The estimated area of direct impacts is 47,415 m^2. Using an average unionid density of 0.3 unionids/m^2, approximately 14,224 unionids occur within direct impact areas (Table 2-9). Mussels would at least be collected and translocated from within the isolated area. Up to 15% of those mussels may be missed during collection, and up to 5% might die due to handling. Minimum number of mussels that would be translocated would be 830 mussels, with mortality of 13,394 mussels (Table 2-12). If mussel collection in all of the direct impact area can be safely done, then

with 15% of the mussels missed and 5% mortality due to handling, the maximum number of mussels that would be relocated would be 11,485.

A mitigation fund would be established to offset the take for the mussels that were unable to be translocated under the Grand Rapids/GRWW Project. The maximum mitigation fund contribution would be based on $34.10/mussel (2020 BA $28.50/mussel escalated for inflation) and would not exceed $456,743 (Table 2-13 updated). This fund would be reduced by the amount of mussels that are translocated multiplied by the cost per mussel as stated above. The objective of the mitigation fund would be to fund projects that provide a direct benefit to mussels to achieve the USFWS "no net loss" policy and offset any potential impacts from mussels that were unable to be translocated. The work performed through the mitigation fund would help inform future conservation and habitat restoration efforts.

2.4 Project schedule – no changes

3.0 Environmental Setting and Biological Resources- no changes

4.0 Species Considered- no changes

5.0 Effects of Proposed Action

Tables 5-1, 5-2, 5-3, 5-4 and 5-5 updated

First paragraph- change areas

The construction area for the NRCS project spans from 91 m (300 ft) upstream of Bridge Street to Fulton Street, 127,600 m^2 (31.5 acres). Of this 47,415 m^2 (11.7 acres) would be directly impacted during construction, and the areas between direct impact areas (80,185 m^2; 19.8 acres) would be indirectly impacted by temporary increases in turbidity and changes in flow patterns associated with causeways and features constructed in the river. Scouring of the existing riverbed outside of direct impact areas is not anticipated during construction. Upstream indirect impacts during construction (38,420 m^2; 9.5 acres) would be limited to slight changes in depth and velocity depending on what construction and project features are in the river. Construction sequencing has been developed to ensure increases in modeled tailwater levels are avoided and minimized during *P. marinus* migration. Barrier criteria for *P. marinus* would be maintained through construction and post-construction, and Great Lakes Fish Commission (GLFC) who monitors the Grand River for *P. marinus*, have been notified of the project.

Third paragraph-change areas and mussel numbers

The Project would be constructed from causeways constructed in the river or with equipment tracking on the river bottom. One small area within the Dam 2 direct impact area would be isolated from the flow of the river for construction. All unionids, and any fish that do not leave the direct impact areas, outside the isolation area may be crushed under causeways or by tracking equipment, excavation, grading, and placement of rock. To minimize mortality of unionid mussels, mussels would be collected and translocated from as much area as practicable within direct impact areas under the Grand Rapids/GRWW project. If an equal mussel density of 0.3 unionids/m^2 is assumed throughout the direct impact areas (47,415 m^2), approximately 128 *E. triquetra*, 1,878 additional Michigan TES, and 12,219 other mussels occur in direct impact areas (Table 5-1). If mussels can be translocated from all of the direct impact area (best case), with a collection efficiency of 85% and 5% mortality due to handling, mortality would only be from

translocation and is expected to include 20 *E. triquetra*, 296 Michigan TES, and 1,924 common species (Table 5-2). This would be the minimum Take (Table 5-4).

Fourth paragraph- change areas and mussel numbers

Under worst case conditions (maximum Take), mussels would at least be translocated from within the small, isolated area (3,285 m^2). The construction team would need to wait for fish and unionids to be moved from within the isolated area before construction. A maximum of 10 days of mussel translocation is allocated for this effort. Approximately 9 *E. triquetra*, 130 TES, and 847 common species occur in the isolated area (Table 5-1). Collection efficiency in this area is expected to be 85%; however, up to 5% mortality could occur from handling. Mortality from the translocation effort is expected to include 1 *E. triquetra*, 21 TES, and 133 common species (Table 5-2). Worst case, mussels would only be collected from the isolated area, mussels in other parts of the direct impact area would be negatively impacted. Mortality from direct impact areas where mussels are not translocated would include 119 *E. triquetra*, 1,748 additional Michigan TES, and 11,372 common species (Table 5-3). Total mortality (uncollected direct impact areas + translocation mortality) would include 120 E. *triquetra*, 1,768 additional Michigan TES, and 11,505 other mussels (Table 5-4).

Fifth paragraph- change areas and mussel numbers

The most likely scenario is if river conditions permit, mussels should be translocated from the isolated area and all areas with ≤0.6 m/sec (2 ft/sec) velocity. The estimated number of mussels in low velocities areas and the isolated area combined includes 32 *E. triquetra*, 462 additional Michigan TES, and 3,010 other individuals. Translocation mortality would include 4 *E. triquetra*, 60 additional Michigan TES, and 388 other individuals (Table 5-2). An additional 93 *E. triquetra*, 1,369 additional Michigan TES, and 8,909 other mussels would be killed in areas where collection could not occur due to unsafe conditions (Table 5-3). Total mortality under this scenario (direct impact areas >0.6 m/sec [not translocated] + translocation take) would be 97 *E. triquetra*, 1,429 additional Michigan TES, and 9,297 common mussels (Table 5-4).

Sixth paragraph-- change areas and mussel numbers

Mussels may also be temporarily affected by increased turbidity and changes in local hydraulic conditions in Construction Area indirect impact areas. No scour holes are expected to develop during construction outside of direct impact areas. Host fish activity in these areas may be altered. Turbidity would be monitored and adaptively managed to minimize these effects. The area of construction indirect impact area is approximately 80,185 m^2 (Table 5-5). Approximately 24,056 mussels, including 216 *E. triquetra* and 3,175 additional Michigan TES could occur in the Construction Area indirect impact area (Table 5-5). These mussels could be temporarily stressed during construction or host fish may not be available during glochidial release, and a few year classes may be lost.

7.0 Conclusions and determination of effects

7.1 Federal Endangered Species- E. triquetra; change numbers

The NRCS Project may affect and is likely to adversely affect *E. triquetra*, but would not jeopardize the continued existence of this species. *Epioblasma triquetra* occur at a low frequency (0.9%) within the Project Area. An estimated 128 *E. triquetra* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *E. triquetra* from within at least the isolated area to minimize harm and 5% mortality is expected during translocation (Table 5-2). At a minimum, 20 *E. triquetra* would be directly harmed during translocation if all unionids in direct impact areas are translocated (Table 5-4). If only mussels in the isolated area are translocated, 120 *E.*

triquetra could be directly harmed (Table 5-4). An additional 27 could be harmed by OMRRR activities (Tables 5-6). OMRRR take would be reduced by translocation if practical. Approximately 104 *E. triquetra* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *E. triquetra*. Approximately 216 *E. triquetra* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. Based on relative abundance at the I-196 bridge, approximately 55 *Epioblasma triquetra* may occur downstream of Fulton Street and could be indirectly affected by any downstream increased turbidity.

7.2 Michigan Endangered Species

Toxolasma parvum (Lilliput)- no changes

7.3 Michigan Threatened Species- change numbers

Cyclonaias tuberculata (Purple Wartyback)

The NRCS Project would result in take of *C. tuberculata*. *Cyclonaias tuberculata* occur at a frequency of 2.9% within the Project Area. An estimated 407 *C. tuberculata* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *C. tuberculata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 64 *C. tuberculata* could be negatively impacted during translocation (Table 5-4). If only mussels in the isolated area are translocated, 383 *C. tuberculata* could be negatively impacted (Table 5-4). An additional 86 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 330 *C. tuberculata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *C. tuberculata*. Approximately 688 *C. tuberculata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Cyclonaias tuberculata* has been collected downstream of Fulton Street and an estimated five could be indirectly affected by any downstream increased turbidity (Table 5-5).

Ligumia recta (Black Sandshell)

The NRCS Project would result in take of *L. recta*. *Ligumia recta* occur at a frequency of 2.9% within the Project Area. An estimated 411 *L. recta* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *L. recta* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). At a minimum, 65 *L. recta* would be directly impacted during translocation if all unionids in direct impact areas are translocated (Table 5-4). If only mussels in the isolated area are translocated, 387 *L. recta* could be directly impacted (Table 5-4). An additional 87 could be directly impacted by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 333 *L. recta* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *L. recta*. Approximately 695 *L. recta* could occur in the Construction Area indirect impact area and could be

temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Ligumia recta* has been collected downstream of Fulton Street and an estimated 255 could be indirectly affected by any downstream increased turbidity.

Alasmidonta viridis (Slippershell)-no change

Acipenser fulvescens (Lake Sturgeon)-no change

Moxostoma carinatum (River Redhorse)-no change

7.4 Michigan Species of Special Concern

Pleurobema sintoxia (Round Pigtoe)-update numbers

The NRCS Project would result in take of *P. sintoxia*. *Pleurobema sintoxia* occur at a frequency of 0.4% within the Project Area. An estimated 61 *P. sintoxia* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *P. sintoxia* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 10 *P. sintoxia* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 58 *P. sintoxia* could be directly affected (Table 5-4). An additional 13 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 50 *P. sintoxia* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *P. sintoxia*. Approximately 103 *P. sintoxia* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Pleurobema sintoxia* has not been collected downstream of Fulton Street, but may occur there and a few could be indirectly affected by any downstream increased turbidity.

Potamilus alatus (Pink Heelsplitter)- update numbers

The NRCS Project would result in take of *P. alatus*. *Potamilus alatus* occur at a frequency of 0.5% within the Project Area. An estimated 77 *P. alatus* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *P. alatus* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 12 *P. alatus* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 72 *P. alatus* could be directly affected (Table 5-4). An additional 16 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 62 *P. alatus* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *P. alatus*. Approximately 130 *P. alatus* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used

during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Potamilus alatus* was collected downstream of Fulton Street, approximately 705 could be indirectly affected by any downstream increased turbidity.

Truncilla truncata (Deertoe)- update numbers

The NRCS Project would result in take of *T. truncata*. *Truncilla truncata* occur at a frequency of 1.7% within the Project Area. An estimated 240 *T. truncata* occur in the direct impact area (Table 5-1).The Grand Rapids/GRWW relocation project would translocate 85% of *T. truncata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 38 *T. truncata* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 226 *T. truncata* could be directly affected (Table 5-4). An additional 51 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 195 *T. truncata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *T. truncata*. Approximately 407 *T. truncata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Truncilla truncata* has been collected downstream of Fulton Street and an estimated 8,530 could be indirectly affected by any downstream increased turbidity.

Venustaconcha ellipsiformis (Ellipse)-update numbers

The NRCS Project would result in take of *V. ellipsiformis*. *Venustaconcha ellipsiformis* occur at a frequency of 0.06% within the Project Area. An estimated 9 *V. ellipsiformis* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *V. ellipsiformis* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 1 *V. ellipsiformis* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 8 *V. ellipsiformis* could be directly affected (Table 5-4). An additional 2 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 7 *V. ellipsiformis* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *V. ellipsiformis*. Approximately 14 *V. ellipsiformis* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Venustaconcha ellipsiformis* has not been collected downstream of Fulton Street, but may occur there and a few could be indirectly affected by any downstream increased turbidity.

Alasmidonta marginata (Elktoe)-update numbers

The NRCS Project would result in take of *A. marginata*. *Alasmidonta marginata* occur at a frequency of 0.7% within the Project Area. An estimated 102 *A. marginata* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *A. marginata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 16 *A.*

marginata would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 96 *A. marginata* could be directly affected (Table 5-4). An additional 22 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 83 *A. marginata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *A. marginata*. Approximately 173 *A. marginata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. A few *A. marginata* were collected downstream of Fulton Street at the I-196 bridge, and a few could be indirectly affected by any downstream increased turbidity.

Lasmigona compressa (Creek Heelsplitter)-no changes

Lasmigona costata (Flutedshell)- update numbers

The NRCS Project would result in take of *L. costata*. *Lasmigona costata* occur at a frequency of 4.0% within the Project Area. An estimated 566 *L. costata* occur in the direct impact area (Table 5-1). The Grand Rapids/GRWW relocation project would translocate 85% of *L. costata* from within at least the isolated area to minimize effects and 5% mortality is expected during translocation (Table 5-2). If unionids are collected from all direct impact areas, 89 *L. costata* would be directly affected during translocation (Table 5-4). If only mussels in the isolated area are translocated, 533 *L. costata* could be directly affected (Table 5-4). An additional 119 could be affected by OMRRR activities (Tables 5-6). OMRRR effects would be reduced by translocation if practical. Approximately 459 *L. costata* could occur in the upstream indirect impact area (Table 5-5). Hydraulic changes to this reach would be minor and are not expected to adversely affect *L. costata*. Approximately 957 *L. costata* could occur in the Construction Area indirect impact area and could be temporarily affected by sporadic increases in turbidity (Table 5-5). Increases in turbidity could affect feeding and reproduction depending on the magnitude and duration of turbidity plumes. BMPs would be used during construction to minimize turbidity, and turbidity would be monitored and adaptively managed to minimize effects. *Lasmigona costata* has not been collected downstream of Fulton Street, but may occur there and a few could be indirectly affected by any downstream increased turbidity.

Utterbackia imbecillis (Paper Pondshell) – no changes

Table 2-1 updated. Existing and Current Project areas and impacts to unionid mussels.

	Existing	2024 Project
Total wetted area at 890 CFS (m2)	167,353	166,020
Permanent impact area	643	4,638
Area available for mussel colonization[1]	166,710	161,382
Estimated no. of mussels in available area	50,013	48,415
Modeled Hydrophysical Habitat[2]	6,080	7,565
Construction Area		127,600
Direct Impact Area	0	47,415
Epioblasma triquetra	-	128
Michigan TES	-	1,878
Other unionid species	-	12,219
Indirect Impact Area		80,185
Epioblasma triquetra	-	216
Michigan TES	-	3,175
Other unionid species	-	20,664
OMRRR mussel area[3]		10,000
Epioblasma triquetra	-	27
Michigan TES	-	396
Other unionid species	-	2,577
Upstream Indirect Impact Area[4]		38,420
Epioblasma triquetra	-	104
Michigan TES	-	1,521
Other unionid species	-	9,901
Downstream Indirect Impact Area[5]		282,600
Epioblasma triquetra	-	?
Michigan TES	-	?
Other unionid species	-	28,260

[1]890 wetted area minus dams, boulders, transient sand, and rock or structures that mussels cannot occupy

[2] Areas with current velocity under 1,200 CFS conditions between 0.12 and 0.50 ft/sec; this defines areas with some flow under low flow, but not scouring flow.
Shear stress at 3,900 CFS >0.01 lb/sf to prevent sand deposition

[3] OMRRR (operation, maintenance, repair, rehabilitation, and replacement)

[4] 6th Street Dam to Construction Area

[5] Fulton St. to Plaster Creek - live E. triquetra have been found downstream of Fulton, insufficient data on E. triquetra and Michigan TES species to evaluate

Table 2-2. Coordinates[1] for sites within the Action Area.

Site	Easting	Northing
Upstream Indirect Impact Area		
Upstream west	608009	4758821
Upstream east	608158	4758823
Downstream west	608003	4758480
Downstream east	608140	4758473
Construction Area		
Upstream west	608003	4758480
Upstream east	608140	4758473
Downstream west	607905	4757597
Downstream east	608053	4757599
Downstream Indirect Impact Area		
Upstream west	607905	4757597
Upstream east	608053	4757599
Downstream north	606128	4756066
Downstream south	606147	4755979
Recipient sites		
Ada	622007	4869419
Riverside Park	608194	4763006
Plaster Creek	606105	4756021

[1] NAD 1983, UTM Zone 16 North

Table 2-3. 6th Street Dam tailwater elevations under construction and post-construction conditions, and change from existing conditions.[1]

Flowrate (CFS)	Hydraulic condition	Existing WSE[2]	Temporary conditions Model 1[4]		Temporary conditions Model 2[5]		Temporary conditions Model 3[6]		Post-construction Conditions		Modeling results
			WSE[2]	Change[3]	WSE[2]	Change[3]	WSE[2]	Change[3]	WSE[2]	Change[3]	
1,200		595.92	596.25	0.33	596.23	0.31	595.59	-0.33	595.62	-0.30	
2,500	75% exceedance	596.64	596.96	0.32	596.94	0.30	596.30	-0.34	596.33	-0.31	
3,900		597.26	597.58	0.32	597.55	0.29	596.91	-0.35	596.93	-0.33	
5,000		597.67	598.00	0.33	597.97	0.30	597.33	-0.34	597.35	-0.32	SRH-2D
7,500		598.50	598.83	0.33	598.80	0.30	598.18	-0.32	598.19	-0.31	
10,000	1 yr flood	599.20	599.57	0.37	599.53	0.33	598.99	-0.21	598.96	-0.24	
13,000	Bankfull	599.90	600.13	0.23	600.07	0.17	599.94	0.04	599.88	-0.02	
18,000	2 yr flood	601.84	602.04	0.20	602.05	0.21	601.92	0.08	601.86	0.02	
26,000	5 yr flood	604.34	604.52	0.18	604.54	0.20	604.39	0.05	604.32	-0.02	
31,000	10 yr flood	605.98	606.14	0.16	606.15	0.17	605.99	0.01	605.93	-0.05	HEC-RAS
38,000	25 yr flood	608.17	608.29	0.12	608.30	0.13	608.09	-0.08	608.04	-0.13	
44,000	50 yr flood	610.26	610.36	0.10	610.37	0.11	610.16	-0.10	610.11	-0.15	
50,000	100 yr flood	612.92	612.98	0.06	612.99	0.07	612.80	-0.12	612.72	-0.20	

Yellow shading indicates conditions when the distance from the crest to tailwater level is <18"

[1]See Appendix D for methods and data

[2]WSE = wetted surface elevation (mean sea level; ft)

[3]Change = Existing - Post-construction or Construction conditions

[4]Assumes casueways to Dams 1 and 2, and causeways downstream of Pearl Street have been installed and all dams remain in place

[5]Assumes that the coffers at Dam 2 have been installed in addition to all causeways and scour protection as described in model 1 and all dams remain in place

[6]Assumes the cofferdam has been removed and all proposed improvements are completed, but all causeways are still present

Table 2-4. Water surface elevation (WSE) at the base of the fish ladder.[1]

							Difference to invert[3]				
			Construction					Construction			
Flowrate CFS	Fish Ladder Invert	Existing[2]	Temp. model condtions 1[4]	Temp. model condtions 2[5]	Temp. model condtions 3[6]	Post constr.	Existing[2]	Temp. model condtions 1	Temp. model condtions 2	Temp. model condtions 3	Post constr.
2,500	597.50	596.64	596.96	596.64	596.30	596.33	-0.86	-0.54	-0.86	-1.20	-1.17
5,000	597.50	597.67	598.00	597.97	597.33	597.35	0.17	0.50	0.47	-0.17	-0.15
7,500	597.50	598.50	598.83	598.80	598.18	598.19	1.00	1.33	1.30	0.68	0.69
10,000	597.50	599.20	599.57	599.53	598.99	598.96	1.70	2.07	2.03	1.49	1.46

[1]See Appendix D for details; WSE = wetted surface elevation in feet

[2] Conditions prior to I-196 construction based on HEC RAS model and 1979 base conditions

[3] Construction and Project elevation minus fish ladder invert (jumping distance to the invert)

[4]Assumes casueways to Dams 1 and 2, and causeways downstream of Pearl Street have been installed and all dams remain in place

[5]Assumes that the coffers at Dam 2 have been installed in addition to all causeways and scour protection as described in model 1 and all dams remain in place

[6]Assumes the cofferdam has been removed and all proposed improvements are completed, but all causeways are still present

Table 2-5. Host fish habitat comparison, existing versus current project.

	Existing	2024 Project
Gradual sloping margins[1]		
Dam to Bridge St	Right bank	Right bank
Bridge St. to Gillett	Right bank	Right bank
Gillette to Pearl St.	Right minimal	Right bank
Pearl St. to Blue Bridge	Minimal	Minimal
Blue Bridge to Fulton	No	No
Moderate depth with cover, slow velocity[2]		
Dam to Bridge St	Left bank	Left bank
Bridge St. to Gillett	Left bank up of beautification dam	Within dam 3 boulders
Gillette to Pearl St.	Dn of beautification dam, Bridge piers	Within and down of Dam 1 riffle
Pearl St. to Blue Bridge	Minimal	Within boulder fields
Blue Bridge to Fulton	Riprap along banks	Within boulder fields
Deeper pools [3]		
Dam to Bridge St	Left bank	Left bank
Bridge St. to Gillett	Bridge piers	Up of dam 2 riffle
Gillette to Pearl St.	No	Minimal
Pearl St. to Blue Bridge	No	No
Blue Bridge to Fulton	No	No
Riffles with large boulders[4]		
Dam to Bridge St	No	No
Bridge St. to Gillett	No	Dam 1 and 2 riffles
Gillette to Pearl St.	No	Dam 1 and 2 riffles
Pearl St. to Blue Bridge	No	No
Blue Bridge to Fulton	No	No
Raceways[5]		
Dam to Bridge St	Throughout	Throughout
Bridge St. to Gillett	Throughout	Throughout
Gillette to Pearl St.	Throughout	Between riffles
Pearl St. to Blue Bridge	Throughout	Throughout
Blue Bridge to Fulton	Throughout	Throughout
Open water[6]		
Dam to Bridge St	Mid channel	Mid channel
Bridge St. to Gillett	Mid channel	Mid channel
Gillette to Pearl St.	Mid channel	Between riffles
Pearl St. to Blue Bridge	Mid channel	Mid channel
Blue Bridge to Fulton	Throughout	Throughout

[1] Habitat for Cyprinidae (Minnows, Shiners)

[2] Habitat for *Lepomis* sp. (Sunfish), juvenile fish, *Catostoma commersoni* (White Sucker)

[3] Habitat for Ictaluridae (Catfish), *Micropterus* sp. (Bass); slow flowing, at least 1 m (3 ft) at 2500 CFS

[4] Habitat for *Percina caprodes* (Logperch), juvenile Ictaluridae (Catfish), juvenile Catostomidae (Suckers)

[5] Habitat for *Moxostoma* sp. (Redhorse), *Hypentelium nigricans* (N. Hogsuckers)

[6] Habitat for *Aplodinotis grunniens* (Freshwater Drum)

Table 2-6. Estimated fish passage success for three length groups of walleye at challenging swim

Location	CFS	Swim path #	50% of Population Would Pass 15" TL	17" TL	20" TL
Upper Ah-Nab-Awen Park (W-Weir/Riffle)	5,000	1	Y	Y	Y
		2	N	N	N
		3	Y	Y	Y
Lower Ah-Nab-Awen (Riffle Structure)	5,000	4	Y	Y	Y
		5	N	N	Y
		6	Y	Y	Y
Museum/JW Marriott	3,900	7	Y	Y	Y
		8	N	N	Y
		9	Y	Y	Y
		10	Y	Y	Y
Downstream of Blue Bridge	2,500	11	N	N	Y
		12	N	N	N
		13	Y	Y	Y
		14	Y	Y	Y
		15	Y	Y	Y

Modified from Holtgren (2024), see Appendix E for fish swimpaths

Y indicates at least 50% of the population would pass, N indicates they would not pass

Table 2-7. Unionid species collected within the lower Grand River, 2013 to 2020.

Species by Tribe	Federal/ State Status[1]	Ionia[2]	Saranac[2]	Flat River[2]	Peace Park[3]	Chief Hazy Cloud[2]	Ada[2]	Roselle Park[3]	Site 7[4]	Riverside Park[4]	Upstream[5]	6th Street Dam to Fulton Street[5]	Dnstream Indirect Impact Area[5]	Plaster Creek Recipient Site[6]	Plaster Creek to M-11 bridge[5,6,7]	Total
Amblemini																
Amblema plicata		27	19	36	7	3	7	45	2	238	523	40	3	L	L	947
Pleurobemini																
Eurynia dilatata		9	2	2	WD	-	-	WD	-	-	FD	WD	WD	WD	-	13
Fusconaia flava		9	11	16	23	3	2	23	WD	35	82	7	FD		L	211
Pleurobema sintoxia	MSC	5	15	2	3	4	4	8	-	1	10	L	WD		-	52
Quadrulini																
Cyclonaias pustulosa		7	5	5	7	1	8	6	WD	6	81	13	2	L	L	139
Cyclonaias tuberculata	MT	6	2	-	6	-	FD	5	-	-	29	7	L	L	-	55
Quadrula quadrula		4	7	2	7	2	1	5	WD	8	137	4	L	L	L	177
Lampsilini																
Actinonaias ligamentina		5	4	4	7	-	2	2	-	-	14	10	L	L	L	48
Epioblasma triquetra	FE, ME	3	2	6	3	4	3	2	WD	FD	3	2	SF	SF	L	28
Lampsilis cardium		22	15	62	8	1	2	10	1	2	40	37	3	3	L	200
Lampsilis siliquoidea		3	2	-	-	-	-	-	-	-	-	L	-		L	5
Ligumia recta	MT	-	10	14	-	-	3	L	-	-	10	7	1	1	L	44
Potamilus alatus	MSC	-	-	-	-	-	-	-	-	-	-	4	2	L	L	4
Potamilus fragilis		-	-		1	-	-	-	-	-	2	8	1	L	L	11
Toxolasma parvum	ME	1	-	1	WD	-	-	-	-	1	-	-	-		-	3
Truncilla donaciformis	ME	-	-	-	-	-	-	-	-	-	-	-	WD		WD	WD
Truncilla truncata	MSC	-	1	-	-	-	-	-	-	-	-	9	L	5	L	10
Venustaconcha ellipsiformis	MSC	-	-	94	1	-	2	1	-	-	WD	L	WD		-	98
Cambarunio iris	MSC	-	-	-	-	-	-	-	-	-	WD	WD	-		-	WD
Anodontini																
Alasmidonta marginata	MSC	1	1	7	FD	1	2	FD	-	-	FD	L	FD		L	12
Alasmidonta viridis	MT	-	-	-	-	-	-	-	-	-	WD	L	WD		-	L
Lasmigona complanata		-	-	-	-	-	-	-	-	-	2	2	L	L	L	4
Lasmigona compressa	MSC	-	-	5	-	-	-	L	-	-	-	-	-		L	L
Lasmigona costata	MSC	2	FD	25	1	1	FD	L	WD	1	47	25	FD	FD	FD	102
Pyganodon grandis		2	4	-	1	-	-	-	-	4	8	L	FD	FD	WD	19
Strophitus undulatus		4	4	6	2	FD	1	1	1	1	24	4	L	L	L	48
Utterbackia imbecillis	MSC	-	2	-	-	-	-	FD	-	FD	FD	FD	WD		FD	2
Total no. live		110	106	287	77	20	37	108	4	297	1012	179	12	9	-	1191
Live species		16	17	16	14	9	12	14	3	10	15	20	12	12	16	25
Total species		16	18	16	17	10	14	17	8	12	21	24	23	16	18	27
CPUE (no. live/hour)		39.8	31.5	169.7	-	-	-	-	-	133	83.7	2.2	-	-	-	-
No./m^2 (±95% conf. int.)		2.4 (±1.0)	3.4 (±1.1)	6.6 (±2.1)	4.5 (±1.3)	4.0 (±1.7)	2.8 (±0.9)	-	0.7 (±0.7)	1.6 (±1.2)	2.2 (±0.7)	0.6 (±0.4)[9]	0.1 (±0.3)	-	-	-
% ≤5 years old[8]		44.4	50.0	42.7	55.8	30.0	59.0	-	50.0	50.0	58.5	83.3	100.0	-	-	-
No./m^2 (±95% conf. int.) 2016		-	-	-	-	-	-	3.6 (±1.0)	-	-	2.2 (±0.7)	0.3 (±0.2)	-	-	-	-
% ≤5 years old[8]		-	-	-	-	-	-	59.3	-	-	61.2	55.6	-	-	-	-
No./m^2 (±95% conf. int.) 2017		-	-	-	-	-	-	3.4 (±0.8)	-	-	1.8 (±0.5)	0.3 (±0.2)	-	-	-	-
% ≤5 years old[8]		-	-	-	-	-	-	64.5	-	-	63.6	43.8	-	-	-	-
No./m^2 (±95% conf. int.) 2017		-	-	-	-	-	-	-	-	-	-	0.3 (±0.1)	-	-	-	-
% ≤5 years old[8]		-	-	-	-	-	-	-	-	-	-	62.5	-	-	-	-

Nomenclature follows FMCS (2023)

FD = Freshly dead shell, WD = Weathered dead shell, SF = Subfossil

[1]FE = federally endangered (USFWS, 2024); ME = Michigan endangered, MT = Michigan threatened, MSC = Michigan species of special concern (https://mnfi.anr.msu.edu/species/animals; accessed February 2024)

[2]ESI (2016); [3]ESI (2017a); EcoAnalysts (2018); [4] ESI (2014) quantitative samples only

[5]Number collected based on combination of quantitative and qualitative samples in 2013 (ESI, 2014);

species found in other studies (JFNew, 2013a, b, c, d; Cardno, 2017) or years (ESI, 2017a; ESI, 2018; EcoAnalysts, 2018, 2019, 2020) are indicate with an L (live)

[6]EcoAnalysts (2021); Species collected by EcoAnalysts (2019) are indicted with an L (live)

[7]Includes Sites 13 and 14 (ESI, 2016; ESI, 2018) and Site I196S (JFNew, 2013b; GEI, 2023); see Figure 3-1

[8]Based on quantitative samples only; [9]Samples were not distributed throughout the Project Area, samples were biased toward higher density areas

Table 2-8. Recipient site areas available for placing TES.[1]

	Ionia	Saranac	Peace Park	Chief Hazy Cloud	Ada	Site 7	Riverside Park[2]	Plaster Creek[2]	Total
Area (m^2)	9,421	5,650	6,749	1,991	23,480	6,675	8,650	286	62,902
Density	2.4	3.4	4.5	4.0	2.8	0.7	1.6	-	
Mussel estimate	22,610	19,210	30,371	7,964	65,744	4,673	13,840	-	164,411
TES Grid Area	-	-	-	-	3,400	-	8,650	286	12,050
No. of TES unionids[1]	-	-	-	-	4,760	-	6,920	-	11,680
Non-TES Area	9,421	5,650	6,749	1,991	15,000	6,675	-	-	45,486
No. mussels[2]	11,305	9,605	15,185	3,982	21,000	2,336	-	-	63,414

[1] No. of mussels that could be placed in the area, assuming density increase will be no more than 50% of resident density

[2]Very few *T. parvum, U. imbecillis, T. truncata* , or *P. alatus* are expected to be placed at these sites

Table 2-9. Estimated number of mussels, including TES within Direct Impact Areas that could translocatec

	Total[1]	≤2ft/sec[2]	Isolated Area[3]
Area (m^2)	47,415	9,560	3,285
No. unionids (0.3/m^2)	14,224	2,868	986
No. *E. triquetra* (0.90%)	128	26	9
No. Michigan TES (13.20%)	1,878	379	130
No. common species (85.90%)	12,218	2,464	847

Relative abundance of species based on Table 1-2

[1]Total direct impact area and estimated number of unionid mussels within direct impact areas

[2]Area within direct impact areas with current velocity ≤2ft/sec under 2500 CFS conditions and considered safe for collecting (excludes isolated area)

[3]Isolated area that would be dewatered and safe for collecting unionid mussels

Table 2-10. Construction and mussel translocation flow rate exceedance probability chart.

Week of	Percent Chance of Exceedance (10 year record)					
	1,500 cfs	2,500 cfs	3,000 cfs	3,500 cfs	5,000 cfs	7,500 cfs
1-Jan	100%	97%	91%	79%	66%	24%
8-Jan	100%	98%	94%	78%	57%	24%
15-Jan	100%	100%	94%	79%	59%	28%
22-Jan	100%	98%	83%	76%	64%	47%
29-Jan	100%	93%	79%	77%	70%	55%
5-Feb	100%	92%	79%	78%	75%	43%
12-Feb	100%	89%	79%	78%	72%	19%
19-Feb	100%	92%	88%	84%	71%	32%
26-Feb	100%	95%	93%	91%	77%	63%
5-Mar	100%	96%	93%	89%	79%	67%
12-Mar	100%	100%	100%	100%	96%	71%
19-Mar	100%	100%	100%	100%	88%	61%
26-Mar	100%	100%	100%	100%	81%	75%
2-Apr	100%	100%	100%	100%	79%	75%
9-Apr	100%	100%	100%	100%	88%	76%
16-Apr	100%	100%	100%	100%	92%	73%
23-Apr	100%	100%	98%	94%	81%	62%
30-Apr	100%	100%	95%	92%	78%	67%
7-May	100%	99%	94%	93%	79%	51%
14-May	100%	95%	93%	91%	77%	60%
21-May	100%	93%	86%	80%	75%	59%
28-May	100%	88%	80%	78%	72%	38%
4-Jun	100%	85%	79%	75%	48%	12%
11-Jun	100%	79%	77%	75%	59%	29%
18-Jun	98%	79%	77%	75%	63%	37%
25-Jun	95%	79%	78%	76%	68%	46%
2-Jul	93%	78%	75%	71%	54%	16%
9-Jul	93%	77%	74%	66%	29%	20%
16-Jul	91%	75%	67%	51%	13%	1%
23-Jul	94%	69%	42%	21%	0%	0%
30-Jul	90%	53%	15%	0%	0%	0%
6-Aug	86%	37%	4%	3%	0%	0%
13-Aug	96%	68%	49%	42%	19%	0%
20-Aug	93%	61%	40%	28%	12%	0%
27-Aug	91%	72%	53%	37%	9%	0%
3-Sep	91%	57%	24%	23%	11%	0%
10-Sep	89%	63%	30%	15%	0%	0%
17-Sep	87%	39%	18%	9%	0%	0%
24-Sep	84%	46%	25%	18%	4%	0%
1-Oct	81%	72%	67%	60%	46%	21%
8-Oct	90%	76%	72%	68%	54%	13%
15-Oct	99%	78%	76%	72%	42%	0%
22-Oct	100%	79%	76%	72%	31%	17%
29-Oct	100%	80%	77%	74%	64%	35%

Table 2-10 (cont). Construction and mussel translocation flow rate exceedance probability chart.

Week of	Percent Chance of Exceedance (10 year record)					
	1,500 cfs	2,500 cfs	3,000 cfs	3,500 cfs	5,000 cfs	7,500 cfs
5-Nov	100%	80%	78%	77%	59%	20%
12-Nov	100%	80%	77%	72%	28%	0%
19-Nov	100%	79%	77%	75%	55%	19%
26-Nov	100%	90%	82%	77%	60%	23%
3-Dec	100%	89%	79%	77%	54%	21%
10-Dec	100%	79%	77%	75%	40%	3%
17-Dec	100%	87%	81%	75%	27%	0%
24-Dec	100%	96%	88%	79%	32%	10%

Table 2-11. Estimated collection effort in Direct Impact areas ≤2 ft/sec under 2,500 CFS conditions.

Construction Area	Total Area (m^2)	Estimated person days[1]	Area (m^2) ≤2 ft/sec[2]	Estimated person days[1]
Dam 2 [3]	6,925	58	810	7
Dam 1	9,045	75	2,470	21
Dam 3 and 4	14,950	125	5,815	48
Down of Pearl	11,240	94	295	2
Isolated area	3,285	27	3,285	27
Scour protection	1,970	16	170	1
Total	47,415	395	12,845	107

[1] Assumes 3 min/m^2, with 1 diver/snorkeler, 6 hours of active collecting/day (see methods in text)

[2] Excludes areas within 10 m of the lowhead dams (see Figure 2-8)

[3] Excluding isolated area

Table 2-12. Potential mussel mortality.

	Isolated area only collected (Maximum mortality)					Area ≤2 ft/sec^2 and isolated area (most likely)					All Direct Impact Areas collected (Minimum mortality)			
	Mortality of mussels outside the isolated area	Mussels within the isolated area	15% not collected	5% mortality	Total Mortality	Mortality of mussels outside the collection area	Est. no. of unionids	15% not collected	5% mortality	Total	Est. no. of unionids	15% not collected	5% mortality	Total
Area (m^2)	44,130	3,285				34,570	9,560				47,415			
No. unionids (0.3/m^2)	13,239	986	148	7	13,394	10,371	2,868	430	18	10,819	14,225	2,134	107	2,240
No. *E. triquetra* (0.90%)	119	9	1	0	121	93	26	4	0	97	128	19	1	20
No. Michigan TES (13.20%)	1,748	130	20	1	1,768	1,369	379	57	3	1,429	1,878	282	14	296
No. common species (85.80%)	11,372	847	127	6	11,506	8,909	2,464	370	18	9,297	12,219	1,833	92	1,924

Table 2-13. Potential unionid mortality and resulting mitigation fund.

	Potential Unionid Mortality[1]			Mitigation Fund[2]		
	All Direct Impact Areas translocated	Isolated and ≤2ft/sec areas translocated	Only isolated area translocated	All Direct Impact Areas translocated	Isolated area and ≤2ft/sec areas translocated	Only isolated area translocated
Area (m^2)	47,415	9,560	44,130			
No. unionids (0.3/m^2)	2,240	10,819	13,394	$76,396.23	$368,934.72	$456,742.77
No. *E. triquetra* (0.90%)	20	97	121			
No. Michigan TES (13.20%)	296	1,429	1,768			
No. common species (85.80%)	1,924	9,297	11,506			

[1] 15% not relocated within collected area and 5% not surviving relocation

[2]Mitigation fund based on mortality x $34.10; $28.50 used in the 2020 BA adjusted for inflation between 2020 and 2024.

Table 2-14. Anticipated permitting and construction schedule.

Task/Milestone	Schedule[1]
Final Biological Assessment Submitted to NRCS	February 2024
NRCS Submittal of Biological Assessment (BA) to USFWS	February 2024
USFWS Formal Consultation of BA	February to May 2024
Biological Opinion	June/July 2024
Endangered species permits issued by MDNR	April 2024
MDNR scientific collecting permit	May-24
Mussel translocation[2]	August to October 2024
Publish Draft EA for Public Review	April 2024
Prepare Draft Final EA	May 2024
EGLE Permit Submission	March 2024
Final EA	June 2024
EGLE Review	90 days
EGLE permit receipt	June 2024
Construction Mobilization	April to May 2025
Construction	June 2025 to October 2026

[1] Dates are tentative

[2] Some translocation may occur in 2025

Table 5-1. Estimated number of unionid mussels in the Direct Impact areas.

		Direct Impact Area (m^2)			
	Relative Abundance (%)[1]	Isolated Area[2]	≤2ft/sec[3]	Other Direct Impact Areas[4]	Total
		3,285	8,395	35,735	47,415
Federal TES					
Epioblasma triquetra	0.90	9	23	96	128
Michigan TES					
Pleurobema sintoxia	0.43	4	11	46	61
Cyclonaias tuberculata	2.86	28	72	307	407
Ligumia recta	2.89	28	73	310	411
Potamilus alatus	0.54	5	14	58	77
Toxolasma parvum	0.00	0	0	0	0
Truncilla truncata	1.69	17	43	181	240
Venustaconcha ellipsiformis	0.06	1	2	6	9
Alasmidonta marginata	0.72	7	18	77	102
Alasmidonta viridis	0.03	0	1	3	4
Lasmigona compressa	0.00	0	0	0	0
Lasmigona costata	3.98	39	100	427	566
Utterbackia imbecillis	0.00	0	0	0	0
Total Michigan TES	13.20	130	332	1,415	1,878
Common species					
Amblema plicata	28.38	280	715	3,042	4,037
Fusconaia flava	4.91	48	124	526	698
Cyclonaias pustulosa	3.95	39	99	423	562
Quadrula quadrula	3.19	31	80	342	454
Actinonaias ligamentina	3.04	30	77	326	432
Lampsilis cardium	33.99	335	856	3,644	4,835
Lampsilis siliquoidea	0.06	1	2	6	9
Potamilus fragilis	1.57	15	40	168	223
Lasmigona complanata	0.12	1	3	13	17
Pyganodon grandis	0.03	0	1	3	4
Strophitus undulatus	6.66	66	168	714	947
Total common species	85.90	847	2,163	9,209	12,219
Total mussels	100.00	986	2,519	10,721	14,225

[1]See Table 1-2 for species relative abundance

[2]Area within isolation measures where no construction or tracking will occur until mussels and fish are salvaged

[3]Areas with ≤2ft/sec current velocity under 2,500 CFS conditions and should be safe to collect mussels

[4] Area outside isolated area, and areas >2 ft/sec under 2,500 CFS

Table 5-2. Estimated minimum and maximum mussel mortality due to translocation.

	Relative Abundance (%)[1]	No. mussels in Direct Impact Areas	No. Unsuccessfully Translocated[2]		
			Isolated area only collected	Area ≤2 ft/sec[2] and isolated area (most likely)	All Direct Impact Areas collected
Federal TES					
Epioblasma triquetra	0.90	128	1	4	20
Michigan TES					
Pleurobema sintoxia	0.43	61	1	2	10
Cyclonaias tuberculata	2.86	407	4	13	64
Ligumia recta	2.89	411	4	13	65
Potamilus alatus	0.54	77	1	2	12
Toxolasma parvum	0.00	0	0	0	0
Truncilla truncata	1.69	240	3	8	38
Venustaconcha ellipsiformis	0.06	9	0	0	1
Alasmidonta marginata	0.72	102	1	3	16
Alasmidonta viridis	0.03	4	0	0	1
Lasmigona compressa	0.00	0	0	0	0
Lasmigona costata	3.98	566	6	18	89
Utterbackia imbecillis	0.00	0	0	0	0
Total Michigan TES	13.20	1,878	21	60	296
Common species					
Amblema plicata	28.38	4,037	44	128	636
Fusconaia flava	4.91	698	8	22	110
Cyclonaias pustulosa	3.95	562	6	18	88
Quadrula quadrula	3.19	454	5	14	71
Actinonaias ligamentina	3.04	432	5	14	68
Lampsilis cardium	33.99	4,835	53	154	761
Lampsilis siliquoidea	0.06	9	0	0	1
Potamilus fragilis	1.57	223	2	7	35
Lasmigona complanata	0.12	17	0	1	3
Pyganodon grandis	0.03	4	0	0	1
Strophitus undulatus	6.66	947	10	30	149
Total Common Species	85.90	12,219	133	388	1,924
Total mussels	100.00	14,225	155	452	2,240

[1]See Table 1-2

[2] 15% not collected, and 5% mortality due to handling

Table 5-3. Estimated minimum and maximum number of mussels (mortality) in areas not translocated.

	Relative Abundance (%)[1]	No. mussels in Direct Impact Areas	No. in uncollected areas[2]	
			Isolated area only collected (Maximum mortality)	Area ≤2 ft/sec[2] and isolated area (most likely)
Federal TES				
Epioblasma triquetra	0.90	128	119	93
Michigan TES				
Pleurobema sintoxia	0.43	61	57	45
Cyclonaias tuberculata	2.86	407	379	297
Ligumia recta	2.89	411	383	300
Potamilus alatus	0.54	77	71	56
Toxolasma parvum	0.00	0	0	0
Truncilla truncata	1.69	240	224	175
Venustaconcha ellipsiformis	0.06	9	8	6
Alasmidonta marginata	0.72	102	95	75
Alasmidonta viridis	0.03	4	4	3
Lasmigona compressa	0.00	0	0	0
Lasmigona costata	3.98	566	527	413
Utterbackia imbecillis	0.00	0	0	0
Total Michigan TES	13.20	1,878	1,748	1,369
Common species				
Amblema plicata	28.38	4,037	3757	2943
Fusconaia flava	4.91	698	650	509
Cyclonaias pustulosa	3.95	562	523	410
Quadrula quadrula	3.19	454	422	331
Actinonaias ligamentina	3.04	432	402	315
Lampsilis cardium	33.99	4,835	4500	3525
Lampsilis siliquoidea	0.06	9	8	6
Potamilus fragilis	1.57	223	208	163
Lasmigona complanata	0.12	17	16	12
Pyganodon grandis	0.03	4	4	3
Strophitus undulatus	6.66	947	882	691
Total Common Species	85.90	12,219	11,372	8,909
Total mussels	100.00	14,225	13,239	10,371

[1] See Table 1-2

[2] See Table 2-12

Table 5-4. Estimated minimum and maximum number of mussels unsuccessfully translocated (mortality).

	Relative Abundance (%)[1]	No. mussels in Direct Impact Areas	No. Unsuccessfully Translocated[2]		
			Isolated area only collected (Maximum mortality)	Area ≤2 ft/sec[2] and isolated area (most likely)	All Direct Impact Areas collected (Minimum mortality
Federal TES					
Epioblasma triquetra	0.90	128	120	97	20
Michigan TES					
Pleurobema sintoxia	0.43	61	58	47	10
Cyclonaias tuberculata	2.86	407	383	310	64
Ligumia recta	2.89	411	387	313	65
Potamilus alatus	0.54	77	72	58	12
Toxolasma parvum	0.00	0	0	0	0
Truncilla truncata	1.69	240	226	183	38
Venustaconcha ellipsiformis	0.06	9	8	6	1
Alasmidonta marginata	0.72	102	96	78	16
Alasmidonta viridis	0.03	4	4	3	1
Lasmigona compressa	0.00	0	0	0	0
Lasmigona costata	3.98	566	533	431	89
Utterbackia imbecillis	0.00	0	0	0	0
Total Michigan TES	13.20	1,878	1,768	1,429	296
Common species					
Amblema plicata	28.38	4,037	3801	3072	636
Fusconaia flava	4.91	698	658	531	110
Cyclonaias pustulosa	3.95	562	529	428	88
Quadrula quadrula	3.19	454	427	345	71
Actinonaias ligamentina	3.04	432	407	329	68
Lampsilis cardium	33.99	4,835	4553	3679	761
Lampsilis siliquoidea	0.06	9	8	6	1
Potamilus fragilis	1.57	223	210	170	35
Lasmigona complanata	0.12	17	16	13	3
Pyganodon grandis	0.03	4	4	3	1
Strophitus undulatus	6.66	947	892	721	149
Total Common Species	85.90	12,219	11,505	9,297	1,924
Total mussels	100.00	14,225	13,393	10,823	2,240

[1]See Table 1-2

[2] Mortality from NRCS (Table 5-3) and relocation project (Table 5-2) combined

Table 5-5. Estimated number of unionid mussels in Indirect Impact areas.

Area (m^2)	Project Area Relative Abund. (%)[1]	Upstream Indirect 38,420	Construction Indirect 80,185	Project Area Total 118,605	Downstream Relative Abund (%)[4]	Downstream Indirect Area 282,600
Federal TES						
Epioblasma triquetra	0.90	104	216	320	0.20	55
Michigan TES species						
Pleurobema sintoxia	0.43	50	103	153	0.00	0
Cyclonaias tuberculata	2.86	330	688	1,018	0.02	5
Ligumia recta	2.89	333	695	1,028	0.91	255
Potamilus alatus	0.54	62	130	192	2.50	705
Toxolasma parvum	0.00	0	0	0	0.00	0
Truncilla truncata	1.69	195	407	601	30.19	8,530
Venustaconcha ellipsiformis	0.06	7	14	21	0.00	0
Alasmidonta marginata	0.72	83	173	256	0.05	15
Alasmidonta viridis	0.03	3	7	11	0.00	0
Lasmigona compressa	0.00	0	0	0	0.00	0
Lasmigona costata	3.98	459	957	1,416	0.00	0
Utterbackia imbecillis	0.00	0	0	0	0.00	0
Total Michigan TES	13.20	1,521	3,175	4,697	29.47	9,510
Common species						
Amblema plicata	28.38	3,271	6,827	10,098	17.95	5,075
Fusconaia flava	4.91	566	1,181	1,747	0.96	270
Cyclonaias pustulosa	3.95	455	950	1,405	6.28	1,775
Quadrula quadrula	3.19	368	767	1,135	1.32	375
Actinonaias ligamentina	3.04	350	731	1,082	1.13	320
Lampsilis cardium	33.99	3,918	8,176	12,094	13.20	3,730
Lampsilis siliquoidea	0.06	7	14	21	6.70	1,895
Potamilus fragilis	1.57	181	378	559	10.99	3,105
Lasmigona complanata	0.12	14	29	43	0.64	180
Pyganodon grandis	0.03	3	7	11	0.00	0
Strophitus undulatus	6.66	768	1,602	2,370	6.97	1,970
Total common species	85.90	9,901	20,664	30,565	70.53	18,695
Total mussels	100.00	11,526	24,056	35,582	100.00	28,260

[1] See Table 1-2

[2] Area within the Project Area not directly affected by construction, but may be affected by local changes in hydraulics

[3] Areas between direct impact areas that may also be affected by construction related turbidity

[4] Downstream relative abundance and density ($0.1/m^2$) based on average of mussels collected between Fulton St. and I-196 by ESI/EcoAnalysts in 2013, 2017, and 2018 (ESI, 2014 and 2018; EcoAnalysts, 2019) and GEI (2023)

Table 5-6. Maximum estimated number of unionid mussels in areas that could be affected by OMRRR[1].

	Relative Abundance (%)[1]	OMRRR area[3] 10,000 m^2
Federal TES		
Epioblasma triquetra	0.90	27
Michigan TES		
Pleurobema sintoxia	0.43	13
Cyclonaias tuberculata	2.86	86
Ligumia recta	2.89	87
Potamilus alatus	0.54	16
Toxolasma parvum	0.00	0
Truncilla truncata	1.69	51
Venustaconcha ellipsiformis	0.06	2
Alasmidonta marginata	0.72	22
Alasmidonta viridis	0.03	1
Lasmigona compressa	0.00	0
Lasmigona costata	3.98	119
Utterbackia imbecillis	0.00	0
Total Michigan TES	13.20	396
Common species		
Amblema plicata	28.38	851
Fusconaia flava	4.91	147
Cyclonaias pustulosa	3.95	119
Quadrula quadrula	3.19	96
Actinonaias ligamentina	3.04	91
Lampsilis cardium	33.99	1,020
Lampsilis siliquoidea	0.06	2
Potamilus fragilis	1.57	47
Lasmigona complanata	0.12	4
Pyganodon grandis	0.03	1
Strophitus undulatus	6.66	200
Total common species	85.90	2,577
Total mussels	100.00	3,000

[1]OMRRR=Operation, maintainence, repair, rehabilitation, and replacement

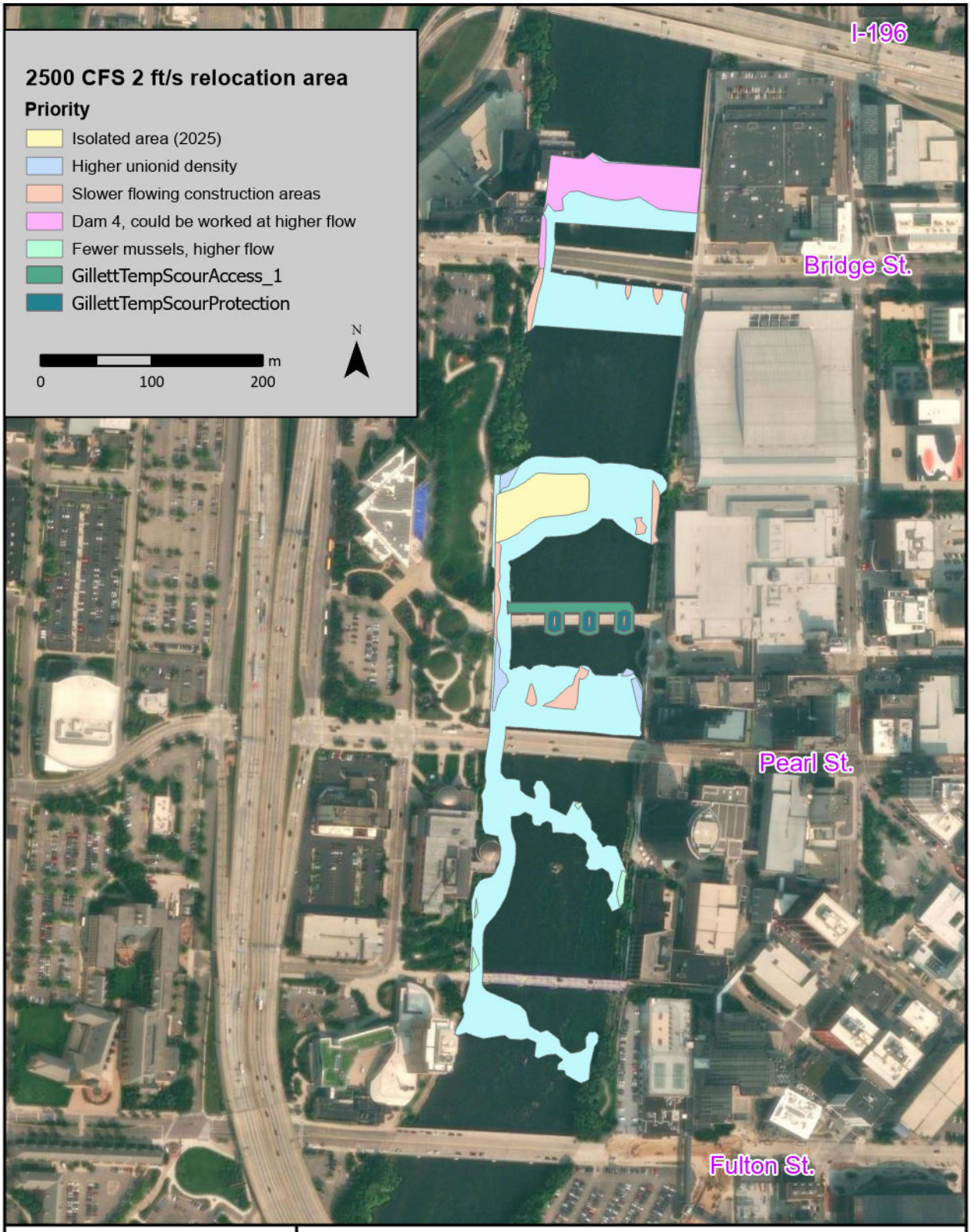
[2] See Table 1-2

[3] Maximum area estimated to be affected by OMRRR activities



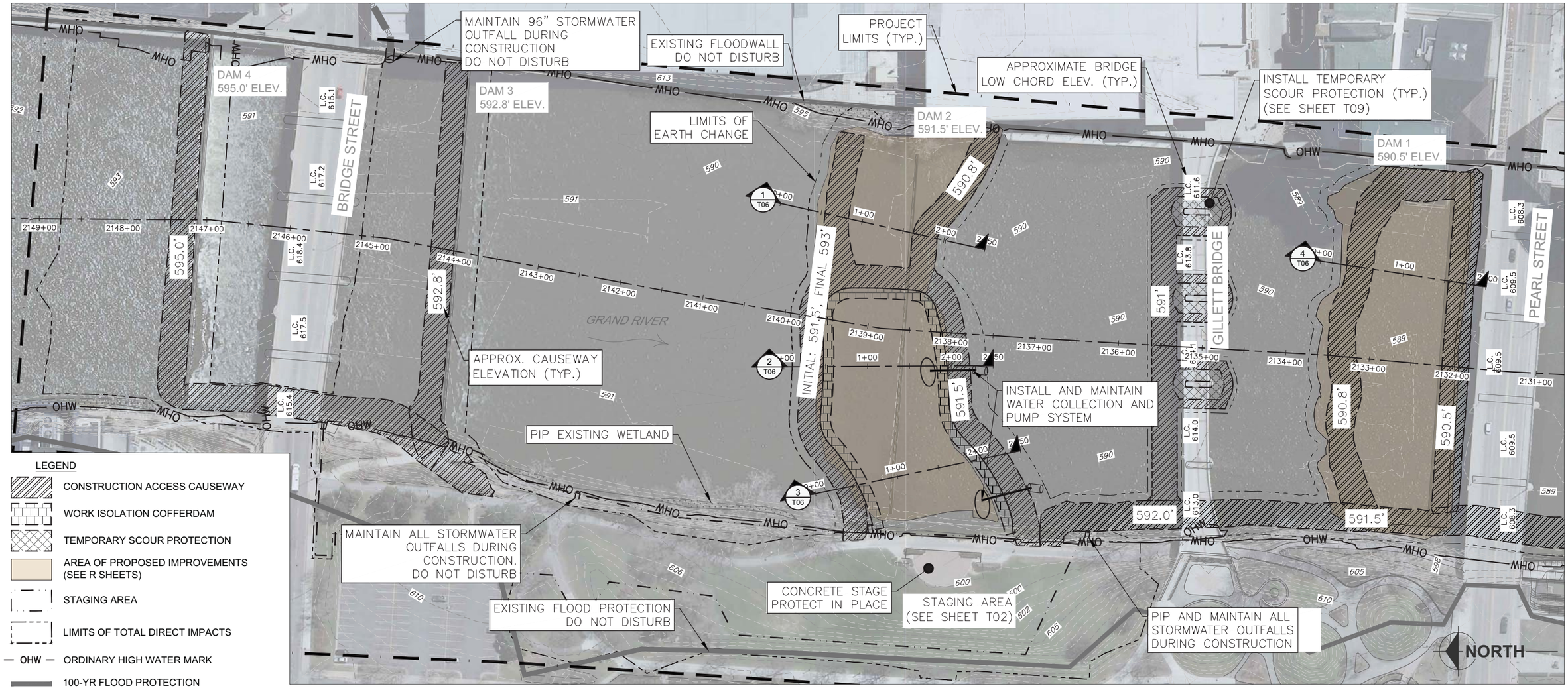
EcoAnalysts, Inc.

Figure 1-1 revised. Components of the RCPP reach Project Area 2024, Direct and Indirect Impact Areas.



EcoAnalysts, Inc.

Figure 2-8 revised. Unionid mussel relocation priorities within Direct Impact Areas.



LEGEND

- CONSTRUCTION ACCESS CAUSEWAY
- WORK ISOLATION COFFERDAM
- TEMPORARY SCOUR PROTECTION
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- STAGING AREA
- LIMITS OF TOTAL DIRECT IMPACTS
- OHW — ORDINARY HIGH WATER MARK
- 100-YR FLOOD PROTECTION

GENERAL NOTES:

1. THE CARE OF WATER PLAN AND TEMPORARY STRUCTURES SHOWN HERE ARE FOR PERMITTING AND COST ESTIMATION PURPOSES ONLY. THIS CARE OF WATER PLAN IS BASED ON CORRESPONDENCE WITH THE CITY OF GRAND RAPIDS AND THE CONSTRUCTION MANAGER ADVISOR. THE CONTRACTOR WILL ULTIMATELY BE RESPONSIBLE FOR DEVELOPING AND MAINTAINING A CARE OF WATER PLAN TO MEET PERMITTING CONDITIONS AND CONSTRUCTION NEEDS.
2. BRIDGE LOW CHORDS REPRESENT LOW CHORD OF BRIDGE DECKS. GILLETT AND PEARL STREET BRIDGES HAVE ARCHED BAYS; LOW CHORDS SHOWN REPRESENT APPROXIMATE HIGH POINT OF ARCHES. CONTRACTOR IS RESPONSIBLE TO VERIFY LOW-CHORD ELEVATIONS AND CLEARANCE HEIGHTS.
3. ALL IN WATER WORK REQUIRES USE OF APPROVED BMP'S TO PREVENT IMPACTS TO WATER QUALITY.
4. PROTECT IN PLACE WETLANDS AND MATURE TREES NOT SPECIFICALLY DESIGNATED FOR REMOVAL OR IMPACT.
5. BE PREPARED TO UN-ISOLATE WORK AREA AND ALLOW FLOW ON BOTH SIDES OF CHANNEL UPON SHORT NOTICE IF OWNER'S REPRESENTATIVE DETERMINES BED SCOUR NEAR BRIDGE PIERS, FLOODWALLS, OR OTHER INFRASTRUCTURE SHOULD BE INSPECTED.
6. CONTRACTOR SHALL MAINTAIN AND MONITOR ALL EXISTING UTILITY OUTFALLS TO FUNCTION OR DRAIN PROPERLY THROUGHOUT CONSTRUCTION; INCLUDING BOTH MARKED AND UNMARKED UTILITIES.
7. ACCESS CAUSEWAYS, WORK ISOLATION MEASURES, AND TEMPORARY GRADE CONTROLS SHALL BE INSTALLED IN THE FLOWING RIVER. REFER TO THE TECHNICAL SPECIFICATIONS FOR FLOW RATE AND DEPTH INFORMATION. CONTRACTOR SHALL SUBMIT PLAN TO PERFORM WORK IN THE FLOWING RIVER WITH MAXIMUM DEPTHS TO PERFORM WORK.
8. SURFACES FOR ALL TEMPORARY CAUSEWAYS AND COFFERDAMS CAN BE PROVIDED TO CONTRACTOR

CONSTRUCTION SEQUECNING NOTES:

1) CAUSEWAYS MUST BE INSTALLED BEFORE REMOVAL OF DAMS OR CONSTRUCTION OF PROPOSED IMPROVEMENTS CAN BEGIN AT ANY GIVEN LOCATION.
2) PROPOSED IMPROVEMENTS AT DAM 3 SHALL BE HELD UNTIL AFTER COFFERDAM AT DAM 2 HAS BEEN REMOVED.
3) PROPOSED IMPROVEMENTS AT DAM 4 SHALL BE HELD UNTIL AFTER COMPLETION OF PROPOSED IMPROVEMENTS AT DAM 2.

MUSSEL RELOCATION NOTES:

1) MUSSEL RELOCATION IS ANTICIPATED TO OCCUR BY OTHERS, PRIOR TO IN-CHANNEL CONSTRUCTION ACTIVITIES BEGINNING WITH THE EXCEPTION OF NOTE 3 BELOW.
2) LOCATIONS UNABLE TO BE ACCESSED FOR MUSSEL RELOCATION WOULD BE RELOCATED DURING CONSTRUCTION, IF FLOW CONDITIONS ALLOW AND RELOCATION IS ABLE TO BE COMPLETED AHEAD OF CONSTRUCTION ACTIVITIES.
3) THE AREA WITHIN THE WORK ISOLATION AT DAM 2 WOULD BE RELOCATED PRIOR TO WORK COMMENCING IN THAT AREA. RELOCATION ACTIVITIES HERE WOULD HAVE UP TO 10 DAYS TO CLEAR THE AREA.

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

CONSTRUCTION PLAN LAYOUT

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

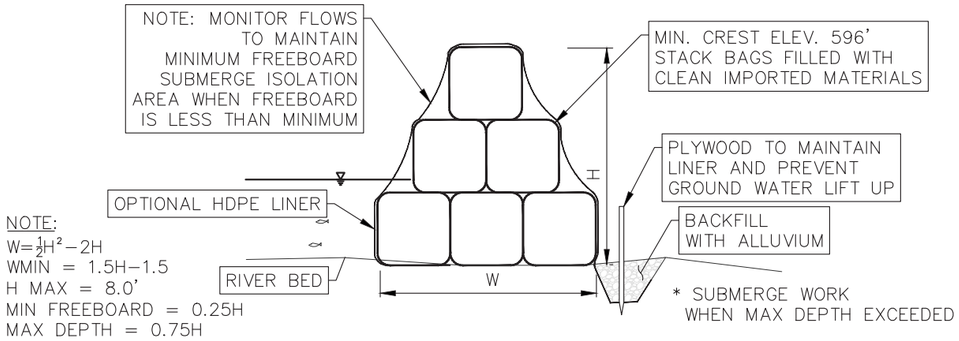
FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

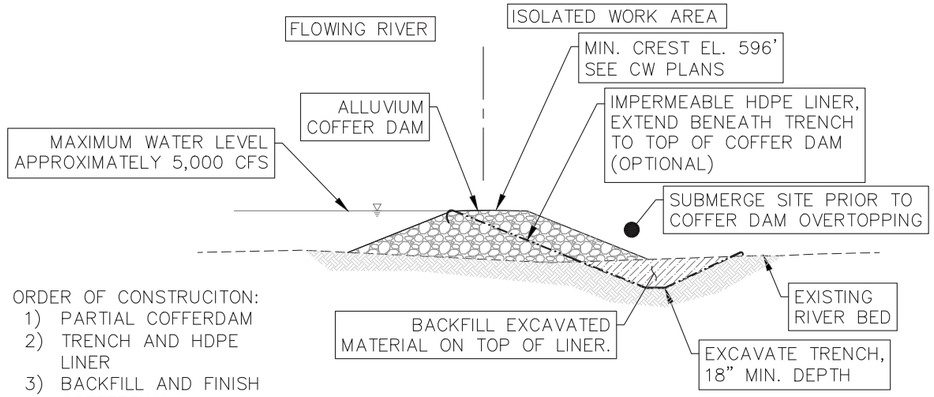
GPF No. 5315

Sheet No. 9 of 34 T04



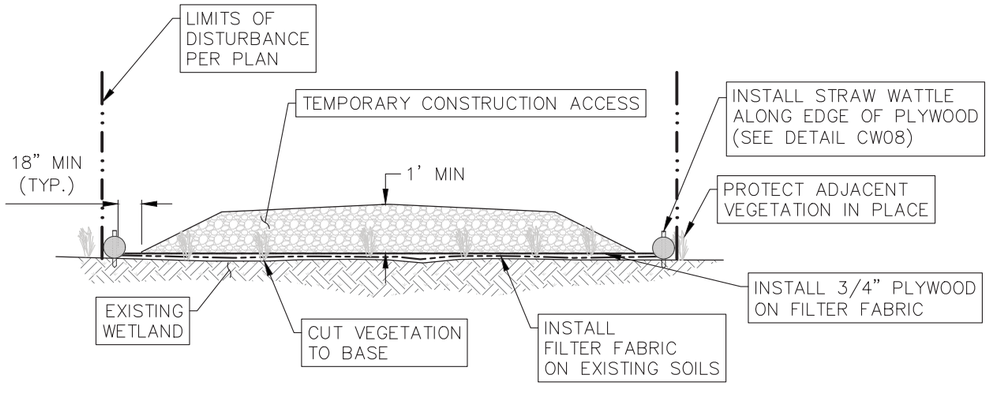
47 AGGREGATE BAGS COFFER DAM (TYPICAL) — 1 / T09

SECTION VIEW – NTS



47 ALLUVIUM COFFER DAM WITH LINER (TYPICAL) — 2 / T09

SECTION VIEW – NTS

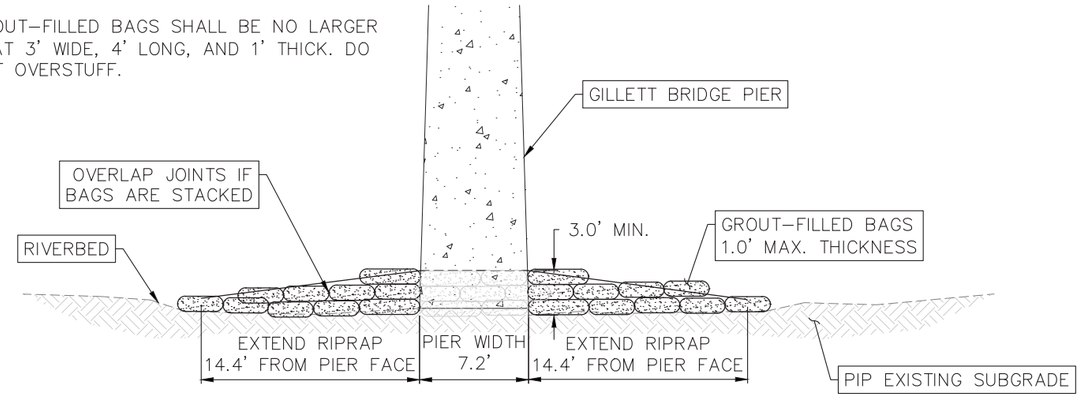


TEMPORARY WETLAND PROTECTION — 3 / T09

NTS

LEGEND: 47 MICHIGAN UNIFIED KEYING SYSTEM – SOIL EROSION & SEDIMENTATION CONTROL MEASURES – SEE SHEET CW00

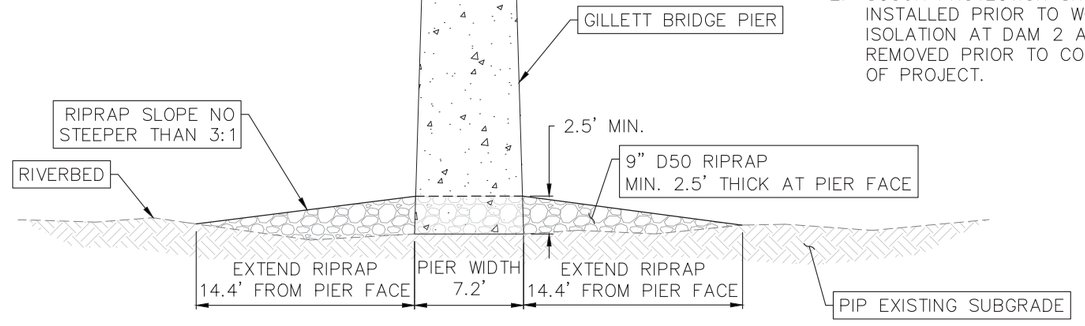
NOTES:
1. GROUT–FILLED BAGS SHALL BE NO LARGER THAT 3' WIDE, 4' LONG, AND 1' THICK. DO NOT OVERSTUFF.



TEMPORARY SCOUR PROTECTION AT GILLETT BRIDGE PIERS GROUT BAG OPTION — 4 / T09

SECTION VIEW – NTS

NOTES:
1. SCOUR PROTECTION SHALL BE PLACED ENTIRELY AROUND BRIDGE PIER AND EXTENDED TO THE LENGTHS SHOWN IN DETAIL.
2. SCOUR PROTECTION SHALL BE INSTALLED PRIOR TO WORK ISOLATION AT DAM 2 AND REMOVED PRIOR TO COMPLETION OF PROJECT.



TEMPORARY SCOUR PROTECTION AT GILLETT BRIDGE PIERS RIPRAP OPTION — 5 / T09

SECTION VIEW – NTS

TEMP. CONSTRUCTION ACCESS & CARE OF WATER - DETAILS

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. 14 of 34 T09

APPENDIX E

Other Supporting Information

Basis of Design Report; May 2024

BASIS OF DESIGN REPORT
GRAND RIVER
REVITALIZATION PROJECT
GRAND RIVER
GRAND RAPIDS, MI

Prepared for:

Grand Rapids Whitewater and the City of Grand Rapids, Michigan

Prepared by:

RiverRestoration.org, LLC
Carbondale, CO

Project No. 17014

Application No. HQ2-Y2FM-WS9TA

May 2024

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degree Fahrenheit
BFE	Base Flood Elevation
cfs	cubic feet per second
$\mu g/m^3$	microgram per cubic meter
ECT	Environmental Consulting & Technology, Inc.
EGLE	Michigan Department of Environment, Great Lakes & Energy
EPA	U.S. Environmental Protection Agency
ft	foot
GRWW	Grand Rapids Whitewater
MDNR	Michigan Department of Natural Resources
mg/L	milligram per liter
NRCS	National Resource Conservation Service
RRO	RiverRestoration.org, LLC
WPP-EA	Watershed Project Plan – Environmental Assessment

1.0 INTRODUCTION

The City of Grand Rapids (City) submitted an application for permits under Parts 301, 303, and 31 of Michigan's Natural Resources and Environmental Protection Act (NREPA) to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to construct the Grand River Revitalization Lower Reach Project (Project) on October 30, 2020 (JPA-HNV-A018-7X9N3). After receiving and responding to three correction requests from EGLE dated November 30, 2020 and February 9, 2021, and June 1, 2022, the City submitted revised materials in support of its permit application on June 25, 2021, including a revised Basis of Design report.

EGLE deemed the permit application administratively complete on August 22, 2022, and placed on public notice between September 15 and October 5, 2022. A public hearing was held virtually on September 29, 2022. A letter or remaining issues was sent to the City by EGLE on November 4, 2022, outlining remaining issues that needed additional conversation and discussion. On December 14, 2022, the United States Environmental Protection Agency Region 5 issued an official objection letter to the City's permit application. After further discussion and conversations with regulatory agencies, the City of Grand Rapids withdrew permit application HNV-A018-7X9N3 on March 9, 2023.

On March 16, 2023, the City and GRWW met with MDNR, EGLE, USFWS, and EPA staff at an in-person meeting in Lansing, MI to develop a new framework to guide the project redesign efforts that are now the subject of a new permit application and this Basis of Design document. It was through this framework, which included EGLE and MDNR as collaborative partners in the design of the new Project, a preferred alternative was developed to meet shared goals and constraints, which were also agreed on between the City, GRWW, EGLE, and MDNR through the re-design process.

The City of Grand Rapids (City) submits this Basis of Design report to EGLE in support of the application submitted by the City for permits under Parts 301, 303, and 31 of Michigan's Natural Resources and Environmental Protection Act (NREPA) to construct the re-designed Grand River Revitalization Lower Reach Project (Project). This Report is intended to provide background information related to the Project, including the purpose of the Project and the many design alternatives that were considered before deciding to pursue the Project. It also describes the Project's impacts on regulated resources and analyzes alternatives to those impacts in accordance with Parts 301 and 303 of NREPA.

This Report first provides an overview of the Project and discusses the Project purpose (see Section 1.3). Next, the Report discusses the reasons the Project is being proposed by the City, including the existing conditions that the Project seeks to improve (see Section 2.0), the collaborative redesign process and shared goals and constraints (see Sections 3.0), and the various alternatives and redesign concepts considered (Section 4.0). The Report then provides a summary of the Project's design (see Section 5.0) and discusses the construction methodology that will be employed (see Section 6.0).

1.1 PROJECT LOCATION

The overall extents of the Project are shown in Figure 1 and Figure 2. The Project is located just above low-head dam # 4, upstream of Bridge Street to Fulton Street on the Grand River in downtown Grand Rapids, Michigan. The Grand River Watershed is the second largest in the State of Michigan with an overall drainage area of 5,572 square miles and an elevation change of approximately 680 feet over about 250 river miles. The upstream drainage for the project location (low-head dam 4 upstream of Bridge Street) is approximately 4,900 square miles. The latitude and longitude of the upstream and downstream extents of the project along the centerline of the river are as follows:

Upstream Extent:
42.97082° N ; -85.67480° W
Downstream Extent:
42.96339° N ; -85.67606° W

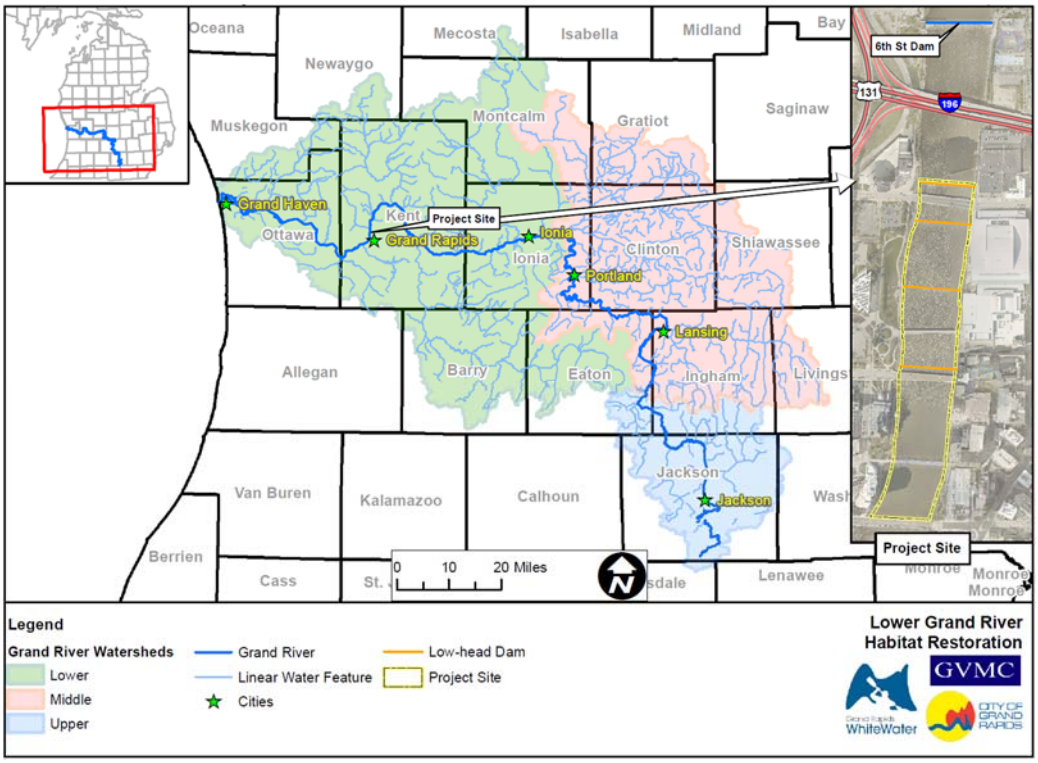

Figure 1: Project Location Map

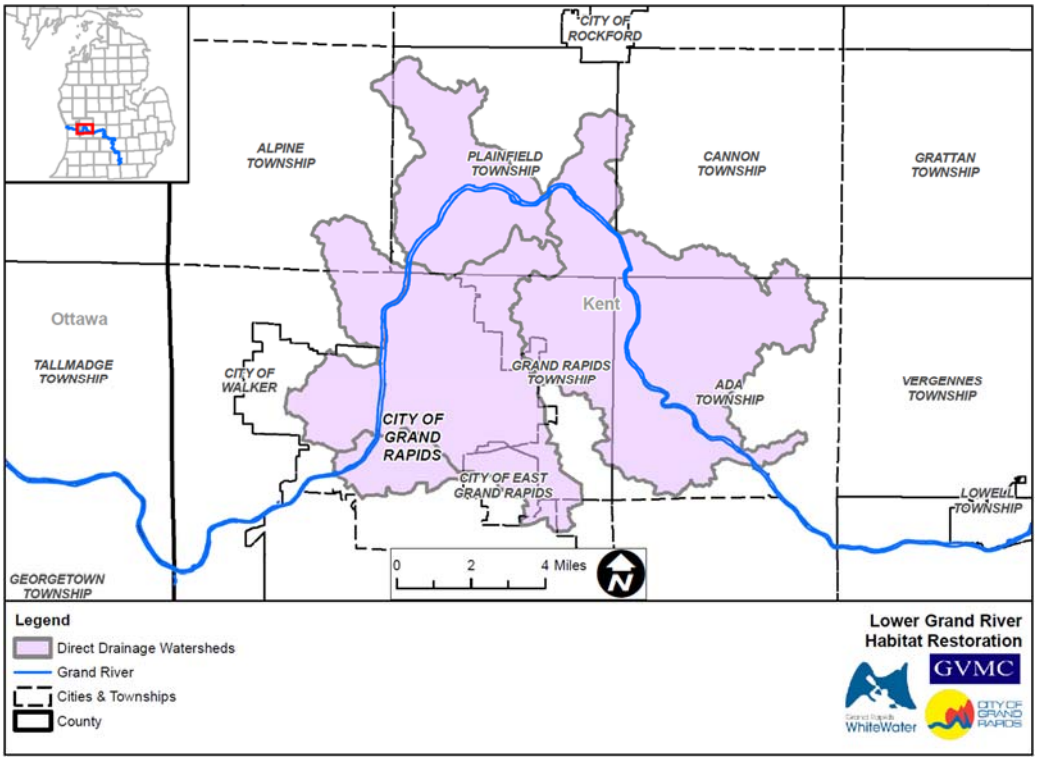

Figure 2: Project Watershed Boundary

The location of the proposed Project is within the most urbanized reach of the Grand River where rapids historically existed within the City of Grand Rapids, Michigan. Between Lake Michigan and Ada, Michigan (a distance of approximately 60 river miles) river gradient steep enough to restore rapid habitat only exists at the project reach. The geographical extent of the Project was identified to maximize restoration potential of bed forms similar to the historic rapids and aquatic habitat for native fish and mussels.

1.2 PROJECT OVERVIEW

The need for the Project arises from the degraded condition of the river, which is an important natural resource for Grand Rapids and the State of Michigan, and several recognized safety problems associated with that degraded condition. Historic physical changes made to the Grand River as it flows through downtown Grand Rapids, including construction of four low-head dams and removal of natural substrate, have impacted native and listed species of fish and mussels, limited public recreational activities, and altered habitat. Studies have concluded that the productivity of fish and mussel communities in the Project area and surrounding portions of the Grand River are currently much lower than what is possible. For example, Hanshue and Harrington (2017) indicate that the low-head dams in the Project area "likely represents a barrier to native fish species (e.g., walleye [*Sander vitreus*], suckers [Family Catostomidae]) during low flow conditions," and the authors go on to state that "Prior to their destruction, the rapids provided substantial rocky spawning habitat for several Lake Michigan species, including cisco [*Coregonus artedi*], lake whitefish [*Coregonus clupeaformis*], lake trout [*Salvelinus namaycush*], and lake sturgeon [*Acipenser fulvescens*]. Although lake-run populations of cisco, lake whitefish and lake trout are no longer extant, restoring the rapids in Grand Rapids would greatly benefit lake sturgeon recovery efforts (Hay-Chmielewski and Whelan 1997, Aadland 2010)." Furthermore, the low-head dams in the Project area have been identified as "One of the largest impediments to the current fish community." Fish Passage Report (Encompass, 2020). The Grand River continues to be a critical river in that it could support lake sturgeon recovery efforts in the Lake Michigan Basin. According to *Lake Sturgeon* Michigan's Lake Sturgeon Rehabilitation Strategy, the Grand River sturgeon population is small and declining yet one of only four believed to be above the Minimum Viable Population Size and where succesful reproduction still occurs (Hayes and Caroffino 2012). The availability of spawning and staging habitats in rivers is considered a major factor limiting the recovery of lake sturgeon in Lake Michigan (Daugherty et. al, 2009, Auer 1999)." The Project would improve sturgeon access, as well as staging and spawning habitat, within the Project area, and would remove barriers to potential future upstream restoration efforts.

Past development has significantly reduced the diversity of aquatic habitat in the river. Along the reach of the river that courses through downtown Grand Rapids, the Grand River drops 18 feet, representing the steepest gradient anywhere along its entire length. Only a small percent of river habitat in the lower peninsula of Michigan is comprised of rapid-type habitat, which is important to the life cycle of many aquatic species. Rapid-type habitat is defined as a river system with a steep energy gradient, coarse bed substrates, and non-uniform distribution of instream velocities. Historic physical alterations to the Grand River have eliminated this habitat from the Project area, affecting fish and mussel communities and limiting public recreational opportunities. In particular, the four low-head dams have altered sediment transport, flow velocity, fish passage, and substrate suitability and have resulted in public safety hazards, leading to multiple deaths. The dams have resulted in significantly reduced habitat diversity; in addition, fish and mussel community diversity and productivity are currently lower than pre-development conditions (Hanshue and Harrington 2017). During five years of sampling in the downtown reach of the Grand River, the most abundant fish family captured was Sunfish. The two most abundant

species were bluegill and mimic shiner, both of which are associated with sedentary and tranquil waters and not rapid habitat that once dominated the area (Encompass, 2023).

The City proposes to make improvements in and along the Grand River within City boundaries to restore the rapids in the lower reach of the river to improve public safety, restore aquatic habitat diversity and suitability for native Great Lakes fish and mussel species, and enhance river access and use.

1.3 PROJECT PURPOSE

The purpose of the project is to Restore the rapids, improve public safety, restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species and enhance river access and use.

-- END OF SECTION 1 –

2.0 EXISTING CONDITIONS

The Project reach is in downtown Grand Rapids, MI, in one of the most heavily modified and urban stretches of the Grand River. The reach has been dredged, filled, walled, and dammed during the last 150 years. The river is encroached by fill and concrete flood walls on the east bank. On the west side, the bank is a riprapped slope with some vegetation. Numerous bridges cross the river and the majority of the bridges have three to five piers within the channel. An oblique aerial image of the project reach with a southerly, down-river view is shown in Figure 3. Refer to Figure 6 for a location map of each low-head dam.

The Project reach is the downstream part of a uniquely steep-gradient stretch of river through downtown Grand Rapids. The downtown stretch of the Grand River is unique compared to the upstream and downstream reaches, in both profile and planform. The steep grade of the river through downtown Grand Rapids, as well as exposed bedrock in the channel, formed the old rapids. Transport of logs from upstream over shallow rapids and the development of downtown Grand Rapids created the need for the construction of the 6th Street Dam and the four low-head dams. The river drops approximately 18 feet of water surface elevation throughout the two miles of channel centered in downtown Grand Rapids, which is over 10 times steeper through this stretch of river as compared to the channel grade upstream or downstream.

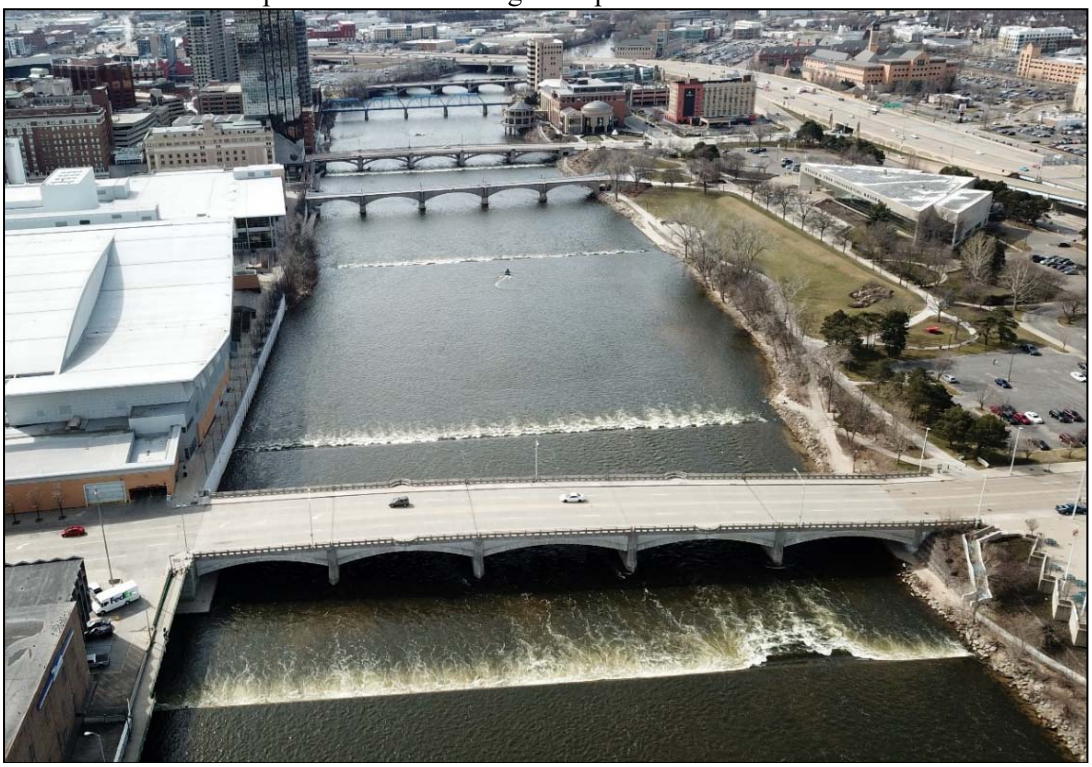

Figure 3: Project reach, with low-head dam #4 and Bridge Street at bottom of photo

2.1 RIVER DIMENSIONS, PATTERN, PROFILE

The Project reach extends from the upstream face of Fulton Street Bridge to 300 feet upstream of the Bridge Street Bridge. The project reach is slightly over a half mile long, through which the Grand River flows from north to south. The river is very straight through the project reach with a sinuosity of 1.0. The channel is laterally confined on both sides by concrete floodwalls on the east and riprap-lined banks with some vegetation on the west. At some locations on the west bank, the 100-year flood protection berms extend laterally away from the channel to allow for isolated upland areas to be inundated by more regular flood flows. In general, the floodwalls and berms function to keep the Grand River disconnected from the floodplain, which has been filled and

heavily developed on both sides. At bankfull, the average channel width is approximately 470 feet and does not vary much from the average through the project reach. The filled floodplain, vertical floodwalls and steep riprap banks in the project minimize expansion of the wetted area during high flow events, so the channel width remains relatively consistent through the annual hydrograph as well. Table 1 shows the average channel width at a range of flows. The determination of the bankfull flowrate is discussed in Section 2.5.

Table 1: Average Channel Width in Project Reach

Flow (cfs)	Average Channel Width in Project area (ft)	Percent of Bankfull average channel width
890	446	95%
5,000	455	97%
10,000 (OHW)	464	99%
13,000 (Bankfull)	470	--
33,000 (10-year)	510	109%
55,000 (100-yr)	565	120%

The average riverbed drops approximately 7.5 feet through the project reach, with the majority of this drop occurring at the four low-head dams. The average channel slope is 0.003 ft/ft. The average channel slope between the dams is 0.0014 ft/ft. A profile of the project under existing conditions is shown in Figure 4.

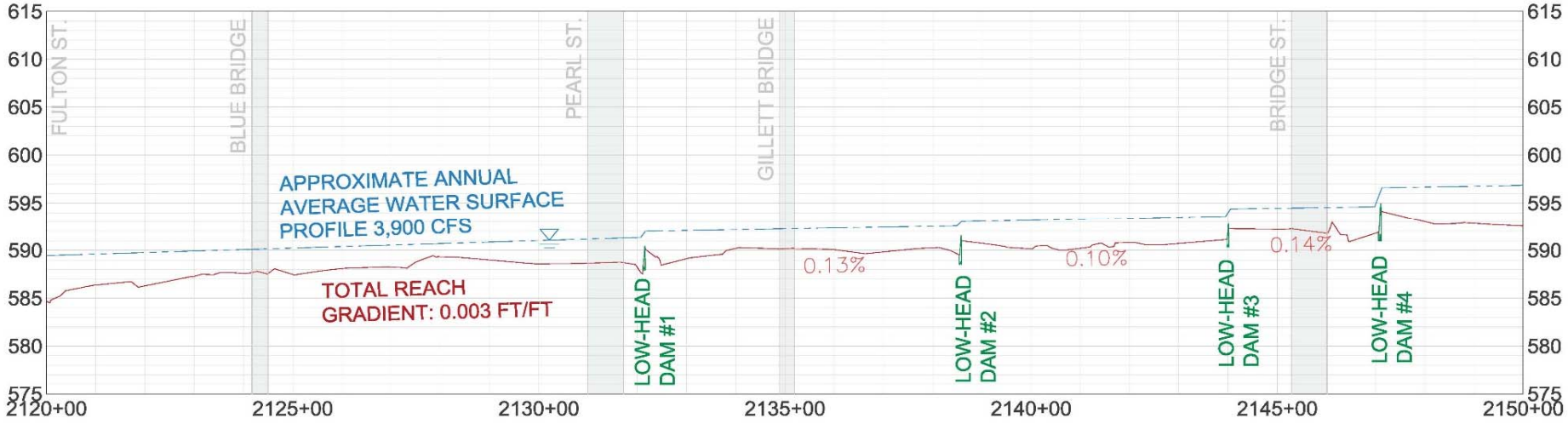

Figure 4: Project Reach Channel Slope

2.2 EXISTING LOW-HEAD DAMS

The existing channel condition has been established through the creation of uniform hydraulics, created by the installation of connectivity-disrupting low-head dams. Significant dredging and mining of large substrate from the channel has also occurred within the Project reach. Figure 5 shows some of this work occurring in the early 1900s.



Figure 5 - Workers removing large substrate from the channel in the early 1900s

The 6th Street Dam is directly upstream of the Project limits. It was originally constructed over 150 years ago in order to facilitate the floating of logs from upstream over the bedrock outcrop on river left. The most recent known maintenance to the dam was 94 years ago in 1929.

There are four channel-spanning low-head dams in the project reach which function to expand and provide uniformity to the width of the channel, help distribute the water surface gradient of the reach, and provide grade control. The low-head dams have between 0.5 and 2 feet of headloss and become submerged by tailwater as flows increase; all four dams are submerged by the bankfull flow of 13,000 cfs.

The four low-head dams were originally constructed in the 1920's as "beautification dams" and were intended to maintain uniform hydraulics and inundation limits to keep sewage from accumulating on the shoreline. The original purpose of these dams is no longer relevant in the context of healthy river ecology, and raw sewage is no longer discharged to the river from the City of Grand Rapids. The dams were constructed of concrete with an ogee-crested shape. Each is approximately 450-feet wide, extending from the floodwall on the east bank to the west bank. The structural height of the dams varies from 1.5-feet to 3-feet and all have a footer that is at least 1-foot thick.

The existing dams impact the ability of fish and other aquatic organisms to thrive, limit fish passage, and prohibit safe recreational uses of the river. The dams pose considerable safety hazards due to the circulating hydraulics downstream of the dams. The reach is rarely used for downstream boating due to this reason. The dams also present an upstream navigation hazard for watercrafts and upstream passage is only possible during flow rates greater than approximately

5,000 cfs when tailwaters have submerged most of the dams. The dams have also deteriorated over the years and show signs of fracturing and toe scour. Approximately 65 feet of Dam #4, just upstream of Bridge Street, has partially collapsed and a significant change in hydraulics is visible 115 feet west of the river centerline at nearly all flow rates. The locations of the four low-head dams are identified in Figure 6. Table 2 summarizes the characteristics of the four structures.

Table 2: Low-head dam descriptions

Low-head Dam #	Location	**Height (ft)** ***(Crest to Top of Footer)***	**Crest Elev. (ft)**	**Bottom of Footer Elev. (ft)**
1	Upstream Pearl St	1.5	590.5	588.0
2	Upstream Gillett Pedestrian Bridge	2.0	591.5	588.5
3	Downstream of Bridge St	1.5	592.8	590.0
4	Upstream of Bridge Street	3.0	595.0	591

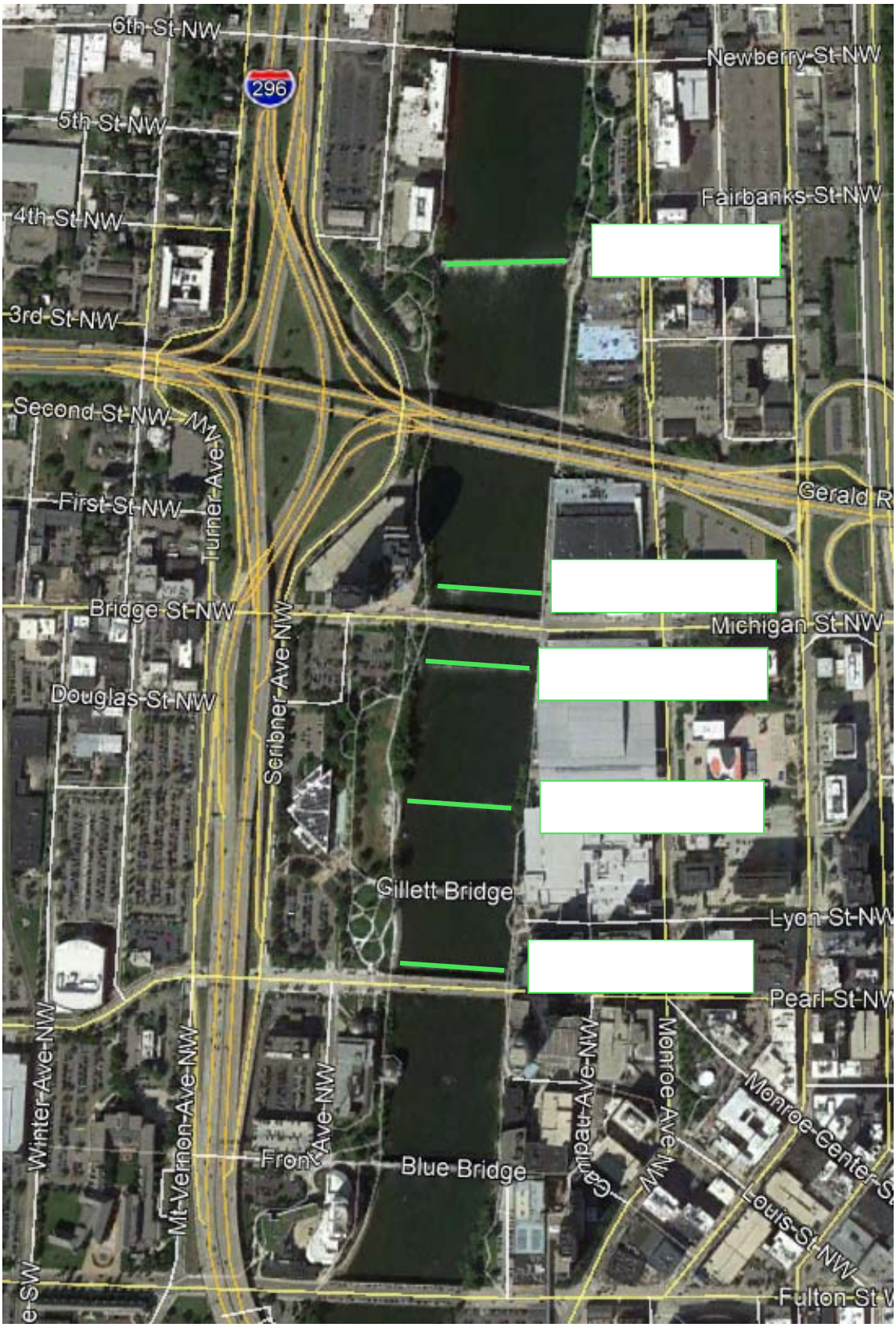

Figure 6: Low-head Dam Location Map (Google Earth)



Figure 7: Low-head dams #4 (upstream) and #3 (downstream) in vicinity of Bridge Street, Low-head dams #2 and #1 are similar in size and headloss to dam #3. Note the failed portion of dam #4 if the upper left corner of this photo.

2.3 DISCHARGE

Per EGLE guidance, harmful interference and flood risk were evaluated based on the flowrates shown in Table 3. These flow rates were determined through correspondence with EGLE (refer to Attachment 2 of TOC No. 5 Hydraulics Report). These flow rates were used in all model runs. The project does not change the hydrology of the Grand River through the project reach or downstream.

Table 3: EGLE Flood Flow Rates

Recurrence Interval	Flow (cfs)
100-yr	50,000
50-yr	44,000
25-yr	38,000
10-yr	31,000
5-yr	26,000
2-yr	18,000

More regular flows which occur throughout a typical summer and fall were used to evaluate suitable aquatic habitat, fish passage, substrate stability, and recreational hydraulics. Flowrates used to evaluate these design elements ranged from the 7Q10 low flow of 890 cfs up to the bankfull flowrate of 13,000 cfs.

Potential impacts to the effectiveness of 6th Street Dam as a barrier to sea lamprey escapement was evaluated by comparing modeled tailwater elevations at 6th Street Dam. Under existing conditions, tailwater elevations completely submerge the crest of the dam during 27,000 cfs and the 6th Street Dam fails meets criteria used by GLFC for restricting upstream migration of sea lamprey. Refer to TOC No. 8 Hydraulic Influence at 6th Street Dam for more information.

2.4 FEMA MAPPED FLOOD ZONES AND ELEVATIONS

The project is located in a detailed study area of the Grand River as described in the FEMA Flood Insurance Study (FIS) (FEMA, 2023). Per FEMA, the project reach is within a flood insurance zone of AE, which specifies that special flood hazard areas are inundated by the 100-year flood, and base flood elevations have been determined by detailed methods. FEMA Flood Insurance Rate Map (FIRM) FIS water surface profiles are presented in in Attachment 5 of TOC No. 5 Hydraulics Report.

2.5 BANKFULL CHANNEL DIMENSIONS AND ELEVATIONS

Due to the large degree of modifications to the river that have been made in the lower project reach (including dredging of the channel bed and construction of dams, floodwalls, and berms), bankfull flow rate is difficult to identify. The floodwalls and berms restrict the river from naturally interacting with the floodplain and dams cause unnatural changes in water levels. Furthermore, the flat tailwater downstream of the project reach causes submergence of the downstream end of the reach at lower flow rates than further upstream.

Reliable bankfull indicators do not exist within the project reach due to the presence of floodwalls and berms. Therefore, indicators of bankfull flow were evaluated upstream of the project reach near Riverside Park. Changes in vegetation and bank slope along the banks of Riverside Park were identified and surveyed. See Figure 8 for a depiction of an example where bankfull indicators were observed near Riverside Park. These elevations were correlated to a flowrate of 10,000 cfs using calibrated hydraulic models. However, due to the influence of 6th Street Dam, this is likely a low estimate of bankfull flow.

According to the National Oceanic and Atmospheric Administration (NOAA), bankfull flow upstream and downstream of the project reach is 13,000 cfs based on the USGS gage in downtown Grand rapids (https://waterdata.usgs.gov/nwis/uv?04119000). Due to the unreliability of basing bankfull flow on field indicators, bankfull flow was determined to be 13,000 cfs based on records from NOAA.

In naturally functioning river systems, bankfull flow typically occurs during flow rates with return intervals of between 1.5 and 2 years. Although the return intervals for the larger floods (2-year and greater) were determined through correspondence with EGLE staff and in reference to earlier hydraulic models, the return intervals of lesser flows were determined using Log-Pearson Type III distribution calculations based on gage flow records. These results are presented in Figure 9. The return interval for the bankfull flow of 13,000 cfs was determined to be 1.4 years.



Figure 8: Bankfull flow Indicator

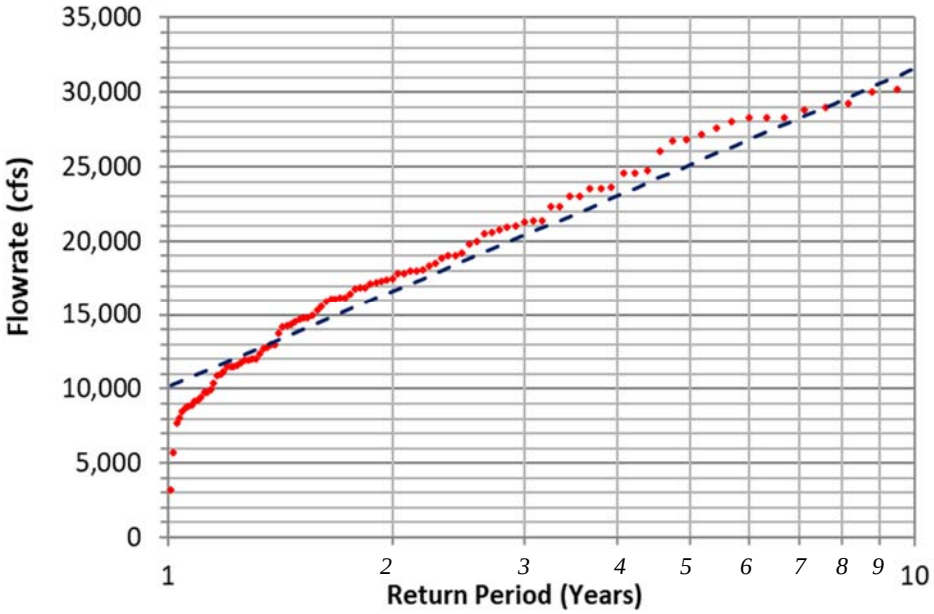

Figure 9: 1-year to 10-year Return Interval Flowrates determined using Log-Pearson Type III distribution calculations

Within the project reach, bankfull channel width ranges from 450 feet to 510 feet, with an average of 475 feet, and flow depth ranges from 7 feet to 11.5 feet, with an average of 9 feet. A typical cross section of bankfull conditions is presented in Figure 10.

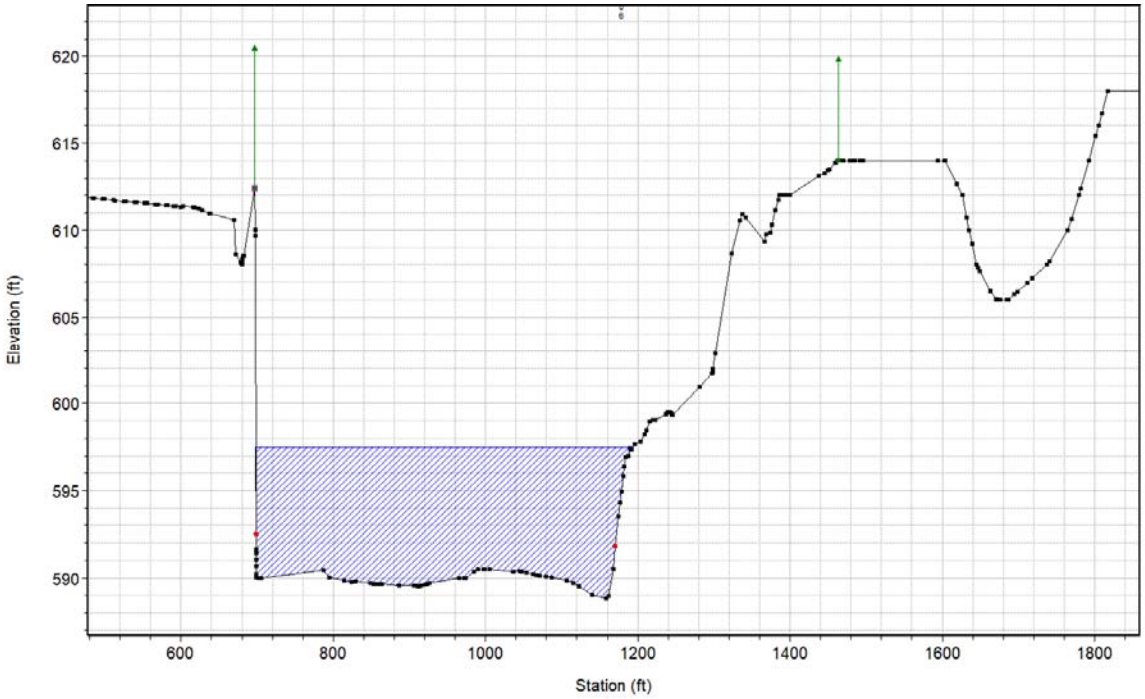

Figure 10: Typical Bankfull Cross Section

2.5.0 BANKFULL WATER SURFACE PROFILE

Due to the change in bed slope near Fulton Street and relatively flat reach downstream, much of the project reach is "submerged" by tailwater downstream of the project reach during the bankfull discharge of 13,000 cfs. This is evident when comparing the change in bed elevation to the change in water surface elevation during bankfull flow; bed elevations increase by more than five feet from 585.6' to 590.9' and corresponding water surface elevations increase less than one foot from 597.0' to 597.9'. A profile with approximate slopes is presented in Figure 11.

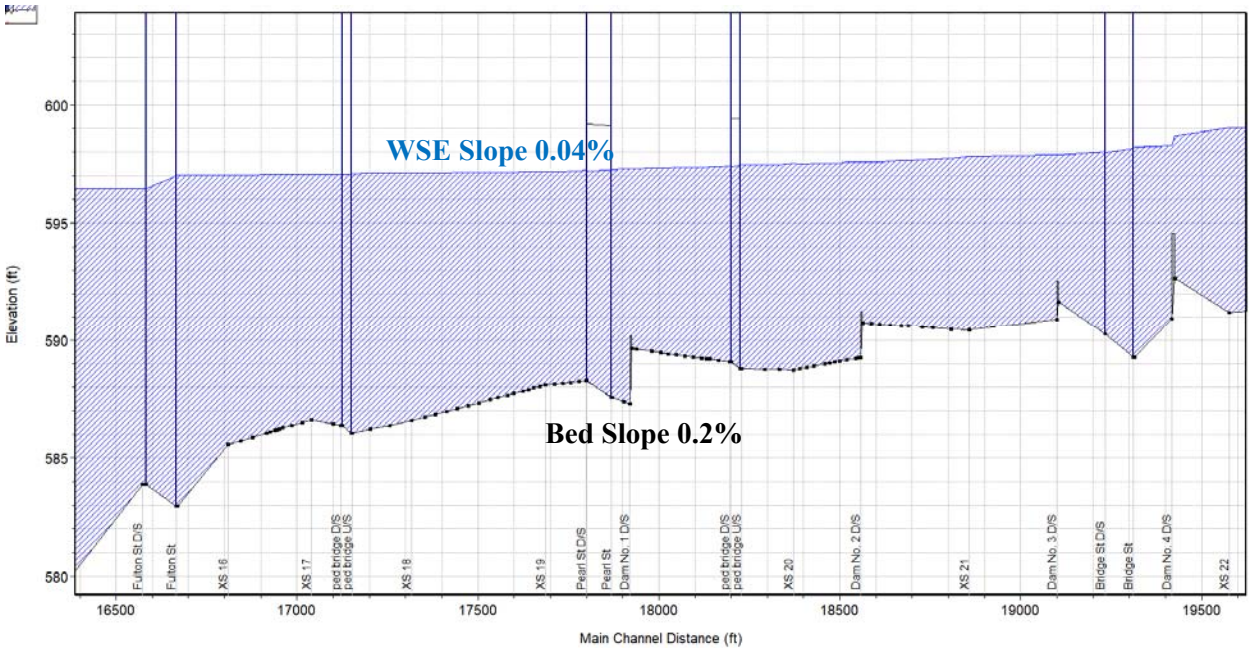

Figure 11: Project Reach Bankfull (13,000 cfs) Profile

2.6 WETLANDS

The Michigan Final Wetlands Inventory (MDEQ 2019) and the National Wetlands Inventory (NWI) (USFWS 2018) were both reviewed to determine the presence/absence of mapped wetland features within the portion of the Project area between the 6th Street Dam and Fulton Street. Neither database shows any wetlands in this portion of the Project area. However, wetland delineation surveys have identified five riverine wetlands currently in or near this area (Golder 2014 [TOC No. 17]; Fishbeck 2019 [TOC No. 17]. Because these features lie within the river banks, the character of these wetlands depends on river stage (depth). They are typically sparsely vegetated except for a few shrubs, primarily small willows (*Salix* sp.), near the banks, although they exhibit submerged aquatic vegetation, emergent vegetation, or both for at least part of the growing season. sp.), near the banks, although they exhibit submerged aquatic vegetation, emergent vegetation, or both for at least part of the growing season.

From upstream to downstream, the first wetland is located on the right descending bank just south of the 6th Street Dam and extends approximately 300 feet south (Golder 2014). The second wetland is located on the right descending bank adjacent to Ah-Nab-Awen Park, between the second and third low-head dam (Fishbeck 2019). The third wetland is located on the left descending bank in front of the DeVos Place Convention center. The fourth wetland lies along the right descending bank from approximately 100 feet downstream of the concrete patio at Ah-Nab-Awen Park to the Gillett Bridge (Fishbeck 2019). A fifth wetland extends along 200 feet of the left descending bank between the Blue Bridge and Fulton Street (Fishbeck 2019).

At the request of EGLE staff in October 2023, Fishbeck developed a wetland boundary verification memo to be included in the permit application package. The intent of the memo was to inspect wetlands within the project area, verify the previously delineated wetland boundaries, and update the wetland boundaries, if needed. The wetland survey determined there were minor changes in wetland boundaries. Wetland 7, wetland 10, and wetland 12 had slight changes to the wetland boundaries with wetland 12 having the largest change as the boundary was extended slightly as a result of erosion and river scour that created a flood bench that supports wetland vegetation. The project will have no impacts in the expanded wetland footprint for wetland 12. The full Wetland Boundary Verification memo from Fishbeck can be found ins (Fishbeck, 2023)

Wetlands within the main portion of the Project area are small, totaling less than 1 acre. Substrates within these features contain concrete, boulders, riprap and other non-natural materials (refuse), and overall wetland quality is low. Common hardy species, including sandbar willow (*Salix exigua*), eastern cottonwood (*Populus deltoides*) and the invasive reed canarygrass (*Phalaris arundinacea*) grow around and through gaps in these coarse materials. Various portions of these wetlands exhibit emergent, scrub-shrub, and forested wetland characteristics. Portions of these wetlands consist of fluvial deposits of sand, indicating that the configuration and extent of these wetlands may change periodically based on river flow.

The riverine nature of these wetlands is not conducive to some of the benefits usually associated with wetlands, such as water retention, biological productivity, and the removal of nutrients and other potential pollutants. However, they do provide habitat for fishes and other aquatic animals.

2.7 AQUATIC HABITAT AND BIOTA

There are existing populations of walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), Salmonids (*Oncorhynchus spp., Salmo spp., Salvelinus spp.*), and other non-migratory fishes in the Grand River. Diverse mussel species also have notable ecological presence within the Project reach. The existing aquatic habitat consists of relatively uniform depths and velocities with minimal deep holes or slower moving water. Fish exploit the tailwater behind the dams for holding areas. Some areas of more suitable conditions for mussels were observed during survey efforts; these generally were found in areas with gently sloping cobble/gravel bars where flow conditions become more diversified. For additional background information, see Section 3.0 of the Biological Assessment (EcoAnalysts, 2024)[TOC No. 24].

2.8 FISH PASSAGE AND LAMPREY ESCAPEMENT

Migratory upstream passage of important aquatic organisms is impacted by the low-head dams within the Project reach, which limit passage during some flow rates. However, unrestricted passage through the project reach only exists for the strongest swimming fish such as steelhead and salmon, which are naturalized but not native Great Lakes fish species. Although mussels do not migrate, their offspring disperse through distribution of glochidia on the gills of fish. Fish hosts of a federal and several state threatened and endangered species [logperch (Percina caprodes), minnows (Cyprinidae), catfish (Ictaluridae), and sunfish (Centrarchidae)] are restricted in upstream mobility past the low-head dam just upstream of Bridge Street and cannot pass downstream without washing over the crest.

The 6th Street Dam is considered by the Great Lakes Fishery Commission (GLFC) to provide a level of sea lamprey (Petromyzon marinus) migration control, although there have been reports of sea lamprey passing upstream of the dam to spawn (USFWS, 2013, 2024).The ability of the 6th Street Dam to continue to provide sea lamprey control as a long-term solution is unknown due to its age and ongoing dam deterioration. The Project has been evaluated and designed to maintain the current level of sea lamprey barrier effectiveness at 6th Street Dam.

2.9 RECREATIONAL USE

Currently, recreational fishing is popular in the Grand River within the Project area. Fishing from the shores and from boats is common, especially during salmon and steelhead spawning in the fall and spring. Angler counts have been conducted for the past four years and has recorded how the majority of angling occurs just below the 6th Street Dam, especially by wading when flow velocities and water depths permit. Recreational activities other than angling are not currently supported by the project reach.

The low-head dams pose a significant safety concern. There have been instances of people either floating over the dams or getting too close to the recirculating tailwater downstream of them while boating or wading, with some instances resulting in injuries and/or fatalities.

2.10 GEOTECHNICAL

The *Map of the Surface Formations of the Southern Peninsula of Michigan*, published by the State of Michigan, indicates the site is in an area of glacial outwash. The Grand River Valley is known to have been a major channel of glacial water flows. Near-surface soil conditions typically are found to be primarily granular with numerous cobbles and boulders, erratics from a distant geologic source. Several areas along the west and east riverbanks are known to have been low-lying floodplain areas prior to development of the area and have been filled with a variety of uncontrolled urban fill materials. Some fill material may have originated from dredging the main channel.

The proximity of bedrock to the riverbed throughout the project reach is relatively shallow compared to other parts of the Grand River. Bedrock includes a limestone and sandstone cap of the Bayport Formation from the north end of the downtown reach of the Grand River to the Gillett Bridge where the Bayport Formation ends and the underlying weathered shale and gypsum of the Michigan Formation continues south below the overburden soil. The top of the Bayport Limestone is exposed at the riverbed at the site of the fish ladder and 6th Street Dam and floodwall drawings in the vicinity indicate bearing directly on bedrock. Near Pearl Street and south where the Bayport Limestone is absent, the Michigan Formation Shale is approximately 10 to 30 ft below the alluvial riverbed.

Subsurface Conditions

During the development of the area during the late 1800's and early 1900's, placement of available miscellaneous material was common to raise low-lying riverbank levels. This fill created additional property for development as well as flood protection for nearby residences and businesses and defines what is now the current river boundary. A majority of the existing riverbanks in the project reach are therefore composed of miscellaneous fill material extending to depths up to 20 or 30 ft.

The miscellaneous fill material is composed of a highly variable assortment of granular and cohesive soil, boulder and cobble (primarily granite erratics), organic material (topsoil, peat and wood), building debris, cinders, brick and the like. Directly adjacent to and within the river channel, granular glacial outwash and post-glacial alluvium are present below the miscellaneous fill material below which relatively shallow bedrock is present as previously discussed. Native cohesive soil is also encountered adjacent to and within the river channel most often in the form of highly weathered shale above more competent shale. A summary of subsurface conditions described at various bridges crossing the Grand River within the study area is provided below including the approximate depth to bedrock and bedrock type.

Table 4: General Subsurface Conditions Encountered at Bridge Structures

Bridge Structure	Overburden Soil	Bedrock Type	Bedrock Depth (ft)
Ann Street	Granular	Limestone	> 60
Leonard Street	Granular	Limestone	1 to 7
Sixth Street	Granular	Limestone	1 to 2
I-196	Granular	Limestone	2 to 3
Bridge Street	Granular	Limestone	3 to 11
Gillett Bridge	Granular	Shale and Gypsum	20 to 30
Pearl Street	Granular	Gypsum and Shale	26 to 30
Blue Bridge	Granular	Gypsum and Shale	10 to 15
Fulton Street	Granular	Shale with Limestone	26 to 30
Wealthy Street	Granular	Shale	7 to 9

Note: Bedrock depth provided is approximate and is measured from bottom of river.

Historical documents indicating the foundation-type and bedrock depth at the Gillett and Blue Bridges were not found during our research. Bedrock information provided in Table 4 for the Gillett and Blue Bridges is based on soil borings performed near these structures.

Mine Research

Gypsum mining formerly located near the study area includes the Plaster Creek Quarry, located southwest of the project limits and the Powers Mine located within the south end of the project. The presence of surface beds of gypsum near Plaster Creek allowed for the formation of an open quarry and corresponding mill around the mid-1800's which remained in operation until the early 1900's. Subsequent development of the area has resulted in filling of the former quarry.

Approximate mining limits were obtained from *The Gypsum of Michigan and The Plaster Industry*, Volume IX, Part II, 1904. Records indicate that a mill was constructed directly above the mine shaft. Historical photographs and city directories place the mill at the northwest corner of the existing Blue Bridge west abutment (former Grand Rapids & Indiana Railroad Bridge).

Based on the existing site topography and no indication of significant ground subsidence in the area, it is suspected that the mine shaft was closed and filled and the underground mine rooms allowed to fill with water. A 1955 letter from a Grand Rapids Public Museum Employee stated that the mine was filled in some time after it was closed. Additional information regarding the closure and possible filling of the mine could not be found.

Materials Testing Consultants (MTC) has performed soil borings directly south and north of the Blue Bridge on the west bank of the Grand River for the GVSU Eberhard Center Project and for the Grand Rapids Public Museum Project with no indication of a mine shaft or void within bedrock encountered to depths up to 82 ft below the former ground surface at the boring locations. The boring information obtained by MTC to-date within this area lends further evidence to historical information describing the mines location, footprint and impact below ground.

Geotechnical Findings and Recommendations

The available information suggests the Grand River originally (prior to City's development in the mid 1800's) dropped 18 ft in elevation in a distance of a little more than one mile. This region of the "Grand Rapids" extended from the approximate current alignment of Leonard Street southward to approximately the current Gillette Bridge. We suspect the Grand River throughout much of the rapids was flowing upon or very near the top of bedrock surface of the Bayport Limestone Formation. It is expected that numerous boulders and cobbles were present in the region of the rapids as glacial outwash flows would have deposited such erratics. Although several feet of variation is noted, the top of bedrock at Leonard Street is approximately elevation 600 ft, while it is approximately elevation 590 ft at Bridge Street. Floodwalls, bridges and the 6th Street Dam throughout this area are largely founded on bedrock.

The gravity sections of boulder floodwalls north and south of Pearl Street are believed to have been constructed with primarily granite boulders pulled from the river and are founded at the river bottom with very little embedment or scour protection.

Soil behind the floodwalls and along the Grand River embankments is primarily miscellaneous fill over shallow bedrock throughout the region of former rapids and miscellaneous fill over postglacial alluvium both north and south of the former rapids. (MTC, 2015). Geotechnical findings are included in TOC No. 15 Geotechnical and Substrate Data and Findings.

2.11 SEDIMENTS

Sediment samples were collected using a petite Ponar Grab sampler on February 20, 2016. The Ponar sampler was lowered from a boat at the sampling locations to the river bottom, released to collect the sample and raised by hand after which the sample was retrieved by an MTC engineer. Retrieved samples were transported to the laboratory for gradation testing.

At each sampling location, about 12 to 15 attempts were made to collect a sediment sample at the river bottom using the Ponar sampler. Multiple attempts were necessary due to the presence of cobble and possible boulder which frequently resulted in little to no recovery. At Sample Location 3, MTC was not able to collect a representative sample of the sediment.

Supplementary probing was performed along the sides of the boat in a repeatable pattern to subjectively evaluate the consistency of the river bottom based on (1) presence of cobble and boulder greater than or equal to 6-inches in size and (2) presence of sand, gravel and cobble smaller than 6-inches in size. Sieve analyses were performed on retrieved samples per ASTM D6913 with material larger than 2-inches measured individually using calipers. A summary of sampling locations and the river bottom consistency based on probing efforts is provided in Table 5. The sediment sampling locations are presented in Figure 12. Refer to TOC No. 15 for substrate sampling data.

Additional sediment sampling was performed in August of 2020 in the locations of proposed excavation for construction of the in-channel features associated with alternative 3a. This effort focused on sampling fine material to evaluate contaminants. Refer to TOC No. 15 for the sampling report and contaminant testing results.

Table 5: Sediment Sampling Location Summary

Sample Location	Location (MI State Plane South)		Water Depth (ft)	River Bottom Consistency Based on Probing (%)	
	Northing	Easting		< 6-inches	≥ 6-inches
1	536129	12773066	4.5	25	75
2	536295	12772921	4.0	10	90
3	536623	12772963	4.2	10	90
4	536936	12773212	2.5	15	85
5	537353	12773028	3.7	50	50
6	537428	12773240	3.0	60	40
7	537827	12773063	2.7	75	25
8	538296	12773381	3.9	40	60
9	538890	12773427	5.8	85	15
10	539147	12773180	3.5	50	50
11	539485	12773506	6.8	Suspected bedrock	
12	539801	12773238	3.7	15	85



Figure 12: Sediment Sampling Location Plan

-- END OF SECTION 2 --

3.0 PROJECT REDESIGN PROCESS AND FRAMEWORK OBJECTIVES

The Project that is the subject of this permit application is the result of an iterative redesign process that took place from March 2023 until the time of application submission in 2024. In March of 2023 the project design team met with federal and state regulatory agency staff and developed an agreed upon framework and objectives for a successful project. The following framework objectives were agreed upon by all parties prior to initiating the redesign process:

- Remove the low-head dams and the associated public safety hazards;
- Achieve fish passage and aquatic habitat enhancement targets as determined by MDNR and project team;
- Diversify recreational opportunities;
- Develop an aesthetically and functionally natural stream design, within the parameters of a large urban river with floodwalls, a constricted floodplain, and multiple bridge crossings;
- Include safe river access consistent with identified objectives and compatible with projects adjacent to the river;
- Protection of critical infrastructure;
- Restoration of rapids;
- Avoid and minimize bed instability and public safety concerns associated with increases in flow velocities and scour potential.

The redesign process relied heavily on the direct coordination with EGLE and MDNR, as well as iterative correspondence with EGLE, MDNR, USFWS, and other stakeholders to achieve the agreed upon framework objectives. Multiple small group meetings occurred since March of 2023.These small groups included staff from MDNR Fisheries Division for fish passage, EGLE for wetlands, flooding/harmful interference, and state permitting, GLFC and USFWS for sea lamprey escapement, and USFWS and MDNR for endangered species.

3.1 PROJECT CONSTRAINTS:

Through the previous design process that spanned nearly 15 years, several constraints on the project were identified. The design concepts, iterations and alternatives presented in this report have been iterated based on these identified project constraints. Project stakeholders analyzed how the various project designs achieved the identified goals and satisfied the constraints. The design process and evaluation of goals and constraints for the project has benefited from extensive and ongoing coordination with the regulatory agencies, including MDNR, EGLE, USFWS, USEPA, and GLFC. Informal consultation with these agencies was initiated in early 2015 and has continued through the completion of this Report.

Throughout this process, topic focused meetings with regulatory agencies have been important in determining specific design elements that address project constraints. The design of the Project has been iterated and revised several times to address comments and concerns raised by regulatory agency staff. The Project presented in this Report is the product of these continued revisions and iterations in design and seeks to provide the most optimal balance of framework objectives while also satisfying constraints and minimizing impacts.

The following constraints were identified and minimizing impacts associated with these constraints has been a key goal of the project design process.

Constraints:

1) Flood conveyance;
2) Public safety;
3) Scour potential and integrity of existing infrastructure;
4) Sea Lamprey escapement at the 6th Street Dam; and
5) Impacts to wetlands and endangered mussels

-- END OF SECTION 3 --

4.0 PROJECT ALTERNATIVES AND REDESIGN CONCEPTS

The Project has been proposed because the past modifications to the Grand River, including the construction of the four low-head dams, have made the channel uniform and homogeneous, which in turn has impaired aquatic habitat, affected fish passage, created public safety hazards, and limited biological diversity of the Grand River. The Project proponents seek to address these impairments while also realizing the benefits of enhancing river access and use.

There is no other location where the benefits of the Project can be realized. The Project seeks to restore aquatic habitat in the Grand River, including demolition of four existing low-head dams (see Section 5.1 of this report). Pursuing restoration opportunities at other locations would not allow removal of the four low-head dams, the restoration of diversified aquatic habitat dependent on steep gradient hydraulics, or the revitalization of the Grand River through downtown Grand Rapids. The Project purpose could not be achieved at another location.

4.1 PREVIOUSLY CONSIDERED ALTERNATIVES

The prior permit application for the project, as referenced in Section 1, analyzed seven different design alternatives. Those alternatives were:

- Alternative 1: No Action
- Alternative 2: Dam Removal Only
- Alternative 2b: Dam Removal with expanded grading
- Alternative 3a: Dam Removal with substrate enhancement (Previous Preferred Alternative)
- Alternative 3b: Dam removal with substrate enhancement
- Alternative 3c: Dam removal with substrate enhancement
- Alternative 4: Dam removal with scattered boulders

As a result of the prior permit application process and the ultimate objection of Alternative 3a, the seven previously analyzed alternatives have been eliminated for additional study or review because:

- **Alternative 1:** Alternative 1is the no action alternative and leaves the river in its existing degraded state and does not achieve any of the project goals and objectives. Alternative 1 would leave four dangerous low-head dams in place and not improve access or usability for the community.
- **Alternative 2 & 2b:** Alternatives 2 and 2b remove the dangerous hydraulics associated with the four low-head dams but produce potential substrate stability concerns resulting from the lack of grade control provided within the Project reach. Alternative 2 and 2b do not meet the agreed upon framework objectives.
- **Alternatives 3a, 3b, & 3c:** Alternative 3a had approximately 11 acres of permanent direct impact area to the river bottom and had an expansive footprint of temporary direct impact areas during construction, which included large alluvial coffer dams to isolate portions of the channel. Following the objections to the previous design as noted in the introduction, the City of Grand Rapids chose to withdraw the application for Alternative 3a and work with EGLE to develop a new design alternative that further reduced impacts. Alternatives 3b & 3c had larger amounts of fill than 3a and also demonstrated increases in the modeled 100 year flood elevations. Alternatives 3a, 3b & 3c do not meet the agreed upon framework objectives.
- **Alternative 4:** This alternative eliminates the hazardous low-head dam hydraulics and adds aquatic habitat enhancements in the form of scattered boulders. However, the removal of existing grade control results in potential substrate stability concerns resulting from the lack of grade control provided solely by scattered boulders within the project reach. This alternative does not meet the agreed upon framework objectives.

4.2 REDESIGN CONCEPTS

Following the withdrawal of the permit application for the previously preferred alternative, the project team met with agency representatives and agreed on the framework objectives discussed in Section 3 that would guide the efforts for a new project design. As part of the redesign process of 2023-2024, EGLE and MDNR representatives expressed a desire to develop additional design concepts to further avoid, minimize, and mitigate impacts to the aquatic resource. Agency staff decided the design team needed to use the former Alternative 2b (Dam removal with expanded grading limits) as the starting point for the project redesign efforts.

Six additional design concepts were developed, and explored different locations, configurations, and number of proposed hydraulic grade control features, along with other natural channel design concepts such as w-weirs, rock arch ramps, and emergent habitat boulders. The six redesign concepts also varied by degree of replaced grade control within the reach, ranging from approximately 30% of replaced grade control provided by the four low-head dams to 100%.

The six redesign concepts included:

- Concept #1: Dam removal with one hydraulic grade control feature at the Dam 3 location and incorporated scattered boulder.
- Concept #2: Dam removal with one hydraulic grade control feature at the Dam 2 location and incorporated scattered boulder.
- Concept #3: Dam removal with two hydraulic grade control features, (Dam 3 location & Dam 2 location), and incorporated scattered boulder.
- Concept #4: Dam removal with two hydraulic grade control features, (Dam 2 location & Dam 1 location), and incorporated scattered boulder.
- Concept #5: Dam removal with three hydraulic grade control features, (Dam 2 location, Dam 1 location, & just downstream of Pearl Street Bridge), and incorporated scattered boulder.
- Concept #6: Dam Removal with four hydraulic grade control features, (Dam 3 location, Dam 2, location, Dam 1 location, and just downstream of Pearl Street Bridge, and incorporated scattered boulder.

4.2.0 METRICS

The metrics used to select a concept design and develop a permit are discussed below. These metrics evaluated seven categories, which were identified as important to the agreed upon framework objectives.

1. **Grade Control and Distribution of Hydraulic Gradient**
   The degree to which each concept replaced the grade control function of the existing low-head dams and distributed the hydraulic gradient of the river over the Project area was identified as the driving design consideration and was therefore first evaluated by the design team (with collaboration from EGLE and MDNR).

   Replacing less grade control within the reach allows for more hydraulic gradient, or energy, of the river to be expended over areas of existing streambed. This results in secondary hydraulic impacts such as decreased flow depth and increased velocities, shear stresses, and scour potential.

2. Aquatic Habitat

Several metrics were evaluated to assess aquatic habitat among the range of concepts. These included:

- Available habitat. This was the wetted area at 890 cfs (7Q10 flow rate). Concept selection was in favor of minimizing reductions to this area.
- Uninhibited movement for fish. These were areas with less than 3 ft/s flow velocities during several flow rates and at least 0.75 ft of flow depth. Concept selection was in favor of increasing this area.
- Deep-water and pool habitat. These were areas with greater than 4 ft of flow depth. Concept selection was in favor of increasing this area.
- Suitable spawning habitat for Lake Sturgeon. These were areas with flow velocity between 1.6 and 4.3 ft/s and substrate size between 0.4 and 3.3 ft in diameter. Concept selection was in favor of increasing these areas.
- Suitable flow conditions for mussel habitat. These were areas with minimum flow velocities between 0.12 and 0.5 ft/s and non-depositional for sand during 3,900 cfs (shear stress greater than 0.01 lb/sf). Concept selection was in favor of increasing these areas.

Other influential impacts were evaluated for fish and mussel species to inform the design, including holding area and uninhibited movement for fish and suitable flow conditions for mussel habitat. Of the remaining metrics, most were compared between concept designs but not evaluated further due to either little change between most concepts or because they were less prioritized than other metrics, such as minimizing area of direct impact to the existing streambed.

3. Fish Passage

Fish passage was evaluated based on metrics developed in collaboration between biologist for the Project team and MDNR Fisheries. These included average velocities and minimum flow depths, and considered the burst and sustained swimming abilities of several resident fish populations (Encompass, 2024). Concept selection was in favor of optimizing fish passage.

4. Avoid and Minimize Impacts to Aquatic Resources

The metric that had the most impact on concept selection, and continued refinement of that concept, was the area of direct impact to the existing streambed. Secondary impacts associated with the aquatic habitat metrics listed above were also considered.

Discussions on how the design avoided and minimized impacts are included in section 5 of this report for permanent impacts and in section 6 for temporary impacts.

5. Bed Stability

To evaluate bed stability, a factor of safety against substrate mobility was assessed. This factor of safety was defined as the critical shear stress of the substrate divided by the maximum calculated shear stress of the hydraulic models. The critical shear stress of a particle size is the shear stress at which that particle begins to mobilize from the bed. Because this is dependent on particle size, it is also dependent on substrate sampling data. Therefore, the evaluation of this metric relied on the findings of the series of substrate sampling efforts for the Project (MTC, 2015-2020). The concept selection was in favor of a minimum factor of safety of 2.0.

6. **Bridge Protection**
   The HEC-18 Manual for pier scour was used to calculate scour depths at all bridge crossings within the Project area. Any bridges with increased calculated scour depths would need to be fully evaluated in the bridge scour analysis for the project as design progressed. Therefore, concept selection was in favor of minimizing increased calculated scour depths at any bridge crossing.

7. **Public Safety at Bridge Crossings**
   Bridge crossings are inherently more dangerous to users than areas of open channel. The metric considered to evaluate public safety at bridge crossings focused on the proximity of peak hydraulics to bridge piers. This metric is directly related to the level of grade control and distribution of hydraulic gradient discussed above. Removing grade control downstream of bridge crossings relocates the hydraulic focus of the river from the grade control (low-head dams) to the bridge crossing. This is due to the narrower flow paths beneath the bridges resulting from flow constriction around bridge piers. Increased velocities near bridge crossings reduces reactions time of users potentially floating into the piers and increases the pinning forces against the piers. The concept selection was in favor of minimizing accelerated flow velocities at bridge crossings.

   Through coordination between the City, GRWW, EGLE, and MDNR, this concern was considered in context with the degree of potential increased risk to public safety as well as the degree of other framework objectives achieved by each concept.

4.2.1 CONCEPT SELECTION

The selection of a concept was based on evaluation of the metrics discussed above, as well as the project constraints discussed in Section 3.

4.2.1.1 Concepts #1 and #2 (One grade control structure)

Concepts #1 and #2, each with only one grade control structure, resulted in the largest amount of increased velocity and scour potential over the areas of existing channel in the Project area. Although these concepts had the least amount of direct impact to the existing streambed, it was determined that they did not maintain enough grade control within the project reach, resulting in large areas of increased velocities and shear stresses which carried adverse impacts to fish passage, aquatic habitat, bed stability, public safety, and protection of critical infrastructure.

4.2.1.2 Concepts #3, #4, and #5 (two and three grade control structures)

Concepts #3, #4, and #5 replaced 60%-90% of the grade control function of the low-head dams, depending on crest elevations and headlosses over each grade control structure. These concepts were able to focus the distribution of the hydraulic gradient of the river at locations of stable fill material (grade control structures) in a way to achieve framework goals within the project reach. The less amount of replaced grade control function resulted in increased velocities and scour potential over the streambed upstream of the project to 6th Street Dam compared to existing conditions. These increases in the upstream reach carried with them potential adverse impacts to fish passage, aquatic habitat, streambed stability, protection of critical infrastructure, and public safety. These impacts were evaluated and considered against the improvements (and level of achieved framework objectives) within the Project reach.

4.2.1.3 Concept #6 (four grade control structures)

Concept #6 replaced the full grade control function of the low-head dams and maintained a similar upstream control elevation to low-head Dam 4. This concept had the largest area of direct impact to the streambed but was also able to avoid the adverse impacts to the upstream reach that

the other concepts could not, resulting in no change in upstream velocities, scour potential, or protection of critical infrastructure. In addition to having the largest area of direct impact to the existing streambed, this concept also resulted in modeled increases in tailwater elevations at 6th Street Dam during some flow rates, indicating a higher potential to change the barrier effectiveness of the 6th Streed Dam compared to the other concepts.

4.2.1.4 Selected Concept (Concept #4) and Preferred Alternative

Concept 4 emerged from the initial concept evaluation process as the concept that would best achieve the agreed upon project framework objectives and further avoid, minimize, and mitigate impacts to the streambed. Through significant coordination with representatives from MDNR and EGLE, Design Concept 4 was selected in August of 2023 as the concept that would be further enhanced and refined over a series of bi-weekly technical project team meetings with agency representatives from MDNR, EGLE, City of Grand Rapids, and Grand Rapids Whitewater. Through this collaborative design effort, it was determined that complete replacement of the grade control function of the low-head dams was unable to be achieved due to increases in modeled tailwater elevations at 6th Street Dam at some flow rates and the potential for decreasing the effectiveness of 6th Street Dam as a barrier to sea lamprey.

Concept #4 was preferred to Concept #5 due to having less direct impact area to the existing streambed. Concept #4 was preferred to Concept #3 because of the upstream grade control structure being located at Dam 2 instead of Dam 3, which is near a large 96" storm sewer and large floodwall on the east side, both carrying with them avoidable public safety concerns associated with ingress/egress and self-rescue. The location of Dam 2, adjacent to an existing and highly utilized public park, which will also be utilized as construction staging for the project, also made it a more advantageous location for the grade control structure.

The selected concept design was iteratively evaluated, modeled, and designed to be optimized for achieving the framework objectives, avoiding or minimizing adverse impacts to project constraints, and minimizing area of direct impacts to the existing streambed. Preliminary design drawings were developed to show locations and elevations of all proposed substrate enhancements.

On January 12, 2024, following review of preliminary design plans, EGLE staff communicated by email that they did not foresee any "redflags that would prevent the project from being successful" and supported the City in moving forward with submitting additional information to move into a formal permit review process with State and Federal agencies. As a result of this coordination with the agencies, Design Concept 4 was selected as the Preferred Project Alternative (Project) and is now the subject of this revised Basis of Design report and permit application.

The framework objectives and project constraints were all evaluated throughout the design of the preferred alternative. Several supporting reports have been developed to discuss these evaluations. Specific objectives or constraints are listed below along with corresponding references to the more-detailed reports which discuss how they have been evaluated.

- **Flood conveyance:**
  The Preferred Project Alternative has been hydraulically modelled and designed to maintain the City's freeboard deficient certification from FEMA. Localized increases in modeled flood stages occur within the project reach; however, the hydraulic evaluation of the project indicates that no harmful interference would result from the project. A CLOMR will be submitted to FEMA to fully address modeled increases in 100-yr flood levels.

Refer to TOC No. 5 Hydraulics Report and TOC No. 10 Temporary Conditions Hydraulics Report more detailed analysis and information.

- **Aquatic habitat, suitable flow conditions for mussel habitat:**
  The project is pursuing a Biological Opinion from the United States Fish and Wildlife Service. All impacts to mussels will be avoided and minimized. The Biological Assessment currently under review by United States Fish and Wildlife Service includes mussel relocation ahead of the project to occur in summer 2024.

  Within the direct impact area (45,445 m2) of the project, there are estimated to be 123 E. Triquetra, 1,800 Michigan TES, and 11,711 other unionid species. Within the indirect impact area (82,155 m2) of the project, there are estimated to be 222 E. Triquetra, 3,253 Michigan TES, and 21,171 other unionid species. Upstream of the project, the indirect impacts are estimated at 104 E. Triquetra, 1,521 Michigan TES, and 9,901 other unionid species. Downstream of the project, there are estimated to be no E. Triquetra, 8,325 Michigan TES, and 28,250 other unionid species.

  Mussels will be relocated from the direct impact areas. Loss of mussels will also be mitigated through the establishment of a mussel mitigation fund.

  Refer to TOC No. 24 Biological Assessment for more detailed analysis and information.

- **Fish passage:**
  A fish swimming performance analysis evaluated the Preferred Project Alternative at fifteen swim paths across four reaches of the project area and demonstrated passage through the project area. Within the evaluation, fish passage was predicted to occur at most difficult hydraulic scenarios and for each of the design elements – boulder clusters, W-weir, and riffles.

  Refer to TOC No. 14 Fish Passage Report for more detailed analysis and information.

- **Bed stability:**
  Incipient motion analyses, which compared modeled maximum shear stresses to critical shear stress values of sampled substrate sizes within the project area, demonstrated that existing and proposed substrates would remain stable with a minimum factor safety against mobility of 2.0. Isolated small areas calculated a factor of safety slightly less than 2.0; these are discussed and explained in TOC No. 6.

  Refer to TOC No. 6 Sediment Transport Report for more detailed analysis and information.

- **Bridge Protection:**
  Analysis of the hydraulic influence on bridge scour was performed for existing and proposed conditions of the Grand River at Grand Rapids, MI. Hydraulic modeling and data analysis using the standard engineering guidelines of HEC-18 indicate that proposed project actions will minimally affect the largest scour producing flows (100-yr and 500-yr return flood, with differences of ~0.5% or less). Increased scour potential is anticipated during lower flow rates (up to 13,000 cfs) at I-196; however, is not expected to erode the primarily bedrock streambed.

Two-dimensional modeling of temporary conditions highlighted the (low probability) of high-scouring conditions at Gillett Bridge if 7,500 cfs is exceeded during work isolation at the Dam 2 location.

Refer to TOC No. 7 Bridge Scour Report for more detailed analysis and information.

- **Sea lamprey escapement at the 6th Street Dam:**
  Modeling results indicate that tailwater elevations would remain at or below existing conditions, within modeling error. Based on this evaluation, the function of 6th Street Dam as a barrier to sea lampreys is anticipated to remain as effective as the existing condition.

  Refer to TOC No. 8 Hydraulic Influence at 6th Street Dam for more detailed analysis and information.

-- END OF SECTION 4 --

5.0 PROJECT DESIGN ELEMENTS AND CONSIDERATIONS

The preferred project alternative was developed by progressing the design of Concept #4, which included proposed grade control structures at the locations of Dams 1 and 2 in addition to bank vane structures and emergent habitat boulder downstream of Pearl Street. Through a collaborative effort with EGLE and MDNR, the Concept #4 design was iterated to optimize for framework objectives and project constraints while also avoiding and minimizing direct impacts to the existing stream bed. This section describes design elements and ways in which this was achieved through design.

5.1 DAM DEMOLITION

The demolition of the dams was determined to be important to achieving project goals and satisfying constraints. Various options considered for the low-head dam demolition are discussed in this section.

Each of the four low-head dams downstream of 6th Street Dam will be demolished so they no longer have a hydraulic control on the river. The low-head dams currently function to provide grade control throughout the reach and help prevent potential head cutting from occurring. Care must be taken with the demolition plan to not destabilize the channel bed or channel banks. Several dam demolition options were studied, including complete demolition of all concrete and partial removal of the concrete to an elevation that no longer influences the flow of the river. These options are discussed below.

5.1.0 LATERAL EXTENT OF LOW-HEAD DAM DEMOLITION

Since the original low-head dam construction and subsequent, often undocumented, modifications occurred over the past 100-plus years, the exact limits of the existing low-head dam structures are not explicitly known in all areas. The concrete dams may extend behind and beneath the floodwalls and adjacent pathways on the east side of the channel, as well as through the riprap bank and under the pathways on the west side of the channel. Three options were considered for lateral extent of dam demolition:

1) Leave dams in place. Leaving the low-head dams in place would not meet the Project purpose and therefore was not considered as a feasible alternative.

2) Remove the entire structure. Depending on the lateral extent of the low-head dam, this option may necessitate excavation, removal, and replacement of existing infrastructure, such as floodwalls, riprap banks and concrete pathways in the vicinity of the dams and overbank areas.

3) Demolish the dams to a lateral extent where the remaining structure is no longer visible or affects the river hydraulically. To the degree possible, the dams would be removed to match the bank grade on both sides of the channel. On the east side of the channel, the dams would be removed laterally to the existing floodwall, finished with a vertical saw cut near the floodwall. On the west side, the dams would be removed to where they meet the existing bank or slightly beyond. Any exposed concrete would be covered with stable material and planted to match existing site conditions.

Due to the potential impacts to floodwalls and other critical infrastructure, the preferred dam demolition option is to remove dams laterally only to the extent to which they are no longer visible and no longer influencing the hydraulics of the river. This option will allow for additional in-channel fill to accomplish project goals, while protecting existing critical infrastructure, reducing construction costs, and reducing the in-water construction footprint associated with complete removal.

5.1.1 VERTICAL EXTENT OF LOW-HEAD DAM DEMOLITION

Each dam location has a specific maximum elevation to which finished grade should be established after demolition to eliminate all effects on hydraulics and allow maximum habitat improvements. Finished grade at the locations of Dams 1, 3, and 4 is the top of the footer elevation of the dam, right at the toe of the downstream face of the structure. Maintaining a 12" minimum cover of alluvium would necessitate complete removal of the dam structure within the channel at these locations, assuming the dam footers are set similar to what historic plans show. At the location of dam 2, some locations of the existing dam are greater than 24" below finished grade of the proposed riffle structures. In these locations, the contractor may remove concrete to an elevation of 24" or greater below finished grade and place coarse alluvium on top to form the constructed riffle.

A range of options have been evaluated to determine the elevations that the dams are to be removed to, at different locations of the river, including partial removal and complete removal of the dam and footer. The foundations of the dams vary from four to six feet in length (in downriver direction) and one to two feet thick based on historic construction plans. The dam foundations were likely poured directly onto the river substrate, without forms to define the bottom of the structure. Several options were considered for the vertical removal of concrete:

1) Leave dams in place. Leaving the low-head dams in place would not meet the Project purpose and therefore was not considered as a feasible alternative.

2) Remove to the elevation of proposed finished grades. This option would remove the concrete dams to the elevation of proposed finished grades without a 12" minimum cover of alluvium. Dam footer structures would be left in the channel for this option. The ability to achieve precise finished elevations for the concrete removal work would be dependent on the equipment required for removal. This option would include avoidance of exposed sharp edges to the maximum extent possible and spreading alluvium over the exposed foundations, though exposed concrete would likely exist in areas. This option avoids destabilizing these areas of the channel bed during construction and would correspond to lower cost for construction and materials. Although the concrete that would be left in the channel would not influence the hydraulics of the river, there may be areas of the channel that would have exposed concrete in the riverbed. This option was not determined to be the preferred option due to the potential of exposed concrete in the flowing river.

3) Remove all concrete associated with the dams from the channel. This option removes all concrete associated with the dams from the channel, including the entire foundation of the dams. The foundations of the dams would be excavated and removed from the channel, the underlying substrate would be verified to be coarse alluvium, and the excavation would be backfilled with riprap or very coarse alluvium with 12-inches minimum of alluvium placed as finished grade. If the substrate is a finer material, then some over-excavation with coarser material backfill would occur. Compared to Options 1 and 2 above, this dam removal option requires more extensive in-channel work and associated material costs, with approximately an additional 400-500 CY of excavation and backfill of riprap. This option would avoid exposed concrete in the riverbed. This is the preferred option in locations where dams are proposed to be removed and no substrate enhancements are proposed to avoid exposed concrete in the flowing river.

4) Combination of Options 2 and 3. A fourth option is essentially a combination of Option 2 and 3 above. Dam removal Option 4 establishes finished grade with at least 12" of alluvium placed on top of any existing concrete or placed riprap in the channel. Along areas of the

dams outside of the proposed grading footprint, concrete would be removed to at least 12" below existing grade, likely resulting in complete removal of the footers for several of the smaller low-head dams (Option 3 above). Areas of the dams within the grading footprint would be lowered to at least 24" below the finished grade elevations and would be covered with proposed fill. This is the preferred option because it avoids exposed concrete in the flowing river and provides potential for more efficient and cost-effective construction.

5.2 SUBSTRATE ENHANCEMENT IMPROVEMENTS

The main design components proposed as part of the Project are grade control structures (which include both constructed riffles and boulder arch structures), bank vane structures, and emergent habitat boulders. These design components function together to achieve the framework objectives of the project. The grade control structures function to distribute the bulk of the hydraulic gradient of the reach, the bank vane structures provide habitat diversity and improved public access, and the emergent habitat boulders enhance aquatic habitat, fish passage, and natural aesthetic function.

Constructed riffles would contain stabilizing riprap core structures within placed coarse alluvium with emergent habitat boulders. Boulder arch structures would have a diversified planform that emulates rock arch designs (Aadland, 2010) and W-weir structure designs (NRCS, 2007); each boulder arch structure would also have a downstream scour hole. Bank vane structures would be installed at locations of existing or future public access points and would function to provide slow-moving water and hydraulic diversity at these locations. Lastly, emergent habitat boulders would be placed in areas of existing riverbed to improve aquatic habitat and natural aesthetics. Refer to Figure 13 for a plan view of the proposed substrate enhancements.

Additional details and information on the design of these substate enhancements are discussed below.

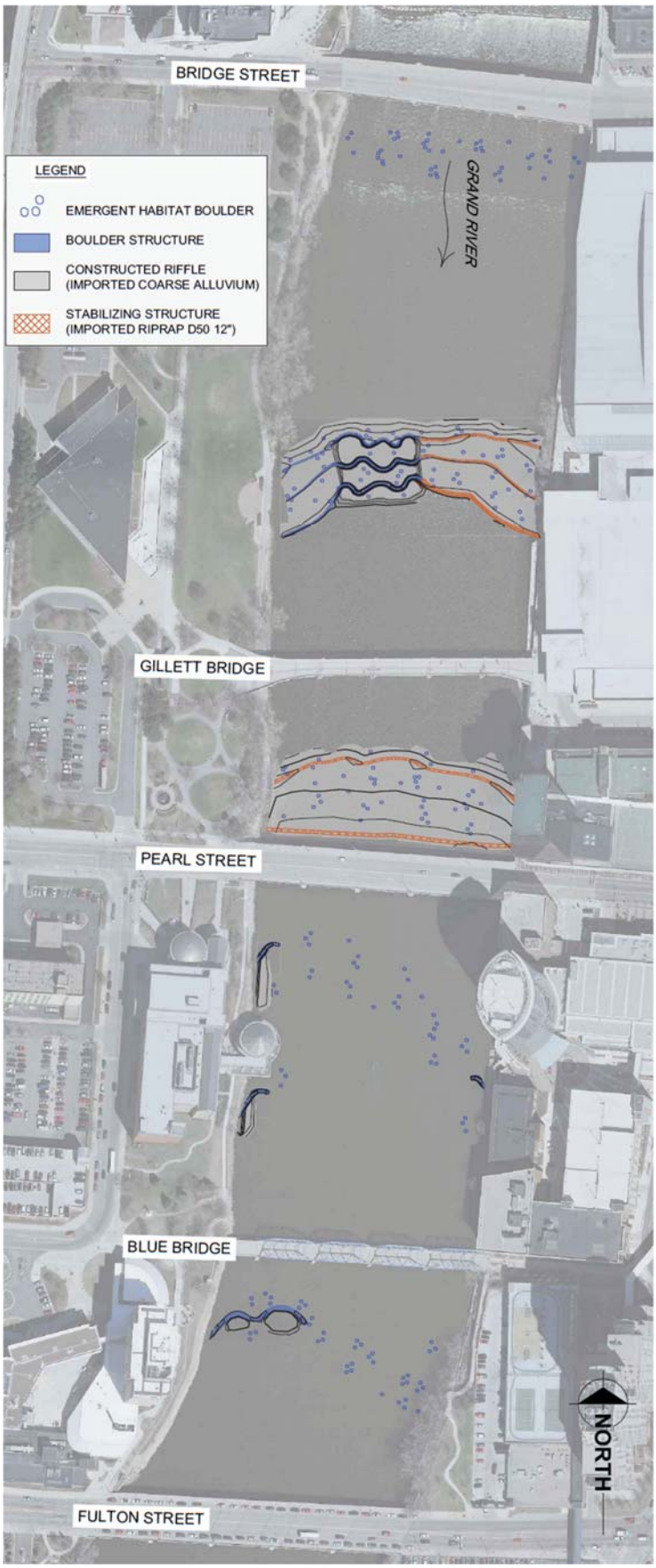

Figure 13: Proposed substrate enhancements

5.2.0 DESIGN DISCHARGES

The design of all substrate enhancement components has been based on the evaluation and hydraulic modeling for a wide range of flow rates, from extreme low flows (890 cfs) up to the 100-year flow event (50,000 cfs). The design discharges for any given area of proposed substrate enhancement are the flow rates at which a structure influences the hydraulics of the river; both downstream and upstream of the structure. Each structure will be submerged by tailwater at a different flow rate, depending on the location within the project reach. The backwater effects migrate from downstream to upstream as the flow rate increases. Once submerged, the structures would not generate hydraulics noticeably different from existing conditions at the same flow rate; the hydraulics would become similar to existing conditions as flow rates and tailwater elevations continue to increase.

5.2.1 GRADE CONTROL STRUCTURES

Two grade control structures are proposed as part of the project. The downstream structure, located between Gillett and Pearl Street Bridge near low-head Dam 1, would be a constructed riffle with emergent habitat boulders and stabilizing riprap core structures at the crest and toe. The upstream structure, located at the location of Dam 2 and adjacent to Ah-Nab-Awen Park, would have two constructed riffles (similar in design to the Dam 1 structure) on either side of a series of three boulder rock arch structures. These grade control structures would function to maintain grade control within the project reach while also functioning to achieve the framework objectives of the project.

5.2.1.1 Crest Elevations

Crest elevations of the proposed grade control structures have been set to provide an optimized balance of the framework objectives of the project with project constraints, which include fish passage, scour potential and integrity of existing infrastructure, sea lamprey escapement, and flood conveyance. The crest elevations for the preferred alternative were determined through the collaborative concept selection effort described in Section 4.

The crest elevations for the grade control structures have been set relative to one another so that the head loss, or change in water surface elevation, over each feature is consistent and the total change in water surface through the reach is gradually distributed. The crest elevations of the grade control structures were also set to minimize increased scour potential compared to existing conditions while balancing framework objectives and project constraints. The project design constraints most important in determining crest elevations include flood conveyance, sea lamprey escapement, bed stability, and protection of critical infrastructure. Boat passage and fish passage were also factors in determining crest height.

The project proposed to lower the hydraulic grade control at the upstream end of the project reach from approximately 595’ under existing conditions (Dam 4) to approximately 593’ under proposed conditions (at location of Dam 2). This allows more hydraulic gradient (energy) to be expended over existing substrates upstream of the project reach, between Bridge Street and 6th Street Dam. This may decrease depths as well as increase flow velocity and scour potential in that upstream reach, having potentially adverse secondary impacts to aquatic habitat, public safety, bed stability, and protection of critical infrastructure. These secondary impacts were evaluated and determined to be acceptably minor in magnitude, and also to be necessary to avoid modeled increases in tailwater at 6th Street Dam during some flow rates, which may impact the effectiveness of the 6th Street Dam as a barrier to sea lamprey. For more information, refer to TOC No. 8 Hydraulic Influence at 6th Street Dam.

Impacts to aquatic habitat were evaluated through the BA (TOC No. 24 Biological Assessment), the Fish Passage Report (TOC No. 14) and through personal coordination with EGLE and MDNR Fisheries. Potential impacts to public safety resulting from increased velocities upstream of the Project reach were evaluated through discussing the public safety metrics described in Section 4.2.0 with the City, EGLE, and MDNR. Bed stability was evaluated by comparing maximum bed shear stresses under proposed hydraulics with critical shear stresses associated with existing substrate sampling to determine the likelihood of increased substrate mobility under post-project conditions. A complete evaluation of substrate stability is presented in TOC No. 6 Sediment Transport Report. Protection of critical infrastructure was evaluated by referencing previous scour reports for bridges and calculating and comparing scour depths between existing and proposed conditions. Refer to TOC No. 7 Bridge Scour Report for more information.

The elevations of all grade control structures and other proposed improvements have been set to avoid increases in modeled flood risk or harmful interference. Refer to TOC No. 5 Hydraulics Report for more information.

5.2.1.2 Configuration

The configurations of the grade control structures were primarily based on framework objectives of achieving an aesthetically and functionally natural design to restore the rapids and improve fish passage, and was constrained by public safety, protection of critical infrastructure and avoidance and minimization of impacts.

The grade control structures are located within the footprint of the low head dam removal areas with minimally expanded grading limits. These grading limits have been reduced to the greatest extent possible. Maintaining open and connected swim paths for fish and minimizing areas where fish may need to traverse water to find more suitable passage hydraulics was also a key design element that influenced the configuration of the hydraulic features.

5.2.2 CONSTRUCTED RIFFLES

The design of the constructed riffles is key to the success of the Project. The proposed constructed riffles at the Dam 1 and Dam 2 locations function in concert with the boulder arch feature at the Dam 2 location to distribute most of the water surface gradient currently controlled by the four low-head dams. The constructed riffles provide improved fish passage connectivity and are intended to restore aquatic habitat and natural aesthetic as well as enhance downriver boating and angling.

Multiple options for riffle feature designs were evaluated throughout the project development process, which contain various horizontal limits of grading, slopes, finished grade variances, and materials. All these design parameters have been adjusted with input from the regulatory agencies to avoid harmful flood interference and minimize impacts on the existing riverbed, threatened and endangered species, and public safety, while maintaining fish passage and aquatic habitat improvement goals. A schematic of the constructed riffle at the Dam 1 location is presented in Figure 14, refer to Figure 16 for the riffles at the Dam 2 location. Options for riffle structure materials, footprint, and substrate thickness were analyzed, and are discussed below.

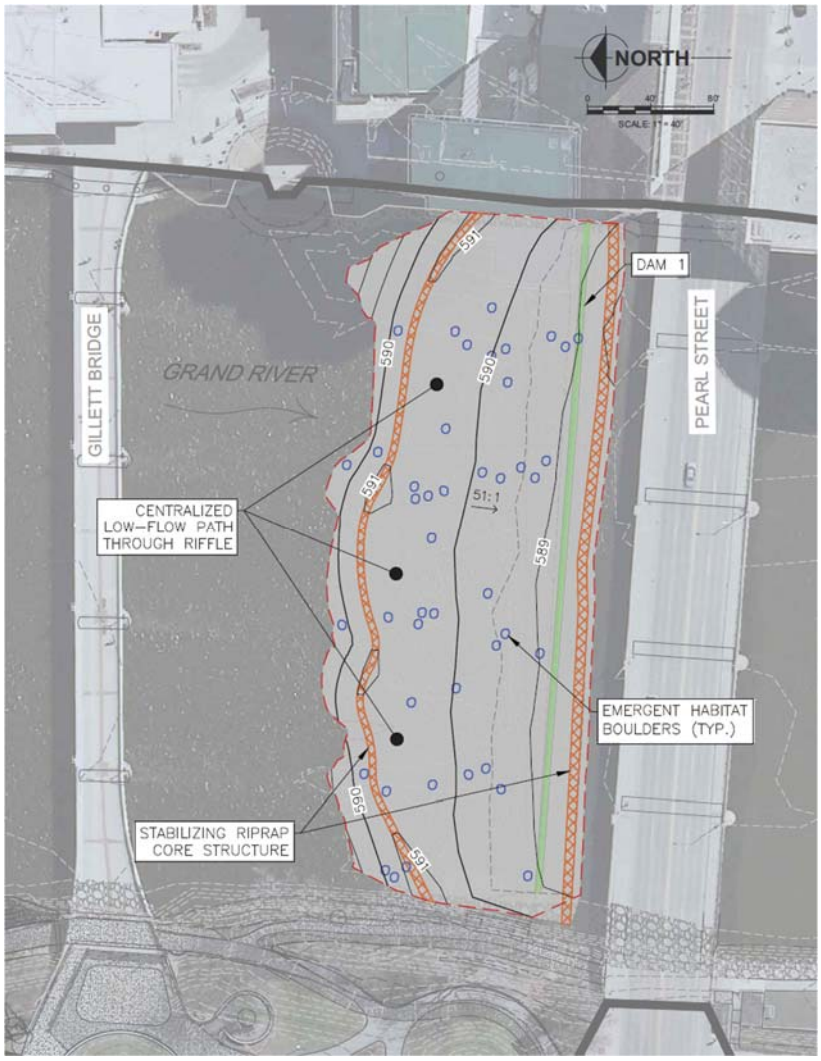

Figure 14: Constructed riffle grade control structure at the Dam 1 location

5.2.2.1 Constructed Riffle Materials

The size and type of the materials used to construct the proposed constructed riffles, including boulder, riprap, and alluvium, were determined by evaluating stability, aquatic habitat suitability, biological health, and user interface (i.e. wading and boating). Different ranges in gradation, type and angularity of rock (i.e. natural weathered rock versus more angular rock blasted from a quarry) of alluvium were considered.

Regarding size, coarser substrates would be more stable but may have reduced habitat suitability and user interface. A uniform gradation consisting of only coarse material contains more void spaces. This correlates to relatively less suitable aquatic habitat, poor biological health and mussel habitat, and increased foot entrapment potential and other user safety concerns. However, if material is sized too fine, long-term stability of the features may become a concern, resulting in higher potential for long-term repairs or rehabilitation costs. Gradations with large portions of finer material may experience "winnowing" over time that results in the removal of smaller material and the general armoring of the finished grading, which is also indicative of relatively less suitable aquatic habitat.

The preferred option is to install well-graded alluvium which includes a continuum of material sizes to fill voids and provide enhanced and diversified biological habitat for macroinvertebrates

within proposed riffles which are anticipated to see elevated dissolved oxygen levels (EPA, 2012). Well-graded alluvium is also important for mussel habitat while also remaining locally stable without mobilizing downstream (EcoAnalysts, 2020). Allowing the substrate to adjust locally to annual changes in flow conditions and establish a more natural bedform is a desired outcome of the project. Emergent habitat boulders will be selectively placed in the riffle sections to provide flow diversity.

The Project will utilize two size classes of imported alluvium for construction of riffle features and backfill around boulder and riprap. The size classes include fine alluvium and coarse alluvium. Imported alluvium will consist of clean, hard, durable, subrounded, and well graded material. Imported alluvium may be screened or crushed material, subrounded material is preferred. Unless specified in drawings, gradation shall match the gradations detailed in the tables below. Materials shall meet the following specification requirements.

- Minimum specific gravity of 2.55.
- Abrasion resistance by Los Angeles Machine; Test Method ASTM C535; Specification Requirement: 28% loss, maximum.
- Soundness by use of Sodium/Magnesium Sulfate, Test Method ASTM D5240-04 Standard Test Method for Testing Rock Slabs to Evaluate Soundness of Riprap by Use of Sodium Sulfate or Magnesium Sulfate; Specification Requirement: 10% loss, maximum.
- Soundness by Freezing and Thawing, Test Method ASTM D5312-04 Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions; Specification Requirement: 10% loss, maximum.

The gradations of the proposed imported substrate sizes were developed to address stability and resistance to shear stress, user safety, and aquatic habitat including biological health. Regarding stability, coarser substrate has been proposed in areas of higher calculated shear stresses. The d_{50} grain size of each gradation was set to be twice as large as the threshold mobile grain size associated with the maximum bed shear of the proposed hydraulics. The threshold mobile grain size was set to be the d_{30} size class. The imported substrate is proposed to be clean, rounded, and well graded in order to provide maximum benefit to aquatic habitat and closely emulate natural material. Well-graded gradations provide increased diversity in macroinvertebrate habitat within the substrate and provides improved mussel habitat. A larger percentage of finer material also increases the benefits to user interfacing through wading or contact with the bottom of a watercraft. Table 6 presents the preferred gradations for the coarse and fine alluvium size classes. These gradations are proposed in areas of relatively lower hydraulic shear stresses, where stability is less of a concern and improved aquatic habitat, biological health, and user interface can be emphasized.

Table 6: Fine and Coarse Alluvium Gradation (inches)

Weight	Indicator	Coarse	Fine
100%	Passing	30”	8”
60%-85%	Passing	20”	6”
35%-65%	Passing	12”	3”
25%-55%	Passing	8”	1.5”
15%-35%	Passing	4”	3/4”
0%-5%	Passing	1.5”	1/2”
	D_{85}	18”	6”
	D_{50}	12”	3”
	D_{30}	4”	3/4”



Figure 15: Coarse Alluvium Gradation Example

5.2.2.2 Constructed Riffle Footprint

The footprint areas of the constructed riffles were reduced from the prior project moving catch lines with existing grade as close as possible to the removal limits of the low-head dams. The final footprint areas were determined by the crest elevation and the slope off the crest to catch existing grade. The crest elevation determination is discussed in Section 5.2.1.1 The target slope of the riffle was between 1% and 2%, based on initial modeling results and consultation with state and federal agencies. These values were confirmed by comparing reference reaches and Newberry Riffle design guidelines. In addition to the basic geometry factors, site-specific constraints also affected the footprint area of the riffle features. These constraints included existing wetlands identified during the wetland delineation [TOC No. 17] and likely endangered mussel habitat areas identified during the mussel survey. Areas of proposed grading also considered existing infrastructure, including bridge piers, floodwalls, and pedestrian pathways and access.

5.2.2.3 Constructed Riffle Substrate Thickness

The proposed substrate thickness of the constructed riffles was determined by considering shear stresses to calculate needed substrate sizes. Once the gradation was calculated based on the expected shear stress and a factor of safety, the minimum thickness of the imported alluvium for the riffle structures was set to twice the d_{50} grain size of the proposed substrate gradation. This allows the alluvium to create a matrix and adds stability to the overall structure. In areas where the difference between existing grade and proposed grade is less than that the minimum thickness, the existing bed will be over excavated and backfilled with the proposed gradation.

5.2.3 CORE STRUCTURES

One function of the low-head dams is to provide grade control throughout the reach and protect against potential head-cutting. The existing configuration focuses the energy loss at each of the four dams, slowing down velocities over substrates upstream of each dam. The impacts to the

scour potential of existing substrates associated with removing the low-head dams was evaluated through the dam removal only alternative. Based on this evaluation, it was determined that maintaining stable grade control within the reach is important to avoid increased scour potential, bed mobility, and to protect critical infrastructure such as piers and floodwalls. Therefore, stable core structures were included within each proposed hydraulic feature. These structures are designed to be keyed into the existing bed, extending down to calculated scour depths. Coarse alluvium with emergent habitat boulders would be placed around these structures to establish the finished grade of the riffles. Options for core structure materials, footprint area, and dimensions and elevation were analyzed, and are discussed below.

5.2.3.1 Core Structure Materials

The core structures consist of large material sizes, including boulder and riprap, and extend from scour depths up to the crest elevations of each hydraulic feature, as shown in the construction drawings [TOC No. 3 Construction Plan Sheets]. Boulder is used as the stabilizing core structure for the west half of the Dam 2 grade control structure; riprap is used at all other locations. The core structures would establish finished grade at the crests of the riffle features. The majority of finished grade of the riffle structures consists of coarse alluvium fill and emergent habitat boulders that have been sized to remain locally stable.

Materials considered for the core structures within the riffles represent varying factors of safety for substrate stability, aquatic habitat suitability, modeled flood risk, and user interface (i.e. wading and boating). Riprap, boulder, alluvium, and concrete were all considered as material options for the core structures.

Concrete would be the most stable and carry the least potential for future maintenance; however, biological health and natural aesthetics ruled it out from selection as the preferred material type. Boulder is larger than riprap and offers a high factor of safety for stability but also results in higher modeled flood elevations due to modeling parameters associated with the larger material. An alluvium core would provide the most suitable habitat for mussels and other aquatic species, as well as the most convenient interface for users, but would have the lowest factor of safety for substrate stability over the lifetime of the project due to the smaller size of the material and would not be prudent. Riprap represents a core material option with a higher factor of safety against substrate mobility than alluvium and has a lower modeled flood risk than boulder. Because it is stable and has less flood conveyance impacts, riprap was selected as the material for the core structure within the riffle features.

5.2.3.2 Core Structure Footprint

The footprint areas of the core structures were determined based on the proposed grading of the constructed riffles. Once a crest elevation was established, the height of the core structure, including key-in depth, was determined. This calculated height and a minimum side slope of 2:1 for riprap and 1:2 for stacker boulder dictated the footprint area.

5.2.3.3 Core Structure Dimensions and Elevations

The dimensions and elevations of the core structures were determined by considering the elevation of finished grade, calculated scour depths, and substrate sizes. Core structures extend from finished grade down to scour depths and have minimum thickness at least as large as the minimum material size. The slopes of the boulder parts of grade controls structures were set based on hydraulic considerations primarily for fish passage but also for enhanced recreational opportunities. The slopes of the riprap portions of the grade control structures were set based on the angle of repose of the material used; these sections of the grade control structures will be covered with imported alluvium to grade the body of the riffle features.

5.2.4 BOULDER ARCH STRUCTURES

Three boulder arch structures are proposed to function in series at the Dam 2 location with constructed riffles on either side of them. The boulder arch structures provide aquatic habitat diversity and improve natural aesthetic to the reach that emulates a natural rapid.

Boulder arch structures would have a diversified planform that emulates elements of rock arch designs (Aadland 2010) and Natural Channel Design W-weir structures (NRCS, 2007); each boulder arch structure would also have a downstream scour hole. Similar to W-weir structures, the boulder arches would be lower at the "bends" of the W and extend up in elevation between "bends" as a way to route flow paths and diversify flow. Additionally, drawing from Aadland (2010) rock arch designs, the boulder arches would "oscillate" opposite of the arches upstream or downstream, further increasing flow diversity, maximum pool depth and area, and enhancing fish passage, resting areas, and aquatic habitat. Lastly, the crest boulders of the arch structures would contain intermittent boulders that are raised up to 12" to add one more layer of flow diversity and benefit to fish passage. Raised crest boulder would have a minimum spacing of 2 feet with a minimum spacing of 12 feet through the lowered portions of the arch structures where the majority of downstream navigation will be routed.

Habitat boulders are proposed to be placed within the pools between boulder arches to enhance aquatic habitat diversity and fish passage. These boulders are located outside of the main flow paths through the structures and would remain submerged.

Refer to Figure 16 for a schematic of the boulder arch structures at the Dam 2 location.

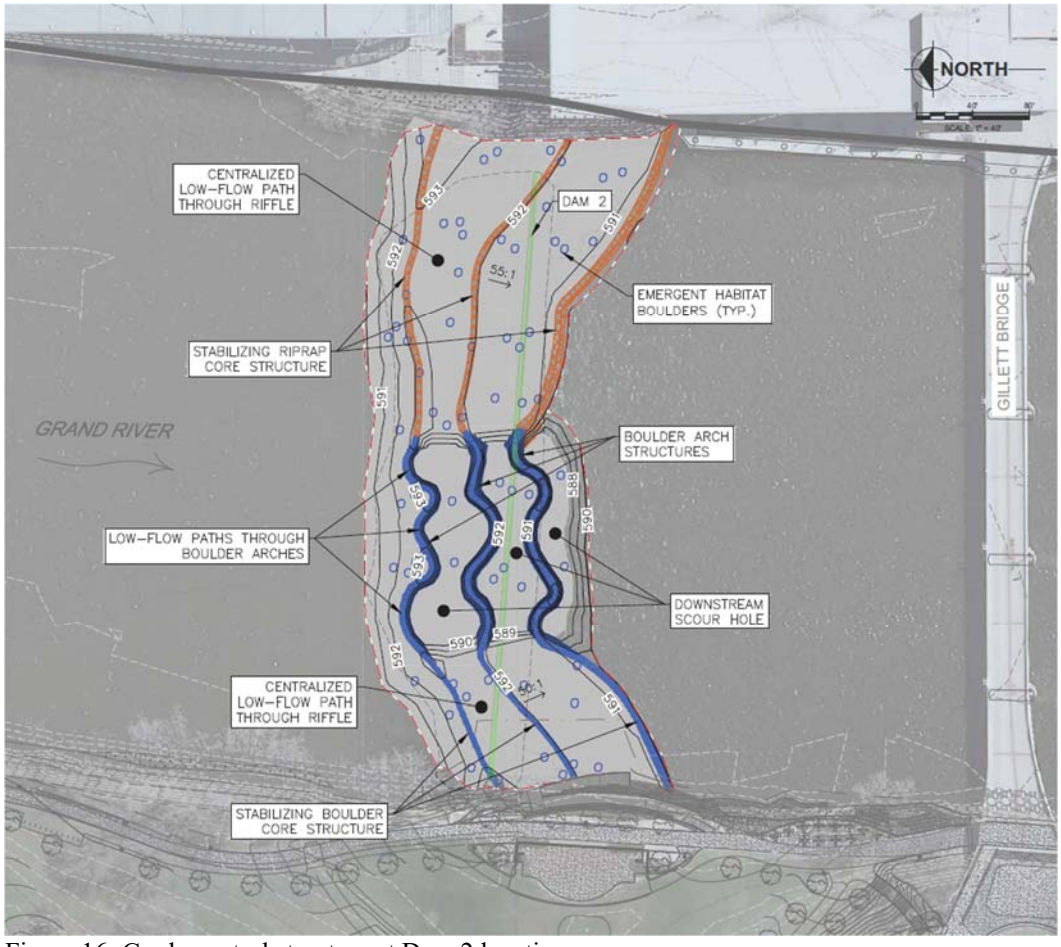

Figure 16: Grade control structure at Dam 2 location

Boulder Vane Structures

Bank vane structures would be installed at locations of existing or future public access points and would function to provide slow-moving water and hydraulic diversity at these locations. These are shown in Figure 17; two vane structures would be installed just upstream of future access points on either side of the Public Museum carousel with fine alluvium landings provided adjacent to future concrete landings at the shoreline. A vane structure would also be installed on the east side of the river where pathway improvements will be constructed as part of a separate project.

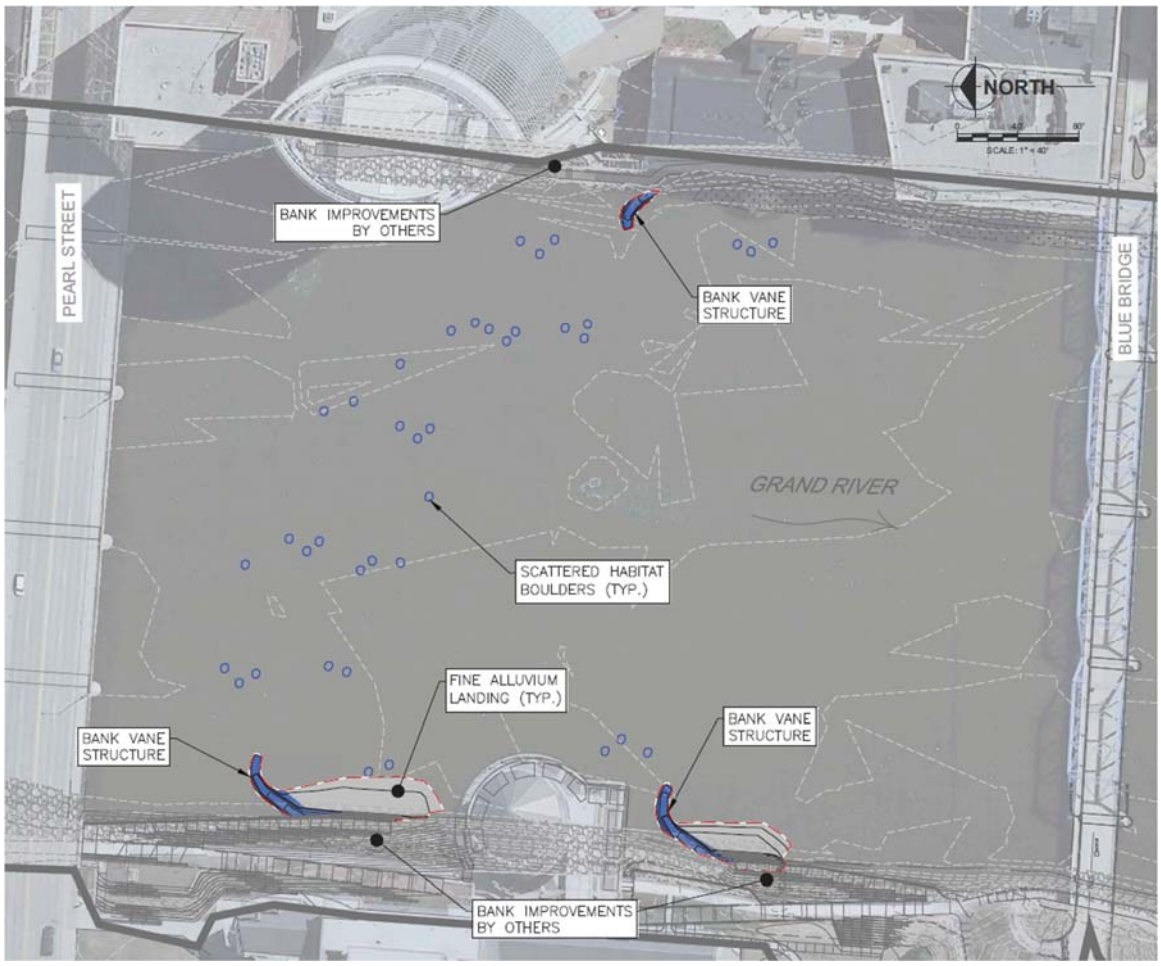

Figure 17: Bank vane structures and emergent habitat boulders

An augmented bank vane structure is proposed to be constructed between Blue Bridge and Fulton Street, adjacent to emergent habitat boulders. Refer to Figure 18. This vane structure would be extended and augmented to emulate W-weir design guidelines for habitat and natural aesthetic improvements. Scour holes would be created downstream of the structure.

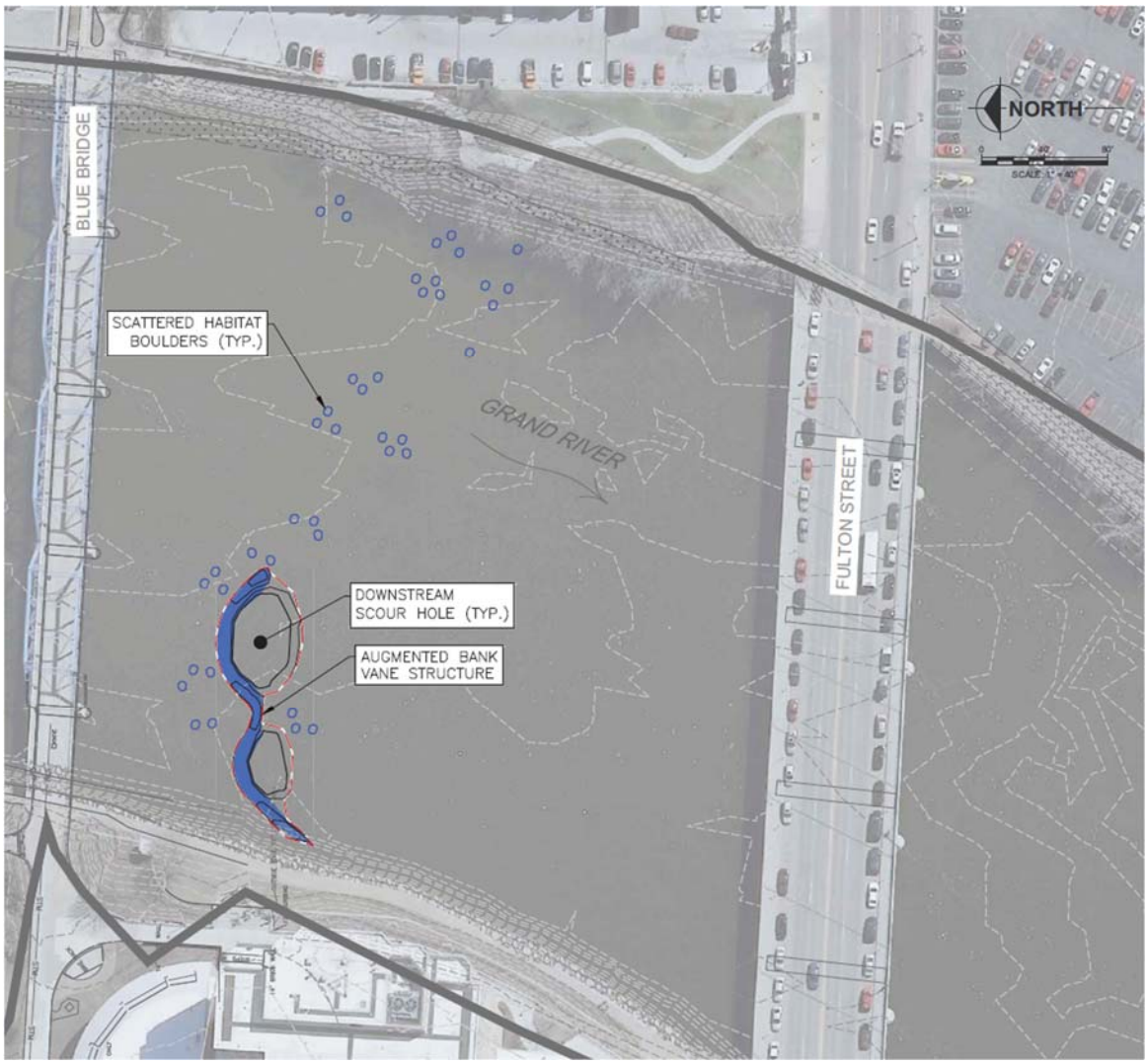

Figure 18: Augmented bank vane structure and emergent habitat boulders

5.2.5 EMERGENT HABITAT BOULDERS

Emergent habitat boulders are proposed to be placed in areas of existing riverbed to improve aquatic habitat and natural aesthetics. Depending on size and armoring of existing substrate, as determined in the field by the contractor and in coordination with the owners representative, up to half of these boulders, and at least one per cluster, would also have footer boulders installed beneath them. Refer to Figure 17 and Figure 18 for the placement of the emergent habitat boulders.

The number and configuration of the emergent habitat boulders was designed through iterative coordination with the regulatory agencies. The emergent habitat boulders would be in clusters of 1-4 boulders with each boulder separated by 4 feet minimum and each cluster separated by 12 feet minimum.

5.3 SUMMARY OF REDUCED IMPACT AREA

Through the re-design process for the project, a major focus was to avoid and minimize impacts to the existing streambed. This was one of the primary concerns expressed by EGLE through that process and was prioritized over secondary hydraulic impacts to aquatic resources. Therefore, all

revisions to the project were evaluated and designed to avoid and minimize the area of direct impact to the existing streambed, while also satisfying the framework objectives of the project. The reduction in direct impact area to the existing streambed achieved through this redesign process is presented Table 7. The expanded grading around dam removals (Alternative 2b from the previous application), which was requested by EGLE through correction requests for the previous project, has been incorporated into the current project. The total increase in impacts associated with this change was 1.7 acres and 2,400 CY of dredge. These expanded impact areas were not included in the previous project. Assuming that this area would have been added on the to previous project as well, the total reduction in direct impacts to the existing streambed for the revised project is 5.6 acres.

Table 7: Impact area comparison

Design Alternative (Alt)	Unavoidable Wetland Impact (ACRES)	Earthwork Below OHWM (CY)		Direct Permanent Impact to Existing Streambed (ACRES)	Earthwork within Floodplain[3] (CY)	
		DREDGE	FILL		DREDGE	FILL
Alt 1	0	0[1]	0[1]	0[1]	0[1]	0[1]
Alt 2b	0	4,100	3,020	4.3	1,230[4]	750[4]
Previous Project	0.01	12,880	20,020	12.7[2]	1,230[4]	750[4]
Current Project	**0.01**	**14,245**	**15,753**	**7.1**	**1,448[4]**	**724[4]**

(1) Zero earthwork for Alt 1 assumes the existing low-head dams will not need to be repaired or replaced in the next 50 years.
(2) Area includes expanded dam removal grading requested by EGLE.
(3) Volumes include associated proposed Ah-Nab-Awen Park improvements. No floodplain impacts would result from in-river improvements.
(4)Floodplain is defined here as the area above and outside of OHW, but within the 100-year flood extents.

Please refer to TOC No. 23 Cumulative Impacts for additional discussions on impacts to aquatic resources related to the Project, labeled "Lower Reach Project" in TOC No. 23.

5.4 AH-NAB-AWEN PARK IMPROVEMENTS

Proposed improvements included in this permit submittal include river access points in Ah-Nab-Awen Park from the river trail above the OHWM to the river edge below, including the construction of step access and installation of a concrete path for accessibility and equity in use and enjoyment of the river. Different locations for the improved access points were considered. Due to the existing steep wooded slopes and the location of the wetlands along much of the river frontage features in Ah-Nab-Awen Park, there are limited areas where access points could be provided with minimal impact while also allowing safe egress to and from the river. Near the concrete stage at Ah-Nab-Awen Park, there is a gradual slope into the river, without wetlands, making it a natural access point.

The first proposed access point (P11 on Design Impact Sheets [TOC No. 4]) is located at the existing concrete access ramp, which will avoid disturbing the trees and wetlands. There are no other locations in the park that will connect to the existing trail, have safe access, and avoid wetlands impacts. A second access point is also proposed to the south (P12 on the Design Impact Sheets). This additional access is necessary, as the river frontage in the proposed access ramp to the north will not be sufficient to allow additional access opportunities to the revitalized river. Therefore, the southern access point is proposed to allow for additional safe access to the river.

Multiple configurations for both access points were considered. The purpose of the access points is to allow the public to move to and from the river. The access points can only achieve this purpose below the OHWM. A landward shift away from the river would not provide safe access to the river users, as it would leave the users below the OHWM and below the wetland, but not in the flowing channel of the river.

While different options were considered, the improved access points have been designed to enhance safe, equitable access to the river by the public without causing adverse impacts to regulated resources.

5.5 BIOLOGICAL CRITERIA

The Grand River is home to a large range of aquatic species, including the endangered snuffbox mussel (*epioblasma triquerta*). Many resident fish species also inhabit the project reach, while other fish species utilize it for upstream spawning migration.

The design of the Project seeks to enhance aquatic habitat and improve the natural aesthetic of the project reach; this includes expanding the range of flow depths, magnitude and direction of flow velocity, and variability in substrate size and type. Clean, rounded, and well graded substrate is proposed, in part to provide maximum benefit to the habitat of fish, mussels, and other aquatic species. Modeling results and habitat suitability analyses indicate that the resulting river system would increase hydraulic diversity, likely improve mussel habitat, maintain or improve aquatic habitat for the large range of resident fish species, and maintain or improve the connectivity of the reach for upstream passage of resident and migratory fishes.

In addition to the habitat improvements listed above, using coarse well-graded alluvium in the construction of proposed riffle features will promote increased biological health and macroinvertebrate habitat by providing interstitial space with increased dissolved oxygen levels within the riffle features. This, combined with the hydraulics of the riffles spreading out swift velocities and avoiding sedimentation, are key to establishing a healthy macroinvertebrate habitat (DEQ, 2008).

5.6 ICE FORMATION

River-ice processes are significantly complex, not well understood, and are a function of multiple parameters contributing to ice formation, breakup, and jamming. These include local channel topography, the temperature of the streamflow, the temperature of the air, and three-dimensional river hydraulics distributions (notably mean-flow and turbulent-energy dissipation). Lai and Shen (1991) group ice formation into frazil, skim, and border ice subcategories. Kempema and Ettema (2010) elaborate on an additional subcategory of anchor ice. Each category of ice is dependent upon instream channel conditions which will vary between existing and proposed conditions. Skim ice forms at the surface of the flow and includes frazil slush pans, ice rubble, and any local surface ice. Border ice forms at the interface of structures or bedforms and the waterline, and anchor ice forms at the channel substrate. Skim ice and border ice may accumulate in certain areas to create ice bridges and channel-spanning freeze-up.

The proposed alterations are not anticipated to change the existing ice supply in sufficient quantity to affect the ice-jam mechanisms at Fulton Street Bridge, which result from breakup of the ice sheet upstream of 6th Street Dam. Any additional volume of ice generated from project actions will be negligible when compared to the continuous ice-sheet supply upstream of the project area. No areas within the downstream altered reach are anticipated to generate local ice jams at an influential scale.

5.6.0 ICE BREAK UP

The break-up of ice is a process which generates incoming floes to downstream river reaches which is critical for ice-jamming and flood concerns (Beltaos, 1997). Break-up can occur at any time when external forces exceed the critical internal strength of the ice formation. For the existing project reach, break-up of the ice sheet upstream of 6th Street Dam occurs during warming cycles, snow melt, and precipitation events. Break-up events float the upstream ice sheet over 6th Street Dam which exceeds the downstream ice transport capacity and initiates ice jams. Project actions do not influence this process or the formation of jams at Fulton Street Bridge.

5.6.1 ANCHOR ICE

Anchor ice is formed where supercooled frazil ice is driven by the current to the channel bottom and affixes to bed materials. Kempema and Ettema (2010) identified that anchor ice formation is directly related to turbulence, flow speed, ambient air temperature, and substrate characteristics. Anchor ice will not form when there is a solid ice sheet over the flow surface. Specific details regarding anchor ice formation in the Grand River under existing conditions are unknown.

The imported alluvium used to construct the riffles, as well as the boulder and riprap grade control structures have been sized to remain stable under ice formation processes in the Grand River. Sizing of these materials considered anchor ice formation and stability. Anchor ice is assumed to form in a contiguous sheet at the channel bottom; all particles at the surface maintain contact with the ice and resist buoyant rafting forces. Table 6 provides the gradations for imported alluvium. The specified d_{50} sediment size for the fine alluvium size class is 3 inches (0.25 ft). It follows to assume a one square-foot area of substrate of 0.25 ft thickness with a specific gravity of 2.65 and corresponding submerged weight of 25.7 lb/ft^3. Ice has a typical specific gravity of 0.93 with a corresponding submerged buoyant force of 4.1 lb/ft^3. Therefore, it would require approximately 6.3 ft of anchor ice thickness to mobilize the substrate (equivalency) or up to 10.0 ft of thickness to actively transport imported materials (factor of 1.5 equivalency). The calculated necessary ice thickness to mobilize and actively transport materials exceeds the typical water depths during winter months in the project reach. Therefore, anchor ice is not expected to mobilize the imported substrate.

5.6.2 BORDER ICE

Border-ice formation is a function of the exposed distance of the waterline on structures where frazil ice may accumulate. Border ice is commonly noted at bridge piers, abutment walls, and channel edges under existing conditions and contributes to the bridging freeze-up upstream of the 6th Street Dam. Empirical relationships have been proposed by Michel et al. (1982) for the formation of border ice, with stability limited by the cumulative drag force acting on the formation. Specific border-ice formations and critical hydraulics for stability are dependent upon the geometry of the river channel, seasonal variability in temperatures, and the seasonal hydrograph.

At low flows, partially exposed substrates may have benthic regions freeze up and form border ice. As flows increase, these regions will be subjective to buoyant forces which may raft substrate. Areas where the benthic sublayer may freeze up at lower flows were sized to resist mobility from border ice related rafting; however, ice thickness required to transport the proposed substrate materials is similar to the anchor ice rafting analysis described above, meaning the required thickness of ice to float and transport substrate is thicker than the expected water depths and therefore transport is unlikely to occur.

5.7 MAINTENANCE

The completed Project will be monitored per the Project's monitoring plan. Refer to TOC No. 16 Monitoring Plan. Many of the same hydrogeomorphic processes that currently require monitoring in the project reach, such as deposition of debris, sediment accumulation, and ice buildup would continue under post-project conditions. Additional areas of focus will include the project's continued ability to provide fish passage and recreational hydraulics.

The proposed grade control structures, riffles, boulder arch structures, boulder vanes, and emergent habitat boulders have been designed to remain stable under anticipated ice formation as discussed in Section 5.6. The proposed project improvements have also been designed and substrates sized to remain stable with anticipated deposition of large woody debris on the structures. Debris removal will still occur similarly to existing conditions where high flood levels carry away large debris. In the case where debris is determined to pose an immediate public safety or flood risk, the City of Grand Rapids will do so according to best management practices and seek permits as needed.

Additional information is provided in TOC No. 11 Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRRR) Report.

-- END OF SECTION 5 --

6.0 CONSTRUCTION METHODOLOGY AND ALTERNATIVES

The construction methodology, including staging, access, care of water, work isolation, and sequencing was determined through coordination with the City's construction management advisor, during which alternative means and methods were considered. Through this process, temporary impacts to the streambed, especially outside the limits of permanent impacts were avoided and minimized to the greatest extent possible.

Refer to TOC No. 9 Recommended Construction Sequencing and Methods for more detail. Also see TOC No. 10 Temporary Conditions Hydraulics Report for a more detailed description of the hydraulic analysis performed for the various stages of construction.

6.1 CONSTRUCTION STAGING

Construction staging and access is extremely limited due to the heavily developed and urban location. In many locations, particularly on the east bank, buildings and structures come right up to the edge of the floodwall. During the planning of the project, several construction staging and access locations were considered and evaluated for impacts and construction feasibility. These locations included Ah-Nab-Awen Park, 555 Monroe Ave. NW, Lacks Park, East River Edge at Fulton St., Scribner Ave. NW, and Gillett Bridge. In the end, it was determined access to the river would be most feasible and prudent from a staging area in Ah-Nab-Awen Park. Ah-Nab-Awen Park is located along the north end of the project reach. It has a large open space and connects to a major street in Grand Rapids. Additional staging and temporary stockpiling will also be made available at 555 Monroe Ave. NW; however, this site would not include construction access into the river channel. Construction staging has been identified above the OHWM. Staging will not be placed in wetlands.

6.1.0 AH-NAB-AWEN PARK

The alternatives evaluation for construction staging established Ah-Nab-Awen Park as the Project's primary construction staging and sole construction access point. The park is well-located, adjacent to most of the proposed in-channel improvements and is large enough to accommodate construction equipment and temporary material stockpiling in the opinion of the CMA. The park is City-owned and its use minimizes impacts to pedestrian use of pathways and other potential staging locations.

With Ah-Nab-Awen's open space and its gradual slope to the river, it makes this a natural entrance for the project into the river, allowing the least amount of streambed impacts due to construction access. Since a large area of the park would be disturbed during construction staging, the project also provided an opportunity for the planned improvements to Ah-Nab-Awen Park to be implemented according to the City of Grand Rapids Park's master plan. These improvements are summarized in section 5.4.

6.1.1 555 MONROE AVE. NW

The 555 Monroe Ave. NW site will be used for temporary construction staging but will not provide access to the river or impact water resources. Temporary access from 555 Monroe Ave. NW was initially considered due to it being on the east side of the river but the additional impacts to the stream bottom to provide access to the project location were not justified.

6.1.2 LACKS PARK AND GRAND RAPIDS PUBLIC MUSEUM

Access from Lack's Park, located on private property at the west end of the Blue Bridge, was originally considered due to its location at the downstream end of the project. Through the design progression process, significant concerns were voiced by the private property owner about

temporary and permanent impacts to the park. In addition, a sinkhole formed in the park in 2017, likely because of the former gypsum mines located beneath this area. As a result of objections from the property owner and public safety concerns regarding the mine, this temporary access point was removed from consideration.

6.1.3 EAST RIVER EDGE AT FULTON STREET

Access from the east edge of the river between Fulton Street and the Blue Bridge was also considered but eliminated as a potential access point due to the steep, high banks resulting in feasibility concerns with installing a functional ramp. There is also a large amount of existing mature vegetation and wetland impacts that would be realized accessing the river from this location so it was removed from consideration.

6.1.4 SCRIBNER AVE NW

Staging and access from Scribner Ave NW was considered early in the project as it was the site MDOT used during construction of the I-196 bridge expansion across the Grand River. However, due to the distance from the project location, this access point was deemed too impactful, and the benefits would not be justified. Therefore, this alternative staging and access site was eliminated.

6.1.5 GILLETT BRIDGE

Early consideration was also given to the use of Gillett Bridge for construction purposes. These purposes included potential use of hauling material in and out of Ah-Nab-Awen Park, stockpiling material on the bridge, and using a crane and barges to stage material along the river edge. The structural integrity of Gillett Bridge and its' capacity to withstand significant and repeat heavy load from construction traffic or crane was a concern to the project team.

Use of the Gillett Bridge as a construction access and staging site would temporarily close the river edge trail to the north and prevent pedestrians crossing the river at this location. Lastly, the use of this location as a staging and access point would also shut off one of the two vehicular access points into the DeVos Place parking garage.

Due to the impacts to river trail use, convention center parking, potential public safety issues because of construction equipment on the bridge, and the determination that barge work would not be feasible, the use of Gillett Bridge was eliminated from further consideration as an access/staging location.

6.1.6 SUMMARY OF CONSTRUCTION STAGING ALTERNATIVES

The alternatives analysis for construction staging resulting in two staging areas being recommended for use during construction. The primary staging area and the location of construction access will be from Ah-Nab-Awen Park and additional staging and temporary stockpiling will be made available from the 555 Monroe Ave. NW site. All other potential staging and access areas were eliminated from consideration due to additional impacts to the stream bottom, additional public safety concerns, or lack of property owner objections.

6.2 CONSTRUCTION ACCESS AND ISOLATION

Access ramps and causeways will provide routes to construction areas from the Ah-Nab-Awen Park staging area. These temporary structures have been configured to result in minimal temporary impacts to the streambed and wetlands. These impacts are shown in detail in the Design Impact Sheets [TOC No. 4]. Alternative means and methods are discussed below, along with impacts associated with construction access are described below. In all cases, equipment and

material will access the in-channel work areas through the designated staging areas via designated ramps and causeways down to the channel bed.

See the temporary care of water and staging area sheets (T sheets) in the construction plan set [TOC No. 3] for the proposed staging and access temporary work structures.

6.2.1 TEMPORARY CONSTRUCTION CAUSEWAYS AND ACCESS RAMPS

Through coordination with the construction management advisor and the regulatory agencies, several alternative means and methods for construction access were considered and evaluated. Barge access, as well as floating causeways, were considered as a way to avoid and minimize impacts to the streambed; however, this option was ruled out due to insufficient depths and velocities during the construction season. Ultimately, temporary aggregate causeways were determined as the most feasible and prudent alternative. The dimensions, including height, top width and side slopes of the causeways were minimized to what was determined necessary for construction by the construction management advisor.

Because construction staging is limited to Ah-Nab-Awen Park, it was determined the only way to safely access equipment into the work areas south of Pearl Street was to build a causeway from Ah-Nab-Awen Park.

A temporary construction causeway will also extend from the Ah-Nab-Awen Park staging area upstream to low-head dams 3 and 4. A causeway would then extend across the river downstream of each dam to provide a working pad for the demolition of the dams in the flowing channel.

Another causeway would extend from the Ah-Nab-Awen staging area down the west bank to the work areas downstream of Pearl Street and Blue Bridge. From this causeway, additional causeways would extend along Dam 1 and within the footprint of the constructed riffle at that location.

The western half of the proposed improvements at the Dam 2 location, including removal of the dam and construction of substrate enhancements, would be performed under isolated conditions. The western portion of the proposed improvements at the Dam 2 location would be accessed by causeways extending around the isolation system. Refer to the T sheets in the construction plan set [TOC No. 3] For the layout of these temporary structures.

Based on discussions with the construction management advisor, causeway and access ramp widths were determined to be 25 feet minimum with assumed 2:1 side slope and minimized to only what would be required for construction access using the existing riverbank as support where possible.

Causeways and access ramps will be composed of crushed, clean aggregate. Coarser aggregate will be used along the side slopes for erosion prevention and finer aggregate will be used for the driving surfaces.

Timber mats were considered as an alternative causeway material, but they were determined to be infeasible for use in the river due to the flow velocity and depths that would be present during construction. Stacking timber mats to necessary elevations to allow construction equipment to drive on, combined with the buoyancy of the mats resulted in this alternative being eliminated from consideration due to stability and safety concerns. However, timber mats will be used at any location where temporary impacts to wetlands cannot be avoided. The timber mats would serve as a protective layer between the aggregate causeway and the wetland.

6.2.2 WORK AREA ISOLATION

As part of the redesigned project, less of the proposed improvements were determined to require work isolation. Based on coordination with the construction management advisor, the placement of the boulder arch structures on the western half of the grade control structure at Dam 2 is the only work that was determined to require work isolation. It was the opinion of the construction management advisor and design engineer that to verify footer elevations, achieve intimate contact between boulders, and fill void spaces between boulder, to achieve the desired intent of the structure, work isolation was required for the construction of the boulder arch structures. The cofferdam structure for this isolation was chosen to be aggregate bags filled with imported sediments. Other options considered include sheet piling and aggregate cofferdams. Sheet piling was determined infeasible due to the coarse, armored nature of the streambed. Aggregate cofferdams weren't preferred due to increased impact footprint and time of installation/removal compared to the aggregate bags.

To minimize temporary impact area, the cofferdam would extend up approximately six feet and would consist of stacked three-foot aggregate bags. Due to the decreased height of the work isolation system, the work area would be inundated by the river during flow rates above approximately 3,900 cfs, which means that isolated work must occur during low flow periods, likely during July and August. The contractor would remove personnel, equipment, and loose materials prior to flooding the isolated area before the cofferdams are overtopped. Refer to the T sheets in the construction plan set [TOC No. 3] for the layout of work isolation system.

6.2.3 WORK IN WET CONSTRUCTION ACTIVITIES

All other construction, other than that described in section 6.2.2 would be performed in the wet, flowing river without work isolation. The temporary causeways would also serve as working pads to provide stable platforms with reduced flow depths. Tracking directly on the riverbed as well as long-reach excavators would be used to reach all areas of proposed improvements. These means and methods were chosen as a way to minimize temporary impact areas to the streambed as well as secondary hydraulic impacts, including potential impact to flooding or scour potential, during construction.

6.3 CONSTRUCTION SEQUENCING

Please refer to TOC No. 9 Recommended Construction Sequencing for a complete discussion of the construction sequencing for the project. This report also contains an explanation of the means and methods of dam removal during construction.

-- END OF SECTION 6 --

7.0 BASIS OF DESIGN REPORT CONCLUSION

After a decade of planning, research, and analysis, followed by a year-long re-design effort that included extensive coordination between EGLE and MDNR, the City and GRWW, and other regulatory agencies, Design Concept 4 was selected as the Preferred Project Alternative (Project) that is the subject of the City's permit application. This Basis of Design report is intended to provide EGLE with background information regarding the Project and the many steps it has taken to get here.

The City and its project partners have raised funding for this Project and acquired property rights to construct the Project. NRCS is nearing a final draft WPP-EA for the construction of this Project. And the USFWS began Formal Consultation on April 23, 2024 for the Biological Assessment submitted on March 29, 2024. A Biological Opinion concluding that the Project and its associated mussel salvage and relocation activities is not likely to jeopardize the continued existence of Snuffbox mussels is expected later in the summer of 2024.

The City and its project partners appreciate EGLE's continued collaboration over the many years that the Project was developed, and is excited to seek approval to construct a project that will have positive impacts on the public trust, riparian rights, and the environment. The City looks forwarding to securing permits under Parts 301, 303, and 31 of NREPA to bring the vision of a revitalized Grand River that everyone can enjoy to reality.

-- END OF SECTION 8 --

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APPENDIX E

Other Supporting Information

Hydraulics Report

May 2024

Hydraulics Report
GRAND RIVER REVITALIZATION LOWER REACH PROJECT
GRAND RAPIDS, MICHIGAN

Hydraulics Report for the Grand River Revitalization Project

Prepared for:
City of Grand Rapids

Prepared by:
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May 2024







This document entitled – Hydraulics Report: Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org, LLC for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.

Approved by
Scott Prins, P.E.

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Section 1 – Introduction and Project Description

This report is intended for the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and follows their Hydraulic Report Guidelines (EGLE, 2019). Section 1 describes the project and the location, Section 2 describes methods of analysis, and Section 3 summarizes the results.

This report, prepared for the City of Grand Rapids, details the harmful interference evaluation of proposed actions of the Grand River Lower Reach Project. Harmful interference is defined by EGLE (2019) as causing an increase stage or change in the direction of flow that causes, or is likely to cause: damage to property, a threat to life, pollution, impairment, or destruction of water or other natural resources.

This report is for the purpose of evaluating harmful interference under EGLE guidelines. The models developed herein are for relative comparison only.

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Date of report: May 2024
Date of Topographic Data used in this report: 2007-2018

Numerous other technical reports and memorandums related to the hydraulic performance of the proposed Lower Reach Project have been prepared as part of the design. The technical reports listed below are included with the permit submittal or available upon request. Subjects addressed include (with the JPA table of contents (TOC) number in parentheses):

- Recommended Construction Sequencing Means and Methods (TOC No. 9)
- Sediment Transport Report (TOC No. 6)
- Temporary Conditions Hydraulics Report (TOC No. 10)
- Bridge Scour Report (TOC No. 7)
- Hydraulic Influence at 6th Street Dam (TOC No. 8)
- Fish Passage Report (TOC No. 14)

1.1 Project Description

The City of Grand Rapids (City) proposes to make improvements in and along the Grand River within City boundaries to improve aquatic habitat/diversity and enhance access to the river (Project). The Project

includes the demolition of four low-head dams, excavation of areas of the existing channel, and placement of coarse fill materials. The overall extents of the Project are shown in Attachment 1.

In summary, for the Project, the Grand River is proposed to be modified by:

- Demolition of four concrete low head dams
- Installation of constructed riffles and aquatic habitat structures, consisting of approximately 16,000 cubic yards of stable fill material, including boulder, riprap, and alluvium.
- Riparian shoreline improvement
- Installation of shoreline access

1.2 Watercourse and Location

The project is located on the Grand River in downtown Grand Rapids, Michigan. The Grand River Watershed is the second largest in the State of Michigan with an overall drainage area of 5,572 square miles and an elevation change of about 680 feet over about 250 miles of length. The location of the project is the approximately half-mile reach through downtown Grand Rapids, approximately 40 river miles upstream of Lake Michigan. The upstream drainage for the project location is approximately 4,900 square miles. The Grand River through the project reach has been heavily modified, including dredging and channelization (Baxter, 1891). The river is encroached by fill and concrete flood walls on the east bank. On the west bank the bank conditions vary. From Fulton Street to 6th Street Dam the bank is a vegetated and riprapped slope. The bank is formed by a concrete floodwall from 6th Street Dam to approximately 950 feet downstream of the Indian Mill Creek confluence (Fishbeck, 2020). Numerous bridges cross the river, and the majority of the bridges have three to five piers within the channel. Four concrete weirs/dams provide grade control in the river through the project reach. They vary in height from 1.5 feet to 3 feet. See photo documentation of the project reach in Attachment 14.

The Project proposes modifications to the channel bed from approximately 300 feet upstream of Bridge Street to upstream of Fulton Street Bridge. The hydraulic influence of the Project terminates upstream at the 6th Street Dam hydraulic control and downstream immediately above Fulton Street.

The low head dam just upstream of the Bridge Street bridge is the upstream extent of the Project reach and is located at the following WGS 84 Coordinates:

42.970814° N
85.674866° W

1.3 Scope of Investigation

This Hydraulics Report investigates the proposed Project on the Grand River through downtown Grand Rapids, Michigan as described in Sections 1.1 and 1.2. An alternatives analysis was performed as part of the design development process, see the Basis of Design Report included with the Joint Permit Application package for details.

1.4 Scope of Analysis

The scope of analysis for this Hydraulics Report is to evaluate the potential of proposed actions to increase water surface elevations (WSE) and energy grade line (EGL) during the 2-, 5-, 10-, 25-, 50-, 100-year flood frequency events. Proposed Conditions Model results will be compared with Corrected Effective Model WSE and EGL within the river and on the adjacent floodplain to evaluate affected properties. The threshold defined by EGLE is an increase in EGL of 0.005 ft or greater (EGLE, 2019). Exceedance of the threshold requires assessment of harmful interference, defined by EGLE as causing an increase stage or change in the direction of flow that causes, or is likely to cause: damage to property, a threat to life, pollution, impairment, or destruction of water or other natural resources (EGLE, 2019).

1.5 Existing Studies

In 2020, Fishbeck finalized the evaluation of the flood protection system through Grand Rapids on behalf of the City. This report, entitled *Grand River Flood Protection System Freeboard Evaluation Report* (Fishbeck, 2020) has been referenced for the hydraulic evaluation of the project. As part of the Federal Emergency Management Agency (FEMA) Flood Map Modernization project an updated hydraulic model created by Stantec and reviewed by Fishbeck was established as the Effective Model FEMA's National Flood Insurance Program in February 2023. This has been used as the baseline model for this hydraulic evaluation. Refer to Section 2.2.2 for more information on the Effective model.

Section 2 – Method of Analysis

2.1 Numerical Hydraulic Model

Analyses conducted in this study used HEC-RAS v.4.1 software (Brunner, 2016a). HEC-RAS is the preferred hydraulic analysis software of EGLE (EGLE, 2019). FEMA has requested that version 4.1 be used for these analyses because it was the version in which the Effective model was developed. The HEC-RAS models assume steady-state, one-dimensional open channel flow conditions. The basic computational procedure of HEC-RAS for steady flow is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction and contraction / expansion. The momentum equation may be used in situations where the water surface profile is rapidly varied.

2.2 Hydraulic Models

2.2.2 Duplicate Effective Model (DEM)

The Current Effective Model (EM) is dated 12/2017 and became effective on February 23, 2023. This model was initially developed as part of FEMA's Flood Map Modernization Project.

The EM was obtained from FEMA and run using HEC-RAS v4.1 to create the Duplicate Effective Model (DEM). HEC-RAS v4.1 was used because this was the version originally used to create the EM. No changes were made to the flow file, geometry, or plan settings from the EM to create the DEM. The DEM HEC-RAS files are included with this report.

2.2.2 Corrected Effective Model (CEM)

The Corrected Effective Model (CEM) was created by updating the EM within the project reach. All cross sections upstream and downstream of the project reach remain identical between the EM and CEM. To generate the CEM, 11 cross sections have been added at the locations of proposed changes to the river or banks. Additionally, the CEM has incorporated more recent survey data collected for the purposes of designing the proposed enhancements. Lastly, bank elevation and levee data has been revised based on certified as built tables from the Grand River Flood Protection System Freeboard Evaluation Report (Fishbeck, 2020).

The added cross sections within the project limits were created to represent the location of proposed channel improvements at the resolution based on coordination with EGLE. In general, cross sections were added at the crests and catch lines of proposed in-channel structures which have hydraulic influence.

No physical changes or additions made to channel geometry or infrastructure since the approval of the EM were included in the CEM. The design team has not identified any physical changes to the project reach that have been made since the approval of the EM. Therefore an "existing conditions" model is not required. The CEM HEC-RAS files are included with this report.

2.2.3 Proposed Conditions Model

The Proposed Conditions model modified cross sections of the CEM, including bed elevations, blocked obstructions, and Manning's roughness, to represent the proposed project improvements.

All proposed in-stream features were modeled with multiple cross sections, including one at each invert. The Manning's roughness selected is described in Section 2.8.3. Manning's n Roughness values in locations of proposed emergent boulder were weighted to model boulders in surrounded alluvium. The four low-head dams downstream of 6th St Dam were removed from the model. These structures will be either demolished entirely from the river or cut to grade and buried so they no longer have a hydraulic effect on river flow. See the permit plans for more information on the low-head dam demolition.

Attachment 3 shows the cross sections overlain on the proposed grading areas. The HEC-RAS output for this model is included with this submittal. Attachment 10 provides a comparison of the Proposed Conditions HEC-RAS cross sections to the CEM cross sections. Detailed cross sections were created for each of the two proposed grade control structure crests.

The Proposed Condition model ties into the CEM at the upstream and downstream end of the project reach. The proposed conditions HEC-RAS files are included with this report.

2.2.4 Temporary Conditions Models

As part of a separate analysis, one-dimensional hydraulic models were developed to analyze the effects of temporary cofferdam installations on flood events in the project reach. The cofferdam will isolate portions of the river during different construction phases to allow for construction of the proposed in-channel features. Refer to the Temporary Conditions Hydraulics Report for a detailed evaluation of flood impacts during temporary construction conditions.

2.3 Horizontal and Vertical Datum

All elevations presented in this report are in the North American Vertical Datum of 1988 (NAVD-88). The use of NAVD-88 was requested by the City of Grand Rapids for consistency with the City datum.

The project was surveyed on, or projected to, the NAD 83 Michigan State Plane South Zone International Feet horizontal datum and NAVD-88. Surveyed data were GPS derived in the NAVD-88 datum using GEOID 12a with NGS benchmarks. All elevations depicted in the permit documents, including drawings and other technical reports, are in the project datum of NAVD-88.

2.4 Topographic/Hydrographic Data

Topographic and hydrographic survey data collected by RiverRestoration has been combined with data collected by FEMA and Fishbeck to establish a combined digital elevation model of the project reach and surrounding area. This combined data has been referenced to establish the model geometry for the Corrected Effective model updates to the Preliminary Effective model.

The combined existing grade surface and the proposed condition grading surfaces were developed in AutoCAD Civil 3D. Cross sections were aligned to represent the proposed bed forms in the model. Cross sections were cut from generated surfaces and exported to HEC-RAS.

2.5 Hydrology

Hydraulic analyses were performed using steady-state simulations at the 2-, 5-, 10-, 25-, 50-, and 100-year flood frequency flow rates as provided in Table 1. These flow rates were dictated through correspondence with EGLE, which is included as Attachment 2.

Table 1 – EGLE Flood Flow Rates

Recurrence Interval	**Flow (cfs)**
100-yr	50,000
50-yr	44,000
25-yr	38,000
10-yr	31,000
5-yr	26,000
2-yr	18,000
Bankfull	13,000

2.6 Extent of Model and Cross section Spacing

The Effective HEC-RAS model extends from Lake Michigan, through the project reach, and upstream of 6th Street Dam to Plainfield Township. The total length of river modeled is approximately 45 miles. The project reach begins at cross section 2121+03.5 and ends at Cross section 2147+20.8, a distance of 0.5 miles.

Cross section maps of the entire modeled reach and a zoom in of the project reach are included as Attachment 3.

A total of 41 cross sections were used to represent the project area, extending from Fulton St. upstream to 6th Street Dam, for an average cross section spacing of 64 feet, approximately 14% of the average channel width. For each feature, cross sections were placed at the downstream and upstream extent and at the crest. Additionally, cross sections were added in locations of scattered habitat boulder and bank vane structures.

Cross section locations are shown in Attachment 3. The cross sections that have been added to the HEC-RAS models to represent the changes in grading and substrate of the proposed improvements are summarized in the cross section Information Tables found as Attachment 4.

2.7 Boundary Conditions

The downstream extent of the HEC-RAS model is Lake Michigan and is represented in the flow file as a known water surface set to 579.17 feet. This boundary condition is the same for all flow rates and has been left unchanged from the Effective model. Per request from EGLE, all plans have been run under "mixed" flow regime. The upstream boundary condition for all flow rates has been set to critical depth. See Attachment 5 for the Effective water surface profile through the project reach.

Upstream and downstream boundary conditions are consistent across the Effective, Corrected Effective, and Proposed Conditions models.

2.8 Variables, Coefficients and Modeling Strategies

2.8.2 Ineffective Flow Areas and Blocked Obstructions

Overbank ineffective flow and blocked obstructions areas are consistent for the CEM and proposed conditions models and were used to represent the effects of bridge openings, floodwalls, buildings, and other structures. The CEM does not have blocked obstructions or ineffective flow areas in the main channel through the project reach. Blocked obstructions were also not used in the main channel of the proposed conditions model. Instead, proposed changes to bed elevations are represented by updates to channel geometry and emergent boulder have been modeled by implementing weighted manning n values, discussed more in the following section.

2.8.3 Manning Roughness Coefficients

EGLE is responsible under the Floodplain Authority found in Part 31, Water Resources Protection, to identify any potential increases in flood stages resulting from the Project. EGLE requested conservative Manning's *n* values be utilized such that increases to flood stages are conservatively represented by the model.

2.8.3.1 Existing Conditions (i.e., Corrected Effective)

The Manning's *n* values for the Corrected Effective Model remained unchanged from Effective Model and were not varied horizontally across the main channel, as the existing substrate is considered fairly uniform

in the river channel. At river station 212766.3 a Manning's *n* value of 0.07 was used to represent an emergent boulder in the main channel. Manning's *n* values used in the CEM are described in Table 2.

Table 2- Corrected Effective model Manning n values (as reviewed by EGLE)

Area land cover	**Manning n value**
River bottom outside of project area	0.020 – 0.040
Native Alluvium within project area	0.028 – 0.030
River Banks	0.045 – 0.080
Overbanks and floodplain	0.045 – 0.080

2.8.3.2 Proposed Conditions

Manning's *n* values were assigned to each cross section varying with material type in the Proposed Conditions Models based on WRIR 86-4127 (Blodgett, 1986) and were varied horizontally across the main channel delineated by the proposed material type as requested by EGLE. Table 10 from WRIR 86-4127 is included for reference as Attachment 6. WRIR 86-4127 was suggested as a suitable reference by EGLE staff through correspondence (EGLE, 2018).

Four material sizes are proposed to be imported and placed in the river for the project: imported fine alluvium, imported coarse alluvium, mix of MDOT plain and heavy riprap, and boulder. The Sediment Transport Report provides additional detail on how these material sizes were chosen. Manning's *n* values were assigned to each material type based on Table 10 in Blodgett (1986) per guidance from EGLE (2018). To remain conservative for analysis of more frequent flow events, a depth range associated with the 10-year event was used for determining the Manning's *n* values in the Proposed Conditions model. The 10-year event has a maximum depth of 21.5 feet, a minimum depth of 12.9 feet, and an average depth of 16.4 feet. For the 100-year event, modeled flood depths in the Grand River through the project reach are a maximum of 27.5 feet, a minimum of 19.5 feet, and an average of 22.4 feet.

Modeled Manning's *n* values for proposed substrate are summarized in Table 3 along with corresponding d_{50} particle sizes. Attachment 7 provides specifications of the imported substrate materials.

Table 3 - Proposed Conditions model Manning n values from Blodgett (1986)

Area land cover	**Manning n value**
Boulder (d_{50} = 36-48")	0.070
Mix of MDOT Plain and Heavy Riprap (d_{50} = 12")	0.055
Imported Coarse Alluvium (d_{50} = 12")	0.049
Imported Fine Alluvium (d_{50} = 3")	0.035
Native Alluvium *(same as existing)*	0.028 - 0.030
River Bottom outside of project area *(same as existing)*	0.020 – 0.040
River Banks *(same as existing)*	0.045 – 0.080
Overbanks and floodplain *(same as existing)*	0.045 – 0.080

Emergent boulders are proposed in various locations of the project, as scattered habitat boulder in native riverbed as well as in imported alluvial riffle structures. Based on coordination with EGLE in December of 2023, Manning's n values at these emergent boulder locations were weighted based on total width of boulder, projected onto the cross sections. Emergent Boulder weighted Manning roughness values are summarized in Table 4. Manning's roughness information for each cross section is found in the cross section Information Tables found in Attachment 4. Manning's *n* values for unmodified sections and overbanks were left unchanged from the values used in the CEM and EM.

Table 4: Weighted Manning n values at locations with emergent boulder

Cross section	Total flow width of boulder (ft)	Total flow width of alluvium (ft)	Alluvial material	Weighted value
2122+50	87.5	167.5	Existing bed, n = 0.03	0.0437
2127+06.3	11.2	393.9	Existing bed, n = 0.028	0.0292
2127+66.3	11.5	192.9	Existing bed, n = 0.028	0.0304
2128+77.2	51.1	154.6	Existing bed, n = 0.028	0.0384
2129+80.5	38.8	144.9	Existing bed, n = 0.028	0.0369
2133+00	123.4	308.8	Imported riprap, n = 0.055	0.0593
2143+99.5	150	303.7	Existing bed, n = 0.028	0.0419

2.8.4 Contraction and Expansion Coefficients

Contraction and Expansion (C&E) coefficients are utilized in HEC-RAS to represent minor losses caused by floodplain contractions and expansions through structures such as culverts and bridges. C&E coefficients were set in the Effective Model based on standard engineering practice, using 0.1 and 0.3 for most cross sections and higher coefficients for approach and departure sections of bridges and other large obstructions in the floodplain or river (USACE, 2016). The 100-year floodplain and active flow channel is contained entirely in the floodwalls through the project reach, so there is minimal contraction or expansion through the bridges compared to a classic example of a smaller opening created by bridge approaches spanning a larger floodplain. Expansion and contraction coefficient information for each cross section is found in the cross section Information Tables found in Attachment 4.

2.8.5 Flow Regime

All flow rates for the Duplicate Effective, Corrected Effective, and Proposed Conditions HEC-RAS models were modeled assuming a mixed flow regime with the boundary conditions summarized in Section 2.7. Sub-critical flow is a conservative estimate of flow depths during these flood events which can be greater than 20 feet with Froude Numbers typically between 0.1 and 0.5.

2.8.6 Bridge Modeling Approach

Bridge modeling approaches, variables and other assumptions are unchanged from the Effective model. All Bridges in the project used the same low flow modeling approach, taking the highest energy answer of the energy equation, momentum equation and the Yarnell equation. Pier coefficients ranged from 1.0 to 1.5 for the momentum equation and 0.9 to 1.15 for the Yarnell equation. For high flow scenarios, bridges whose low chord was submerged were modeled as pressure/weir flow. The remaining bridges in the HEC-RAS model were high flow modeled as energy only. Default values were used for the submerged inlet and

outlet coefficients. The bridge modeling approaches were kept the same for all HEC-RAS models used in the project analysis.

Attachment 8 lists the modeling approach and coefficients used for each bridge in the project reach.

2.8.7 Weir Discharge

There are five in-line structures in the EM and CEM HEC-RAS models, the four low head dams in the project reach and the 6th Street Dam. When present in the modeled scenario, all dams are modeled identically in all project models and have remained unchanged from the EM. The four low head dams have been removed from the Proposed Conditions models and replaced with cross sections representing the proposed channel improvements. The proposed in-channel features are in general wide and gently sloping. Modeling these proposed features as in-line structures in HEC-RAS would not be appropriate. Table 5 summarizes the relevant paraments for each in-line structure.

Table 5 – In-line structure modeling parameters

Structure	River Sta	Weir Crest Shape	Width	Weir Coefficient
Low-head Dam #1	2132+16.5	Broad Crested	5	3.2
Low-head Dam #2	2138+54.3	Broad Crested	3.3	3.2
Low-head Dam #3	2143+96.4	Broad Crested	4.2	3.2
Low-head Dam #4	2147+16.2	Broad Crested	7.3	3.2
6th St Dam	2160+28.2	Broad Crested	10	2.6

Section 3 - Modeling Results

3.1 Duplicate Effective Model Comparison to Corrected Effective Model

The 100-year Water Surface Elevation (WSE) of the Duplicate Effective Model was compared to the 100-year WSE with the Corrected Effective model. The addition of 11 cross sections (see Section 2.6) through the project reach results in locations of increased calculated water 100-yr water levels within the project reach and extending up to 6th Street Dam. The maximum increase was calculated to be 0.02 feet downstream 6th Street Dam. Calculated increases in 100-yr water levels upstream of 6th Street Dam are 0.01 feet directly upstream of the dam and gradually decrease to 0.00 feet at the upstream extent of the model. Water surfaces downstream of the project reach are identical between the two models. Figure 1 compares 100-yr water surface profiles for the DEM vs CEM.

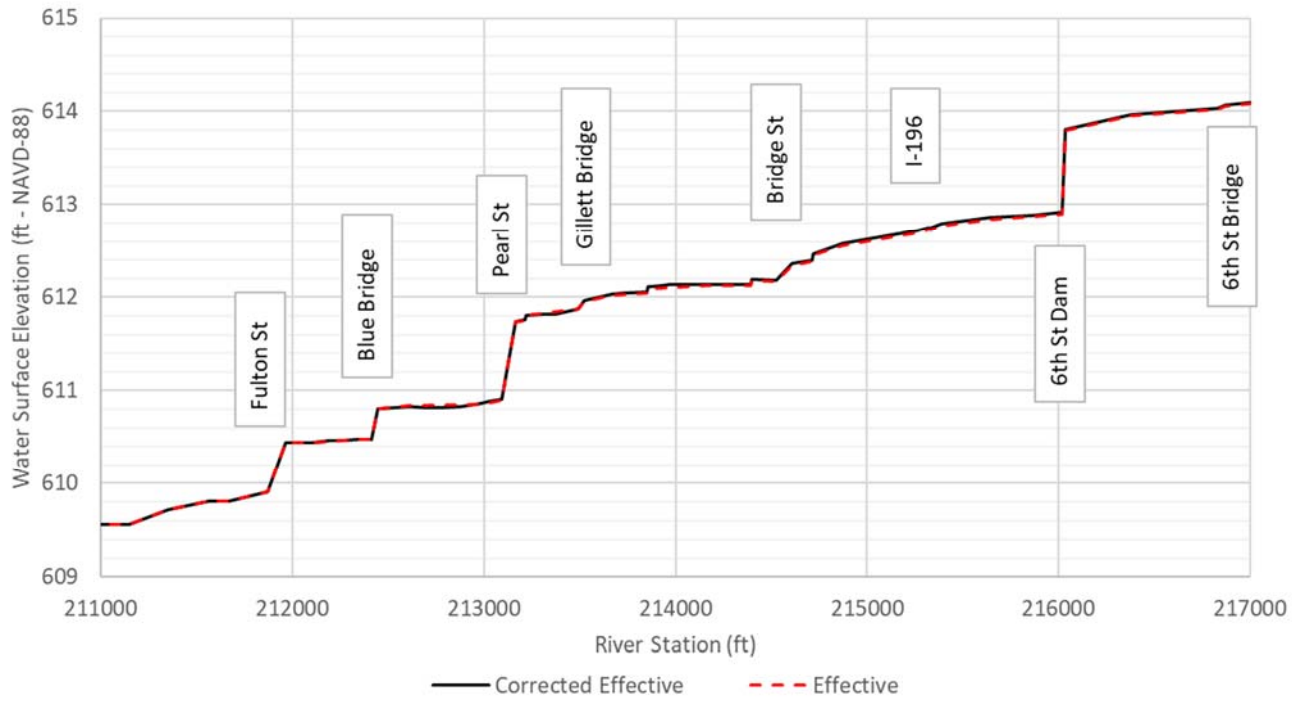

Figure 1 – Duplicate Effective model compared to Corrected Effective model (100-yr Flow Event)

3.2 Corrected Effective vs Proposed Conditions

Tabular modeling results for the WSE and EGL of the Corrected Effective and Proposed Conditions models, as well as comparisons between the two models, are presented in Attachment 11. Profile plots of the WSE and EGL for each flow event are provided in Attachment 12. Planimetric extents of the inundation limits for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-year are provided in Attachment 9.

Table 6 and Figure 2 compares the Corrected Effective model to the Proposed Conditions model for the 100-year flow event. The cross sections included in the table and figure correspond to the channel between Fulton St. Bridge and the 6th Street Bridge, which includes the entire project reach. Small increases in 100-yr water surface elevation were calculated within the project reach. These increases, ranging between 0.01 – 0.05 ft (0.1 - 0.6 inches), all remain within the flood protection system and are being addressed through a CLOMR process with FEMA. The CLOMR will address rises modeled in the CEM (discussed in Section 3.1) and Proposed Conditions. FEMA and EGLE have agreed that the CLOMR and State permit review process will happen concurrently.

The tables in Attachment 11 and the profiles in Attachment 12 also show the modeling results for flows less than the 100-year event. For these smaller flow events, there are water surface increases in the reach between Fulton St Bridge and the 6th Street dam. The largest increases are for the lowest modeled flow events; the 2-year increases are 0.27 ft maximum and 0.07 ft average. As is shown in the Attachment 12 profiles, all increases are contained within the floodwall system and City of Grand Rapids easements and do not cause harmful interference. There are some private property owners adjacent to the flood

protection system between Fulton St Bridge and the I-196 Bridge. Attachment 13 includes a table of each adjacent property and the adjacent calculated increase in water surface for each flow rate.

Although reductions in water levels are calculated at the downstream cross section of 6th Street Dam (RS 2160+20.2), 25-year flood modeling results show rounding adjustments within the model at a few isolated cross sections upstream of the dam result in 0.01' increases being shown in the HEC-RAS results tables when set to round to two decimal places. These small increases seem to be a result of inconsistencies in the HEC-RAS calculations and cannot be explained hydraulically, given the lower tailwater elevations calculated at 6th Street Dam. Three decimal places have been reported in the Attachment 11 tables where these inconsistencies occur. Given that the tailwater elevation is lower during these flow rates and subcritical flow is present, these rounding adjustments are not an actual hydraulic concern.

Table 6 – Comparison of Calculated 100-yr Water Surface Elevation (WSE): Corrected Effective comparison to Proposed Conditions

River STA	*Notes*	Water Surface Elevation (ft)			Energy Grade Line (ft)		
		Corrected Effective (CEM)	Proposed Conditions (PC)	Difference (PC - CEM)	Corrected Effective (CEM)	Proposed Conditions (PC)	Difference (PC - CEM)
216869.4	*Sixth St U/S*	614.07	614.01	-0.06	614.53	614.48	-0.05
216832.0	*Sixth St D/S*	614.03	613.97	-0.06	614.50	614.45	-0.05
216378.8	*XS 25*	613.96	613.90	-0.06	614.38	614.32	-0.06
216034.2	*Dam No. 5 U/S*	613.81	613.75	-0.06	614.25	614.20	-0.05
216020.2	*Dam No. 5 D/S*	612.92	612.73	-0.19	613.32	613.14	-0.18
215862.7	*XS 24*	612.89	612.70	-0.19	613.29	613.11	-0.18
215642.2	*XS 23*	612.86	612.67	-0.19	613.24	613.06	-0.18
215385.6	*I-196 West U/S*	612.79	612.60	-0.19	613.19	613.01	-0.18
215330.5	*I-196 West D/S*	612.75	612.56	-0.19	613.15	612.97	-0.18
215315.2	*I-196 East U/S*	612.75	612.56	-0.19	613.14	612.96	-0.18
215253.2	*I-196 East D/S*	612.71	612.52	-0.19	613.10	612.92	-0.18
214870.9	*XS 22*	612.58	612.39	-0.19	613.02	612.84	-0.18
214720.8	*Dam No. 4 U/S*	612.47	612.35	-0.12	612.98	612.81	-0.17
214711.5	*Dam No. 4 D/S*	612.40	612.35	-0.05	612.82	612.80	-0.02
214608.3	*Bridge St U/S*	612.36	612.32	-0.04	612.79	612.76	-0.03
214526.8	*Bridge St D/S*	612.18	612.15	-0.03	612.68	612.64	-0.04
214399.5	*Dam No. 3 U/S*	612.19	612.18	-0.01	612.63	612.57	-0.06
214393.3	*Dam No. 3 D/S*	612.14	612.18	+0.04	612.53	612.56	+0.03
214151.6	*XS 21*	612.13	612.15	+0.02	612.48	612.50	+0.02
213966.6		612.13	612.14	+0.01	612.45	612.47	+0.02
213926.6		612.12	612.11	-0.01	612.45	612.45	0.00
213856.9	*Dam No. 2 U/S*	612.11	612.10	-0.01	612.43	612.39	-0.04
213851.6	*Dam No. 2 D/S*	612.06	612.11	+0.05	612.35	612.38	+0.03
213726.4		612.04	612.06	+0.02	612.34	612.35	+0.01

River STA	*Notes*	Water Surface Elevation (ft)			Energy Grade Line (ft)		
		Corrected Effective (CEM)	Proposed Conditions (PC)	Difference (PC - CEM)	Corrected Effective (CEM)	Proposed Conditions (PC)	Difference (PC - CEM)
213666.4	*XS 20*	612.03	612.05	+0.02	612.33	612.34	+0.01
213522.5	*ped bridge U/S*	611.97	611.98	+0.01	612.31	612.33	+0.02
213489.9	*ped bridge D/S*	611.87	611.89	+0.02	612.23	612.24	+0.01
213370.1		611.82	611.84	+0.02	612.21	612.22	+0.01
213300.0		611.82	611.79	-0.03	612.19	612.20	+0.01
213220.0	*Dam No. 1 U/S*	611.81	611.81	0.00	612.18	612.13	-0.05
213213.0	*Dam No. 1 D/S*	611.76	611.81	+0.05	612.08	612.12	+0.04
213163.8	*Pearl St U/S*	611.74	611.78	+0.04	612.08	612.11	+0.03
213093.7	*Pearl St D/S*	610.91	610.94	+0.03	611.27	611.30	+0.03
213028.2		610.88	610.91	+0.03	611.26	611.29	+0.03
212980.5	*XS 19*	610.86	610.87	+0.01	611.25	611.28	+0.03
212877.2		610.83	610.86	+0.03	611.23	611.26	+0.03
212766.3		610.82	610.83	+0.01	611.21	611.23	+0.02
212706.3		610.82	610.82	0.00	611.20	611.22	+0.02
212611.5	*XS 18*	610.83	610.84	+0.01	611.18	611.19	+0.01
212446.8	*ped bridge U/S*	610.81	610.82	+0.01	611.16	611.17	+0.01
212414.5	*ped bridge D/S*	610.48	610.49	+0.01	610.84	610.85	+0.01
212334.2	*XS 17*	610.48	610.50	+0.02	610.83	610.84	+0.01
212250.0		610.46	610.48	+0.02	610.81	610.82	+0.01
212188.7		610.46	610.46	0.00	610.80	610.80	0.00
212103.5	*XS 16*	610.44	610.44	0.00	610.79	610.79	0.00
211964.7	*Fulton St U/S*	610.44	610.44	0.00	610.68	610.68	0.00
211868.1	*Fulton St D/S*	609.91	609.91	0.00	610.15	610.15	0.00

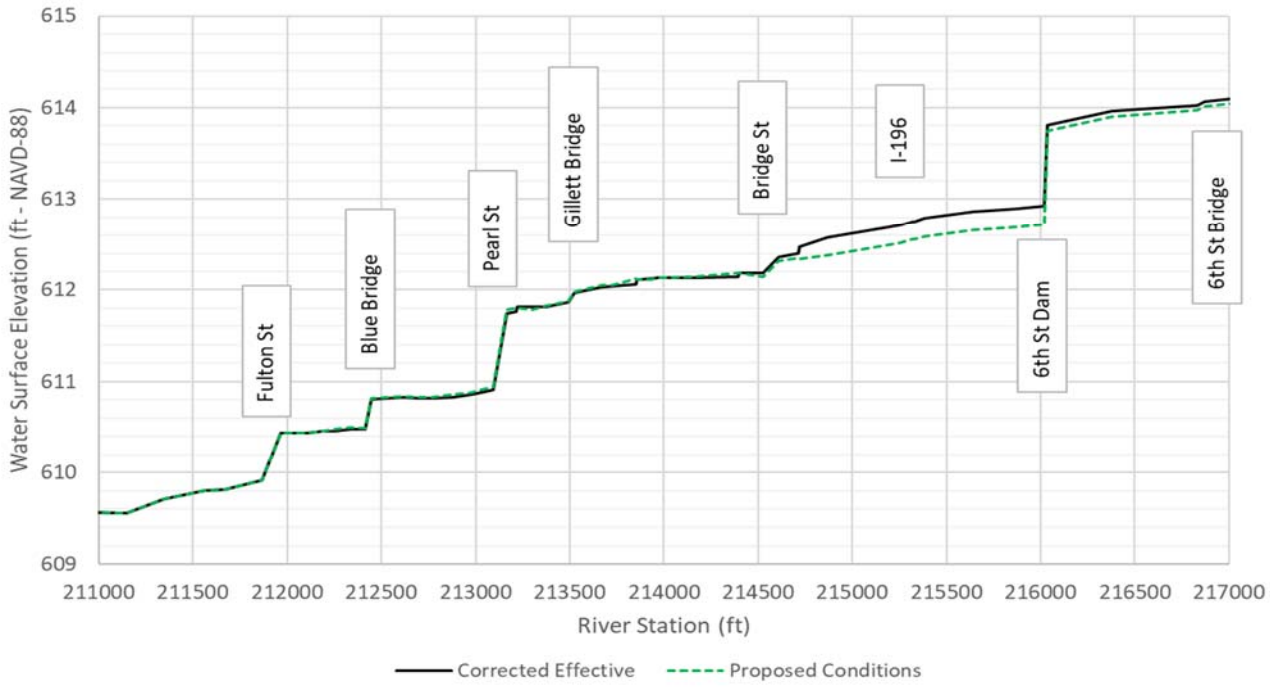

Figure 2 – Corrected Effective compared to Proposed Conditions (100-yr Flow Event)

The increases in modeled base flood elevation compared to the EM are being addressed in a Conditional Letter of Map Revision (CLOMR) that will be developed by the project team and submitted to FEMA as part of the project's permitting process.

3.3 Floodway Analysis

All fill associated with the project is located in the main channel of the Grand River, within the current Effective Floodway boundaries and within the City's flood protection system. A floodway evaluation is being completed as part of the CLOMR review FEMA has requested; any potential revisions to the Floodway boundaries will be discussed through that CLOMR process.

3.4 Conclusion

It is the opinion of the engineer, Scott Prins (RiverRestoration.org, LLC), that based on the hydraulic modeling results and analysis presented herein, the proposed project does not create a harmful interference as defined in the EGLE Hydraulic Report Guidelines (EGLE, 2019) as "causing an increase stage or change in the direction of flow that causes, or is likely to cause: damage to property, a threat to life, pollution, impairment, or destruction of water or other natural resources".

The proposed conditions model calculates modeled increases of up to 0.05 ft within the project reach. However, increases do not extend upstream or downstream of the project and remain within the City's flood protection system. A CLOMR request details these changes to the 100-yr flood profile and is being reviewed by FEMA. Increases in water surface elevations are present for the 2- through 50-year flood events, but the increases are also contained within the City of Grand Rapids' flood projection system and do not result in Harmful Interference as defined by EGLE.

Section 4 – Abbreviations

Crit W.S. – Critical water surface elevation

E.G. Elev – Energy Grade Elevation

E.G. Slope – Energy grade slope

EGL - Energy Grade Line

HGL – Hydraulic Grade Line

Min Ch El – Minimum channel elevation

Q Total – Total Discharge of water flow

Vel Chnl – Average velocity of flow in the channel

W.S. Elev (WSE) – Water Surface Elevation

WSE – Water Surface Elevation

Section 5 - References

Barnes, HH (1967) Roughness Characteristics of Natural Channels. United States Geological Survey, Water Supply Paper 1849, 213 pp.

Blodgett, J.C. (1986). Rock Riprap Design for Protection of Stream Channels Near Highway Structures. Water-Resources Investigations Report 86-4127.

Brunner, G. (2016). "HEC-RAS River Analysis System – Hydraulic Reference Manual Version 5.0." US Army Corps of Engineers Hydrologic Engineering Center. CPD-69.

Chow, V.T., 1959, Open-channel hydraulics: New York, McGraw-Hill, 680 p.

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EGLE, 2018. "Manning's *n* references." Email correspondence from Luke Trumble. December 11, 2018.

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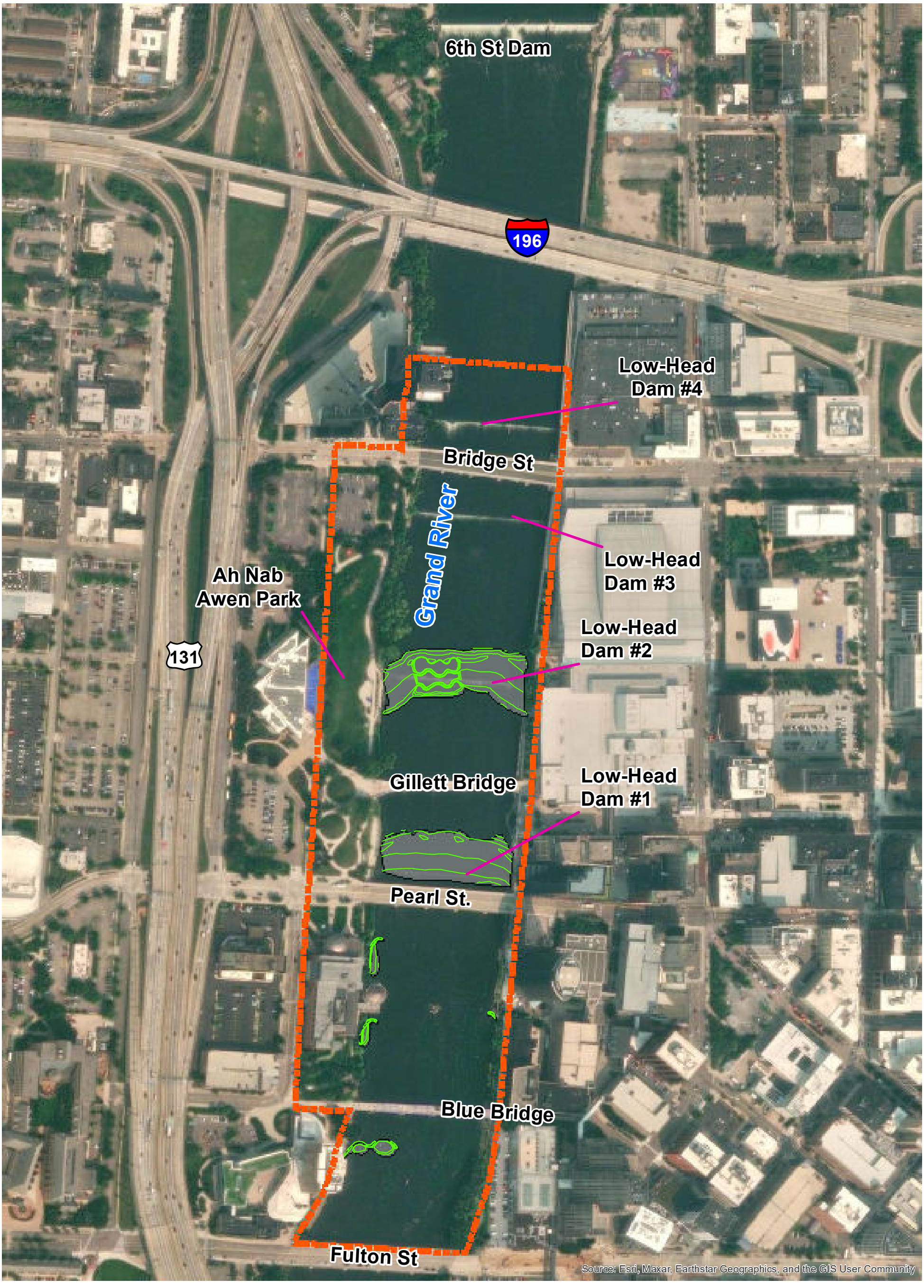
Fishbeck, 2020. "Grand River Flood Protection System Freeboard Evaluation", prepared for the City of Grand Rapids, MI. January 30, 2020.

Leopold, L.B. Wolman, M.G. and Miller, J.P., 1964, Fluvial process in geomorphology: New York, Dover Books on Earth Sciences.

ATTACHMENT 1:
PROJECT OVERVIEW



Grand Rapids Revitalization Lower Reach Project

Hydraulics Report - Attachment 1

Legend

- Proposed Contours
- Lower Reach Project Fill/Cut
- Lower Reach Project Limits

N

0 250 500 1,000 Feet

ATTACHMENT 2:
HYDROLOGY CORRESPONDENCE

RE: flood or low flow discharge request (ContentID - 168812)

GL -wrd-qreq <GL -wrd-qreq@michigan.gov>

Thu 3/24/2022 5:37 PM

To: Scott Prins <scott.prins@riverrestoration.org>

We have processed the discharge request submitted by email on March 11, 2022 (Process No. 20220143), as follows:

Grand River at 6th Street Dam, Section 24, T7N, R12W, City of Grand Rapids, Kent County, has a total drainage area of 4637 square miles and a contributing drainage area of 4531 square miles. The 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% chance peak flows are estimated to be 18000 cubic feet per second (cfs), 26000 cfs, 31000 cfs, 38000 cfs, 44000 cfs, 50000 cfs, 57000 cfs, and 65000 cfs, respectively. (Watershed Basin No. 14 Grand).

Please include a copy of this letter with your application for permit. These estimates should be confirmed by our office if an application is not submitted within one year. If you have any questions concerning the discharge estimates, please contact Ms. Susan Greiner, Hydrologic Studies and Floodplain Management Unit, at 517-927-3838 or by email to GreinerS@michigan.gov. Any questions concerning the hydraulics or the proper procedure for filing for a permit should be directed to Mr. Jacob Patin, Water Resources Division, Grand Rapids District Office, at 616-204-7176 or email to PatinJ1@michigan.gov.

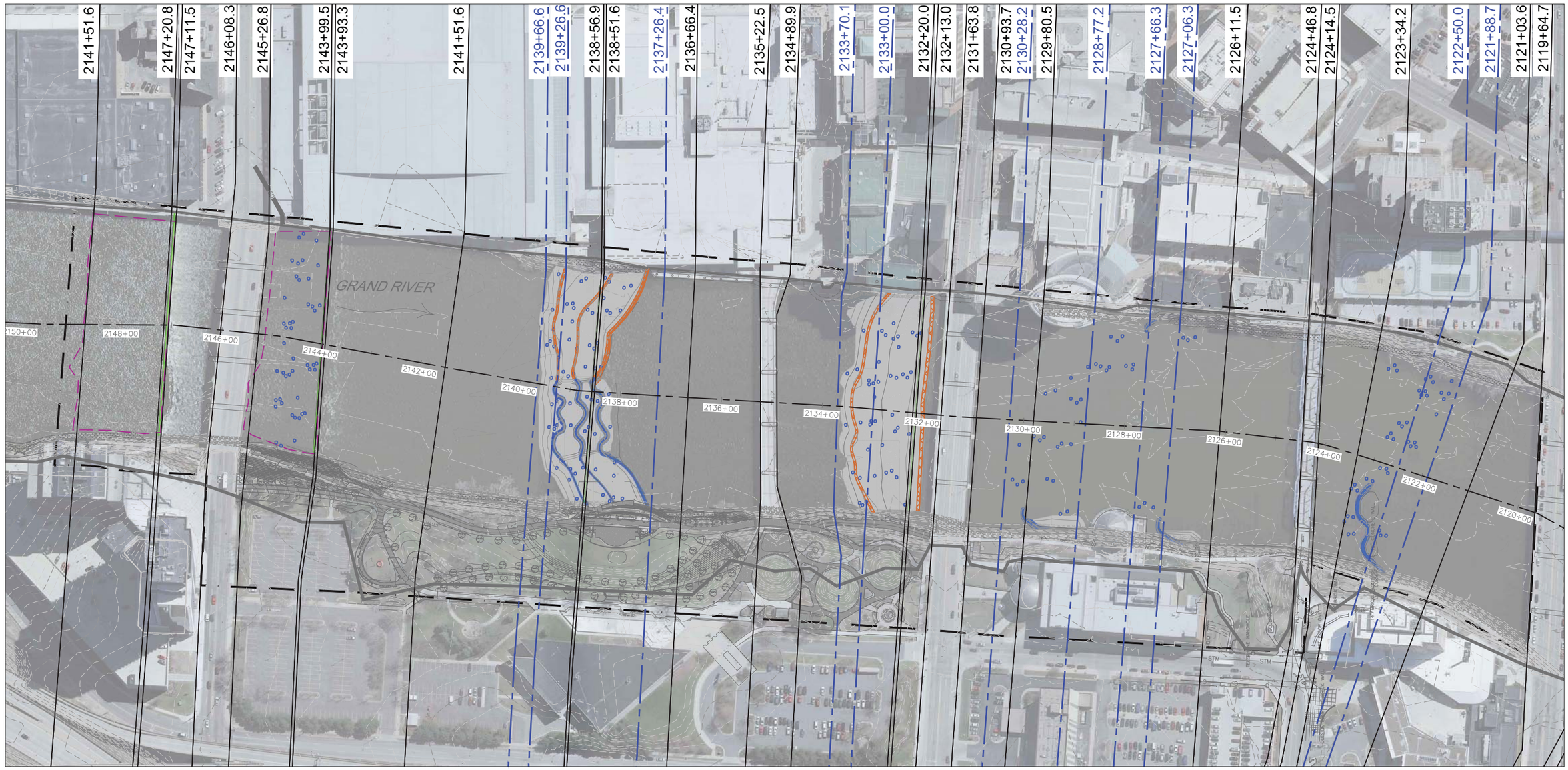
Low flows are provided in a separate email.

-----Original Message-----
From: DoNotReply@michigan.gov <DoNotReply@michigan.gov>
Sent: Friday, March 11, 2022 4:30 PM
To: GL -wrd-qreq <GL -wrd-qreq@michigan.gov>
Subject: flood or low flow discharge request (ContentID - 168812)

Requestor: Scott Prins
Company:
Address: PO Box 248
City: Carbondale
Zip: 81623
Phone: 9709479568
Date: 2022-03-11
F50percent: Yes
F20percent: Yes
F10percent: Yes
F4percent: Yes
F2percent: Yes
F1percent: Yes
F0.5percent: Yes
F0.2percent: Yes
Monthly95: Yes
Monthly50: Yes E

MonthlyMe n e
90D yQ10 e
Lowe t95 e
Lowe t50 e
H rmonicMe n e
FlowExceed nceC rve e
Cont ctAgency Other
Cont ctPer on
Waterco r e Gr nd River
Loc lN me
Co ntyLoc tion Kent
CityorTown hip Gr nd R pid u
Section 41
Town 07N
R nge 12W
Loc tion 6th Street D m t Gr nd R pid , MI. Up tre m of I-196 Bridge Cro ing
FFR1 Floodpl in
fpReqEm ailAddr cott.prin @riverre tor tion.org u

ATTACHMENT 3:
HYDRAULIC MODEL CROSS SECTION MAPS



LEGEND

- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

HEC-RAS CROSS SECTIONS:

- FEMA PRELIMINARY EFFECTIVE SECTION
- CORRECTED EFFECTIVE SECTION - ADDED FOR PROJECT

NORTH

0 100' 200'

SCALE: 1" = 100'

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

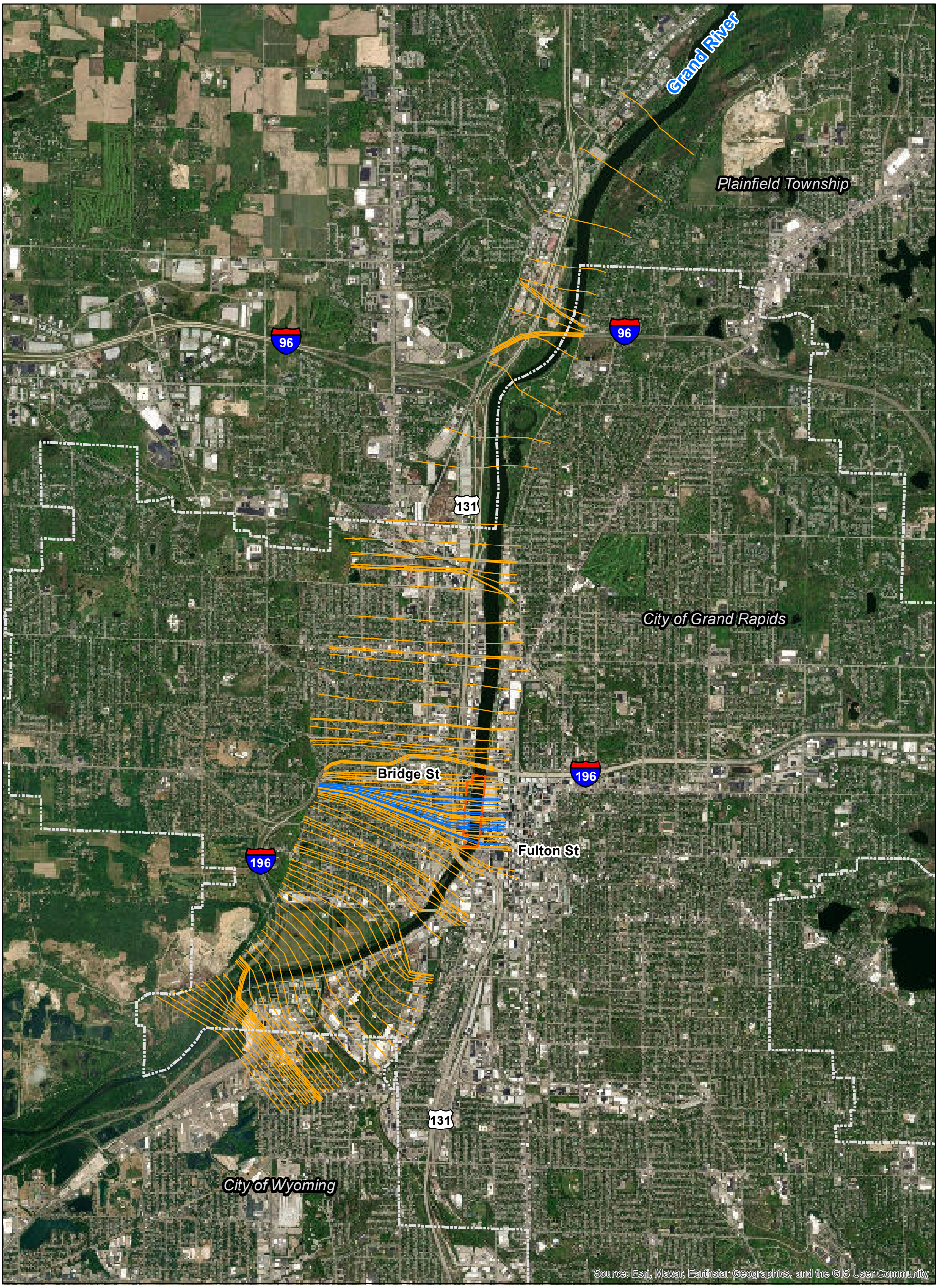
(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. ___ of 32

Grand Rapids Revitalization Lower Reach Project



Legend

- City Boundary
- Lower Reach Project Limits
- Corrected Effective Cross Section
- Effective Cross Section

N

0 0.5 1 1.5 2 Miles

Hydraulics Report - Attachment 3b

ATTACHMENT 4:
CROSS SECTION INFORMATION TABLES

Summary of Changes made to the Effective Model for Creation of the Corrected Effective Model

Note: All bridges and inline structures have remained unchanged from the Effective Model (EM)

Fulton Street to Blue Bridge

Cross Section STA	Change	Justification
2119+64.7	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2121+03.5	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2121+88.7	Cross Section Added	Added to allow for direct comparison immediately downstream of proposed improvements. Includes more detailed channel bottom and floodplain information.
2122+50.	Cross Section Added	Added to allow for direct comparison of proposed improvments along crest of boulder structure. Includes more detailed channel bottom and floodplain information.
2123+34.2	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2124+14.5	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck

Blue Bridge to Pearl St

Cross Section STA	Change	Justification
2124+46.8	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2126+11.5	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2127+06.3	Cross Section Added	Added to allow for direct comparison of proposed vane structure and scattered habitat boulder. Includes more detailed channel bottom and floodplain information.
2127+66.3	Cross Section Added	Added to allow for direct comparison of proposed vane structure and scattered habitat boulder. Includes more detailed channel bottom and floodplain information.
2128+77.2	Cross Section Added	Added to allow for direct comparison of propsoed scattered habitat boulders. Includes more detailed channel bottom and floodplain information.
2129+80.5	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2130+28.2	Cross Section Added	Added to allow for direct comparison immediately upstream of proposed improvements. Includes more detailed channel bottom and floodplain information.
2130+93.7	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck

Pearl St to Gillett Bridge

Cross Section STA	Change	Justification
2131+63.8	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2132+13.	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2132+20.	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2133+00.	Cross Section Added	Added to allow for direct comparison of proposed riffle crest. Includes more detailed channel bottom and floodplain information.
2133+70.1	Cross Section Added	Added to allow for direct comparison immediately upstream of proposed improvements. Includes more detailed channel bottom and floodplain information.
2134+89.9	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck

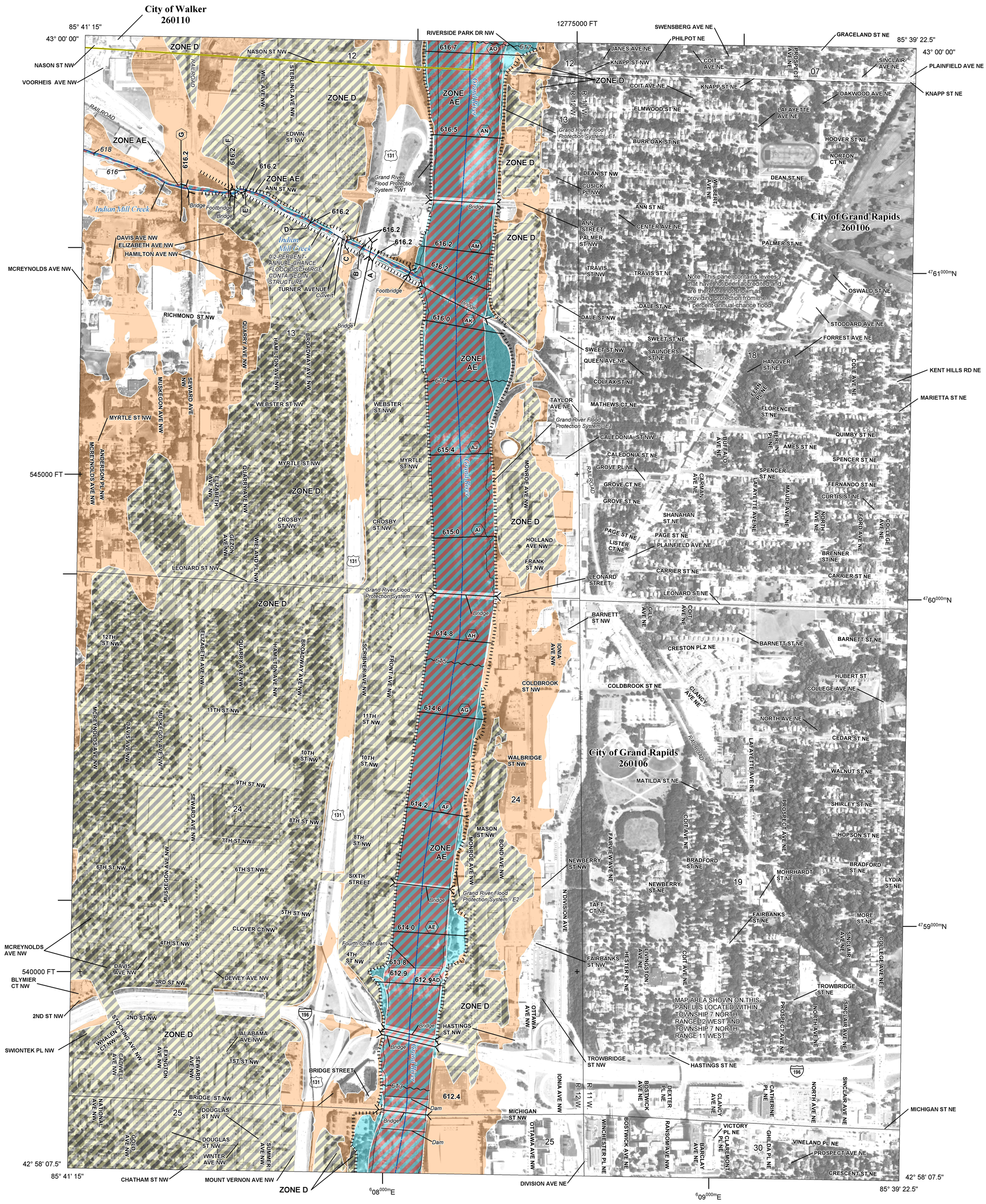
Gillett Bridge to Bridge Street

Cross Section STA	Change	Justification
2135+22.5	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2136+66.4	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2137+26.4	Cross Section Added	Added to allow for direct comparison immediately downstream of proposed improvements. Includes more detailed channel bottom and floodplain information.
2138+51.6	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2138+56.9	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck
2139+26.6	Cross Section Added	Added to allow for direct comparison of proposed structure crest. Includes more detailed channel bottom and floodplain information.
2139+66.6	Cross Section Added	Added to allow for direct comparison immediately upstream of proposed improvements. Includes more detailed channel bottom and floodplain information.
2141+51.6	Updated from EM	Levee data and bank elevations updated or verified by Fishbeck

Attachment 4 - Cross Section Information Table

Cross-section Station (*ft*)	Description of Cross Section	Description of Proposed Grading	Description of Proposed Substrate	Contraction, Expansion Coefficients	Notes
2121+03.6	Existing EM Section	No change	Native alluvium	0.7, 0.9	
2121+88.7	Added for Proposed Feature Between Blue Bridge and Fulton Street	Immediately downstream of proposed improvements		0.1 , 0.3	
2122+20.6		Crest of structure, scatter boulder	Boulder, Native alluvium	0.1 , 0.3	Weighted n value to represent scattered emergent boulder
2123+34.2	Existing EM Section	No change	Native alluvium	0.1 , 0.3	
2123+94.1				0.1 , 0.3	
2124+14.5				0.1 , 0.3	
2124+46.8				0.1 , 0.3	
2126+11.5				0.1 , 0.3	
2127+06.3	Added for Proposed boulder vane downstream of carousel	Boulder vane on west bank, boulder cluster on east side of channel	Boulder, Native alluvium	0.1 , 0.3	Weighted n value to represent scattered emergent boulder
2127+66.3	Added for proposed boulder vane on east side of channel	Boulder vane on east bank, boulder cluster on west side of channel		0.1 , 0.3	
2128+77.2	Added for proposed scattered habitat boulders	Scattered habitat boulder		0.1 , 0.3	
2129+80.5	Existing EM Section	Boulder vane on west bank, scatter boulder in the channel		0.1 , 0.3	
2130+28.2	Added for proposed improvements	Immediately upstream of proposed improvements	Native alluvium	0.1 , 0.3	
2130+93.7	Existing EM Section	No change	Native alluvium	0.1 , 0.3	
2131+63.8				0.1 , 0.3	
2132+13.0		Dam demolition and restoration of riverbed	Coarse alluvium, Native alluvium	0.1 , 0.3	
2132+20.0				0.1 , 0.3	
2133+00.0	Added for Proposed Feature Between Gillett Bridge and Pearl Street	Structure crest	Riprap substructure, emergent boulder	0.1 , 0.3	Weighted n value to represent scattered emergent boulder
2133+70.1		Immediately upstream of proposed improvements	Native alluvium	0.1 , 0.3	
2134+89.9	Existing EM Section	No change		0.1 , 0.3	
2135+22.5				0.1 , 0.3	
2136+66.4				0.1 , 0.3	
2137+26.4	Added for Proposed Feature Between Bridge Street and Gillett Bridge	Immediately downstream of proposed improvements	Native alluvium	0.1 , 0.3	
2138+51.6	Existing EM Section	DS edge of riffle and scour hole	Riprap substructure, Coarse alluvium	0.1 , 0.3	
2138+56.9		DS edge of riffle and DS boulder arch	Riprap substructure, Boulder	0.1 , 0.3	
2139+26.6	Added for Proposed Feature Between Bridge Street and Gillett Bridge	Structure crest		0.1 , 0.3	
2139+66.6		Immediately upstream of proposed improvements	Native alluvium	0.1 , 0.3	
2140+51.6	Existing EM Section	No change		0.1 , 0.3	

ATTACHMENT 5:
EFFECTIVE FLOOD INSURANCE RATE MAP AND FIS WATER SURFACE PROFILES



FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT HTTPS://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A,V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN — Areas of Minimal Flood Hazard *Zone X*
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- E — 18.2 / 17.5 — Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 — Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 — Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

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To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Base map information shown on this FIRM was provided in digital format by multiple agencies. The following sources provided base data: Kent County, Michigan, the United States Geological Survey (USGS), the United States Department of Agriculture (USDA), and the Center for Shared Solutions and Technology Partnerships. Imagery was provided in digital format by the United States Department of Agriculture, dated 2016, and has a 1-meter ground resolution.

NON-ACCREDITED LEVEE SYSTEM: This panel contains a levee system that has not been accredited and is therefore not recognized as reducing the 1-percent-annual-chance flood hazard.

SCALE

N

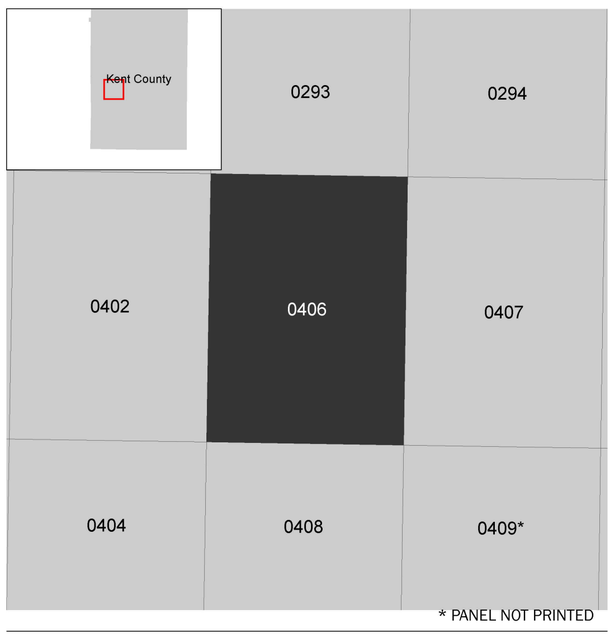
Map Projection:
NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl;
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet 1:6,000

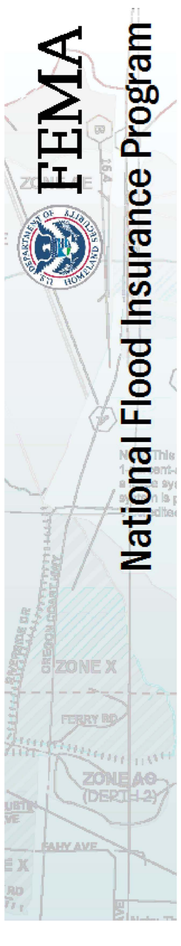
0 500 1,000 2,000 feet

0 125 250 500 meters

PANEL LOCATOR



* PANEL NOT PRINTED



NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

KENT COUNTY, MICHIGAN
All Jurisdictions

PANEL 406 OF 625

Panel Contains:

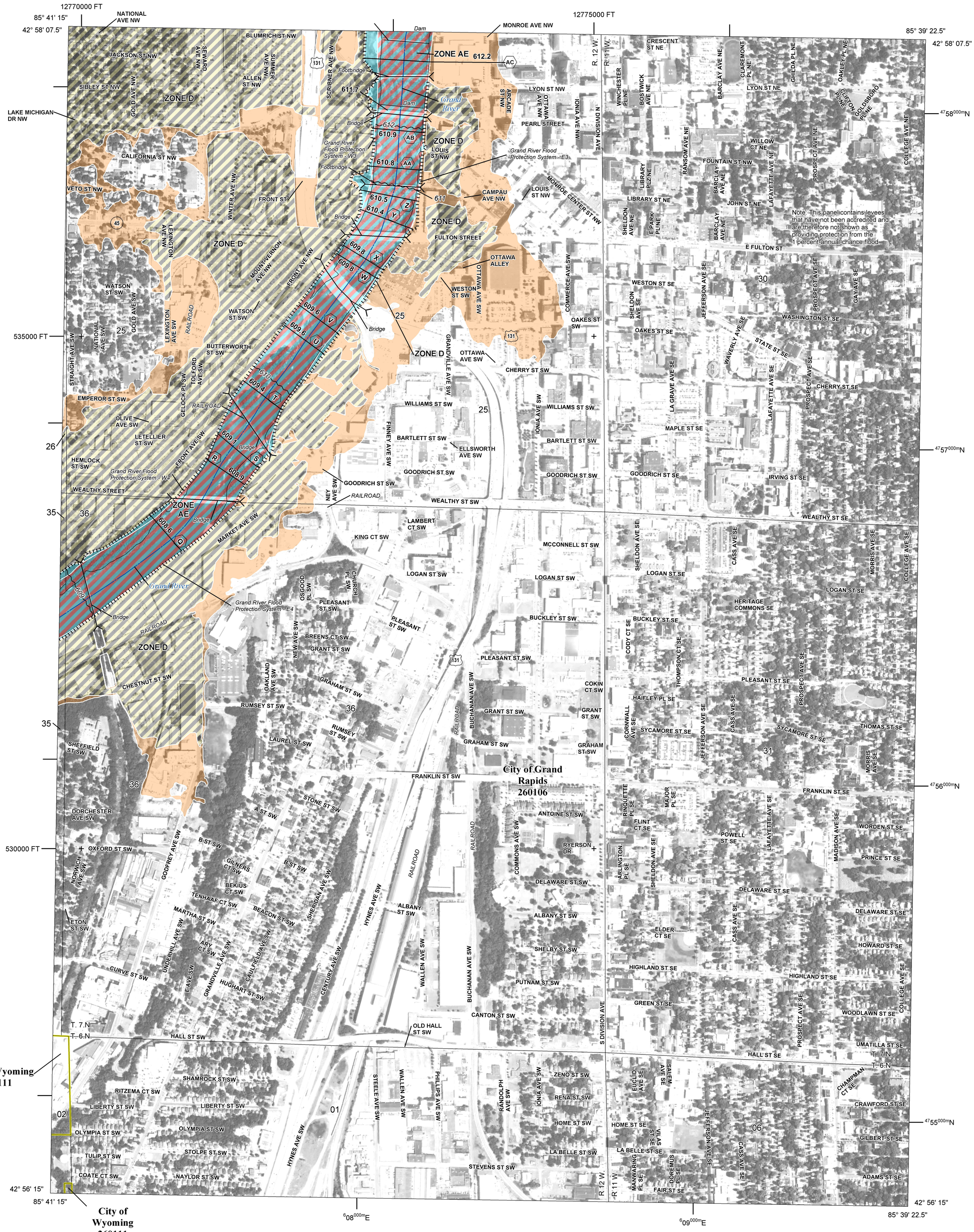
COMMUNITY	NUMBER	PANEL	SUFFIX
GRAND RAPIDS, CITY OF	260106	0406	D
WALKER, CITY OF	260110	0406	D

FEMA

VERSION NUMBER
2.6.3.0

MAP NUMBER
26081C0406D

EFFECTIVE DATE
FEBRUARY 23, 2023



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GENERAL STRUCTURES
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- Levee, Dike, or Floodwall

OTHER FEATURES
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NON-ACCREDITED LEVEE SYSTEM: This panel contains a levee system that has not been accredited and is therefore not recognized as reducing the 1-percent-annual-chance flood hazard.

SCALE

N

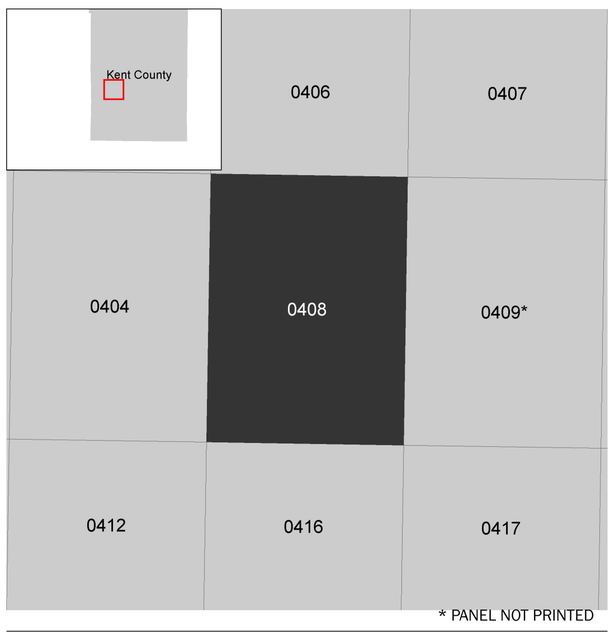
Map Projection:
NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl;
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet 1:6,000

0 500 1,000 2,000 feet

0 125 250 500 meters

PANEL LOCATOR



* PANEL NOT PRINTED



NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

KENT COUNTY, MICHIGAN
All Jurisdictions

PANEL 408 OF 625

FEMA

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
GRAND RAPIDS, CITY OF	260106	0408	D
WYOMING, CITY OF	260111	0408	D

VERSION NUMBER
2.6.3.0

MAP NUMBER
26081C0408D

EFFECTIVE DATE
FEBRUARY 23, 2023

ELEVATION IN FEET (NAVD)

635
625
615
605
595
585
575
565
555
545

INTERSTATE 196 WESTBOUND
INTERSTATE 196 EASTBOUND
CONFLUENCE WITH PLASTER CREEK
RAILROAD
WEALTHY STREET
RAILROAD
U.S. HIGHWAY 131
FULTON STREET
PEDESTRIAN BRIDGE

M N O P Q R S T U V W X Y Z

LEGEND
- 0.2% ANNUAL CHANCE FLOOD
- "1%+" ANNUAL CHANCE FLOOD*
- 1% ANNUAL CHANCE FLOOD
- 2% ANNUAL CHANCE FLOOD
- 4% ANNUAL CHANCE FLOOD*
- 10% ANNUAL CHANCE FLOOD
- STREAM BED
- A CROSS SECTION LOCATION
- * DATA NOT AVAILABLE

202,000 203,000 204,000 205,000 206,000 207,000 208,000 209,000 210,000 211,000 212,000 213,000 214,000 215,000

STREAM DISTANCE IN FEET ABOVE MOUNTH

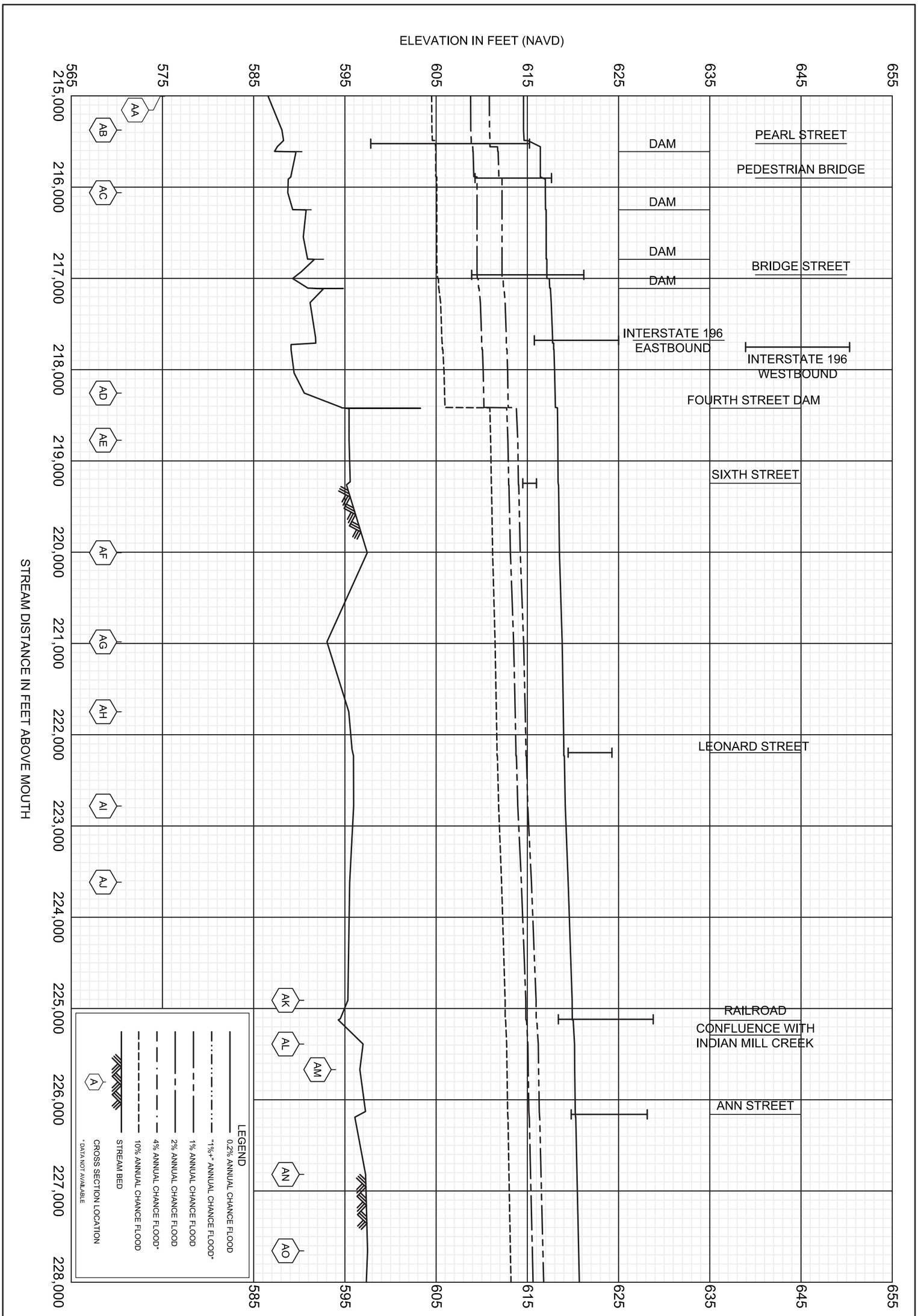
FLOOD PROFILES

GRAND RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

KENT COUNTY, MI
(ALL JURISDICTIONS)

030P



FEDERAL EMERGENCY MANAGEMENT AGENCY

KENT COUNTY, MI

(ALL JURISDICTIONS)

FLOOD PROFILES

GRAND RIVER

031P

ATTACHMENT 6:
WRIR 86-4127, TABLE 10

Table 10. Manning's roughness coefficient, n, for selected values of mean depth and median bed material size.

Mean depth, d_a (ft)	Median diameter of bed material, D_{50}, in feet													
	Fine sand	Medium sand	Coarse sand	Fine gravel			Medium gravel	Coarse gravel	Small cobble	Medium cobble	Large cobble	Boulders		
	0.0005	0.001	0.005	0.010	0.015	0.020	0.10	0.20	0.30	0.40	0.50	1.0	1.25	1.50
1	0.019	0.019	0.019	0.021	0.022	0.024	0.035	0.044	0.053	0.061	0.068	0.117	0.151	0.198
2	.021	.021	.021	.021	.022	.023	.032	.039	.045	.050	.054	.077	.089	.101
3	.022	.022	.022	.022	.022	.023	.032	.038	.042	.046	.050	.066	.074	.082
4	.023	.023	.023	.023	.023	.023	.031	.036	.041	.044	.047	.061	.068	.074
5	.024	.024	.024	.024	.024	.024	.031	.036	.040	.043	.046	.058	.064	.069
6	.025	.025	.025	.025	.025	.025	.031	.035	.039	.042	.045	.056	.061	.066
7	.026	.026	.026	.026	.026	.026	.030	.035	.038	.041	.044	.054	.059	.063
8	.026	.026	.026	.026	.026	.026	.030	.035	.038	.041	.053	.053	.057	.061
9	.027	.027	.027	.027	.027	.027	.030	.035	.038	.041	.043	.052	.056	.060
10	.027	.027	.027	.027	.027	.027	.030	.035	.038	.040	.042	.051	.055	.059
12	.028	.028	.028	.028	.028	.028	.030	.034	.037	.040	.042	.050	.054	.057
14	.029	.029	.029	.029	.029	.029	.030	.034	.037	.039	.042	.049	.053	.056
15	.029	.029	.029	.029	.029	.029	.030	.034	.037	.039	.041	.049	.052	.055
20	.031	.031	.031	.031	.031	.031	.031	.034	.037	.039	.041	.048	.050	.053
25	.032	.032	.032	.032	.032	.032	.032	.034	.036	.039	.040	.047	.050	.052
30	.033	.033	.033	.033	.033	.033	.033	.034	.036	.038	.040	.046	.049	.051
35	.033	.033	.033	.033	.033	.033	.033	.034	.036	.038	.040	.046	.048	.050
40	.034	.034	.034	.034	.034	.034	.034	.034	.036	.038	.040	.046	.048	.050

Relationships used in preparing table:

Equation 12 $$n = \frac{0.0926\, d_a^{0.167}}{0.794 + 1.85 \log d_a/D_{50}} \quad \text{for } 1.5 < d_a/D_{50} < 185$$

Equation 17 $$n = 0.0185 d_a^{0.167} \quad \text{for } 185 < d_a/D_{50} < 30{,}000$$

ATTACHMENT 7:
IMPORTED SUBSTRATE SPECIFICATIONS

IMPORTED BOULDERS SPECIFICATION

Imported Boulders may be quarried or excavated and generally smooth in shape with the largest rock faces being approximately flat. Boulders shall be of a consistent material for the entire project and shall be a color that is aesthetically neutral with the native landscape. Boulder gradations shall conform to Table 1 by number, and measurement of the intermediate axis ("B"-Axis). The minor axis (shortest dimension or "C"-Axis) shall not be less than indicated in Table 1. Boulders exposed in the grade controls and keyed into the toe of each structure shall have a minimum intermediate axis (B-Axis) of 48 inches.

Table 1. B-Axis Rock Gradations (inches)

Percent of Stones	Indicator	24 inch	36 inch	48 inch	60 inch	72 inch
< 10%	Greater	36	48	60	72	84
> 75%	Between	32&18	42&30	54&36	66&	78&60
0%	Less	15	21	28	38	48
C-Axis	Greater	10	15	20	25	30

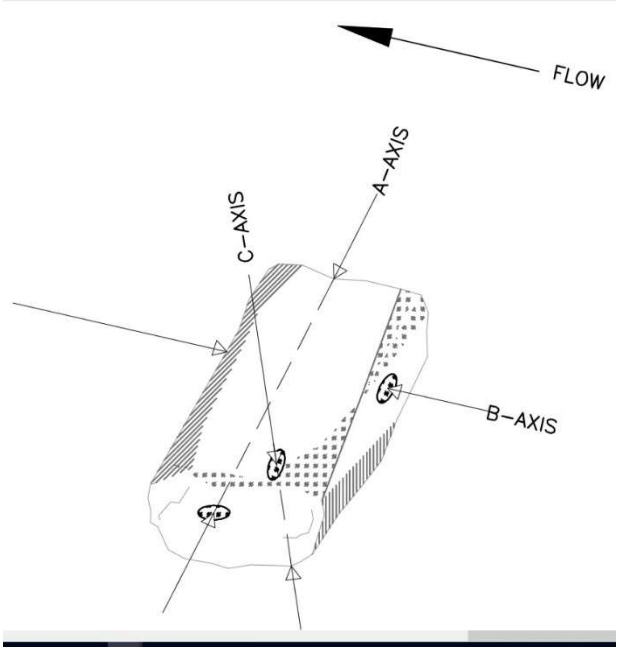


Figure 1. Dimensional axes of a boulder

Natural Boulders shall consist of hard, dense durable stone, resistant to weathering. Surface stones must have an aesthetic, neutral color and be consistent material throughout the project unless specified in plans. Stone shall be suitable for incidental human contact. CONTRACTOR shall submit source information and samples to ENGINEER. Erratic boulders in the lower peninsula of Michigan that have been subjected to weathering such as glacial or alluvial flows will be preferred and may be approved by Engineer based on visual inspection.

The Engineer may require the Contractor to furnish laboratory results if, in the Engineer's opinion, the material is marginal or unacceptable. At the request of the Engineer, the Contractor shall furnish laboratory test results indicating that the material meet the requirements including those for abrasion resistance and soundness as indicated below:

---Boulders shall have a minimum specific gravity of 2.65.

---Abrasion resistance by Los Angeles Machine; Test Method ASTM C535; Specification Requirement: 20% loss, maximum.

--Soundness by use of Sodium/Magnesium Sulfate, Test Method ASTM D5240-04 Standard Test Method for Testing Rock Slabs to Evaluate Soundness of Riprap by Use of Sodium Sulfate or Magnesium Sulfate; Specification Requirement: 5% loss, maximum.

--Soundness by Freezing and Thawing, Test Method ASTM D5312-04 Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions; Specification Requirement: 5% loss, maximum.



Figure 2. Glacial run natural boulders 48-inch gradation

IMPORTED ALLUVIUM MATERIAL

The Project will utilize two size classes of imported alluvium: Coarse Alluvium and Fine Alluvium. Coarse Alluvium shall be used for in-river construction of riffle structures and Fine Alluvium shall be used in specified locations on plans. Both gradations may be used to backfill voids within boulder and riprap structures. Imported Alluvium shall consist of clean, hard, durable, rounded, and well graded material. Imported Alluvium may be screened or crushed material. Unless specified in drawings, gradations shall match those detailed in Table 2. Materials shall meet the following specification requirements.

---Minimum specific gravity of 2.55.

---Abrasion resistance by Los Angeles Machine; Test Method ASTM C535; Specification Requirement: 28% loss, maximum.

--Soundness by use of Sodium/Magnesium Sulfate, Test Method ASTM D5240-04 Standard Test Method for Testing Rock Slabs to Evaluate Soundness of Riprap by Use of Sodium Sulfate or Magnesium Sulfate; Specification Requirement: 10% loss, maximum.

--Soundness by Freezing and Thawing, Test Method ASTM D5312-04 Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions; Specification Requirement: 10% loss, maximum.

Glacio-fluvial erratic materials deposited in the lower peninsula of Michigan may be approved by Engineer upon visual inspection.

Table 2. Coarse and Fine Alluvium Material Gradations (inches)

By weight	Indicator	Coarse Alluvium	Fine
100%	Passing	30”	8"
60%-85%	Passing	20”	6"
35%-65%	Passing	12”	3"
25%-55%	Passing	8”	1.5"
15%-35%	Passing	4”	3/4”
0%-5%	Passing	1.5”	1/5”
	D_{85}	18”	6"
	D_{50}	12”	3"
	D_{30}	4”	3/4”



Figure 2. Example of suitable alluvium material

IMPORETED RIPRAP MATERIAL

Riprap shall be used as shown in plans to form the stabilizing core and toes structures of the constructed riffles as well as the toe backfills at dam removal locations as shown on plans.

Riprap materials should comply with the 2012 Michigan Department of Transportation (MDOT) Standard Specifications for Construction, Section 916 – Erosion and Sedimentation Control with the following exceptions:

1. Only natural stone is permitted. Solid precast concrete blocks and sound pieces of broken concrete are not permitted. No reinforcing steel is permitted.
2. Riprap Substructure shall consist of 50 percent (by volume) MDOT spec Plain Riprap and 50 percent (by volume) MDOT spec Heavy Riprap. The Contractor is permitted to mix the two size classes on site with equipment. The resulting mix shall be a well-mixed gradation with a D50 of 12 inches.

Construction and installation of Riprap should comply with the 2012 Michigan Department of Transportation (MDOT) Standard Specifications for Construction, Section 813 – Slope Protection with the following exceptions:

1. Geotextile liner is only needed where shown on plans along banks. Geotextile liner is not required beneath riprap substructure places on the horizontal plane of the channel bed.
2. Riprap will be placed in the horizontal plane of the channel as shown in the plans in horizontal individual lifts not to exceed 30 inches, backfilling with alluvium between lifts. Placement of riprap shall maintain intimate contact between riprap material within matrix of rock.
3. Riprap placed along banks will be placed as shown in the plans and in accordance with MDOT Standard Specifications for Construction, Section 813.



Figure 3. Imported riprap example

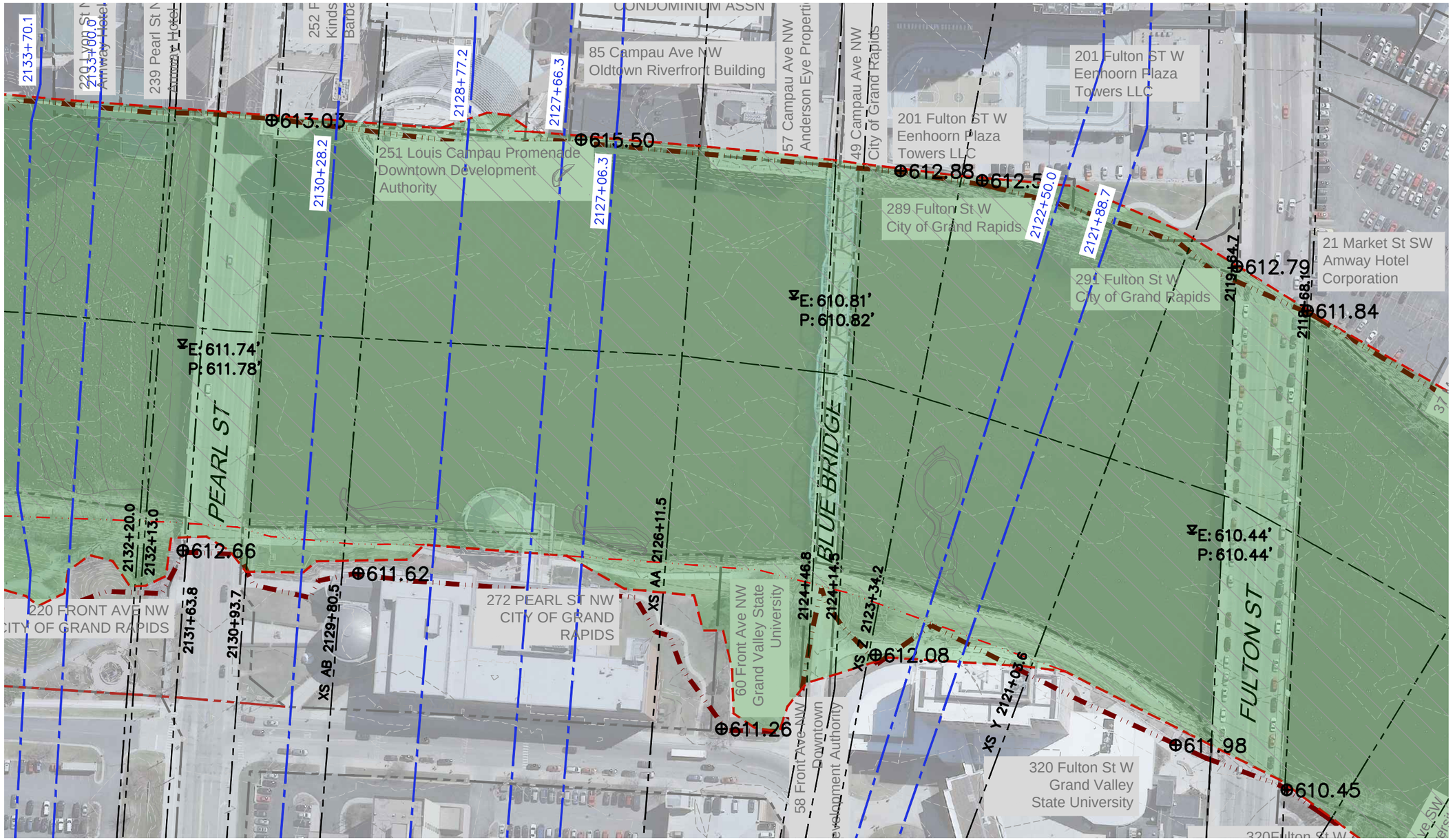
ATTACHMENT 8:
BRIDGE MODELING APPROACH TABLES

Attachment 8
Bridge Modeling Approach Table

Bridge Crossing	River Station	Low flow Methodology	Momentum Pier C_d	Yarnell Pier C_d		High Flow Methodology	Submerged Inlet C_d
North Park	235+119.7	E, M, Y --> highest	1	1.05		pressure/weir	0.8
I-96 West	234+529.4	E, M, Y --> highest	1.33	0.9		energy only	
I-96 east	234+433.5	E, M, Y --> highest	1.33	0.9		energy only	
Ann	223+766.0	E, M, Y --> highest	1.33	0.9		pressure/weir	0.8
U/S Railroad	222+724.2	E, M, Y --> highest	1.1	1.08		energy only	
Leonard	219+802.8	E, M, Y --> highest	1	1.05		energy only	
6th Street	216+850.9	E, M, Y --> highest	1.1	1.08		energy only	
I-196 West	215+358.1	E, M, Y --> highest	1	1.05		energy only	
I-196 East	215+284.2	E, M, Y --> highest	1	1.05		energy only	
Bridge Street	214+566.8	E, M, Y --> highest	1.25	1.1		pressure/weir	0.8
Gillett Ped Bridge	213+506.2	E, M, Y --> highest	1.33	0.9		pressure/weir	0.8
Pearl St	213+128.6	E, M, Y --> highest	1.5	1.15		pressure/weir	0.8
Blue Ped Bridge	212+431.8	E, M, Y --> highest	1.5	1.15		pressure/weir	0.8
Fulton St	211+918.1	E, M, Y --> highest	1.5	1.15		pressure/weir	0.8
US-131	211+242.4	E, M, Y --> highest	1.33	0.9		energy only	

E = Energy Equation
M= Momentum Equation
Y = Yarnell Equation

ATTACHMENT 9:
INUNDATION LIMITS COMPARISON MAPS



N

0 60' 120'

SCALE: 1" = 60'

LEGEND

- PROPOSED EFFECTIVE IMPACT AREA
- AREA OF INCREASED IMPACT
- AREA OF DECREASED IMPACT
- EXISTING FLOOD EMBANKMENT
- EXISTING FLOODWALL
- EFFECTIVE FEMA FIS 100 YEAR LIMITS OF IMPACT
- FEMA FLOODWAY BOUNDARY
- PROPERTY PARCEL BOUNDARY
- EFFECTIVE SECTION
- CORRECTED EFFECTIVE SECTION
- ⊕ ELEV. FLOOD PROTECTION ELEVATION
- ⧖ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION HARMFUL INTERFERENCE EVALUATION PEARL ST TO US-131 100 YEAR FLOOD

NOT FOR CONSTRUCTION

No.	REVISION/UPDATE	Date

CLIENT NAME AND ADDRESS

Grand Rapids WhiteWater

502 Second Street NW Suite 300
Grand Rapids, MI 49504
grandrapidswhitewater.org

DESIGN FIRM NAME AND ADDRESS

P.O. Box 248
Carbondale, CO 81623
www.RiverRestoration.org

PROJECT NAME AND ADDRESS

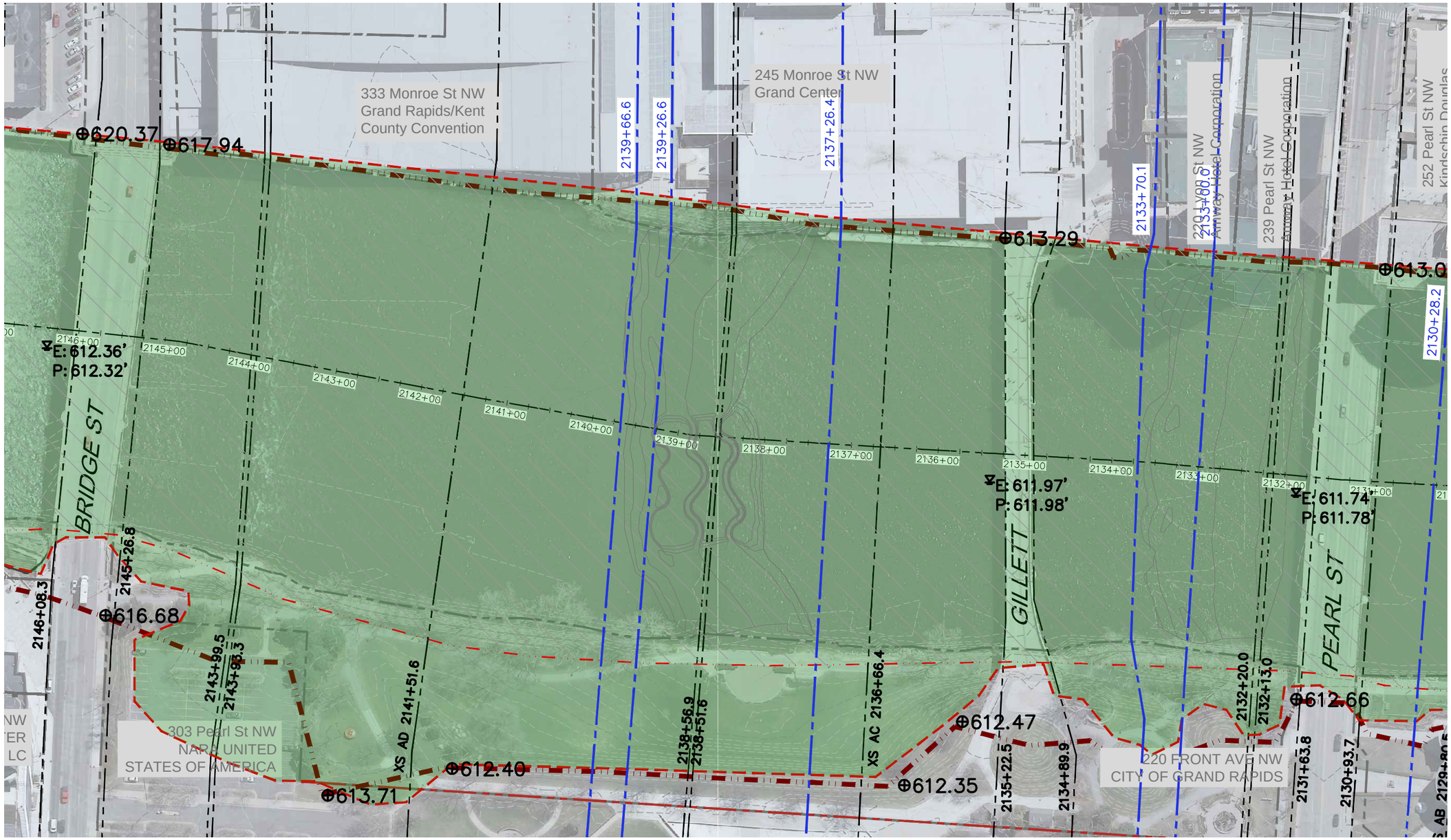
Grand River Revitalization
Grand Rapids, Kent County MI

Project 02.MI01.001

Date MAR 2022

Scale 1" = 60'

Sheet 1



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- EFFECTIVE SECTION
- CORRECTED EFFECTIVE SECTION
- ⊕ ELEV. — FLOOD PROTECTION ELEVATION
- ⧩ ELEV. — MODELED 100 YEAR FLOOD ELEVATIONS

N

0 60' 120'
SCALE: 1" = 60'

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
BRIDGE ST TO GILLETT
100 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand Rapids, Kent County MI

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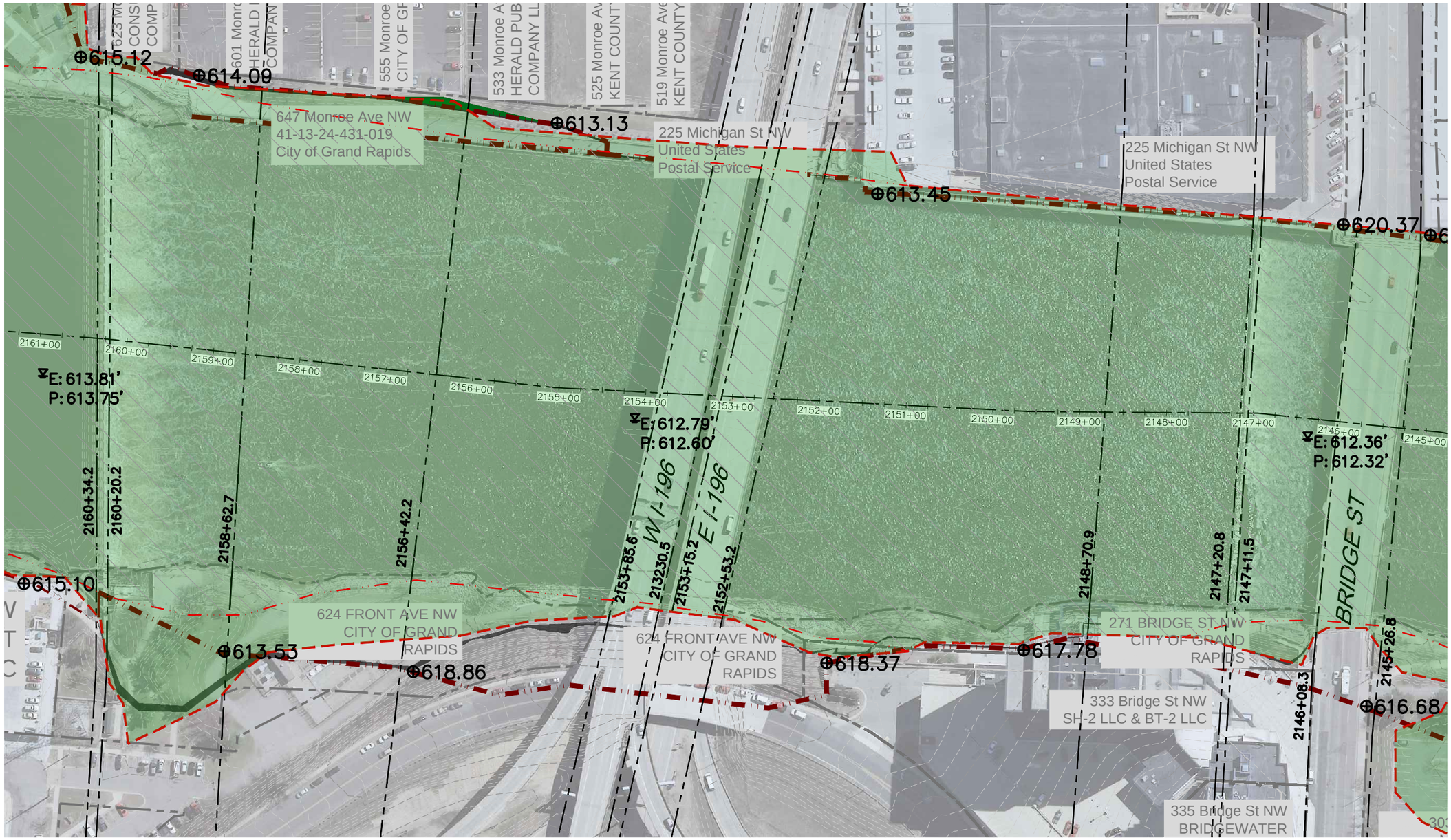

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
6TH ST DAM TO BRIDGE ST
100 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand Rapids, Kent County MI

Project	Sheet
02.MI01.001	3
Date: MAR 2022	
Scale: 1" = 60'	



N

0 60' 120'

SCALE: 1" = 60'

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- ⧩ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION HARMFUL INTERFERENCE EVALUATION PEARL ST TO US-131 50 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand Rapids, Kent County MI

Project 02.MI01.001
Date APR 2024
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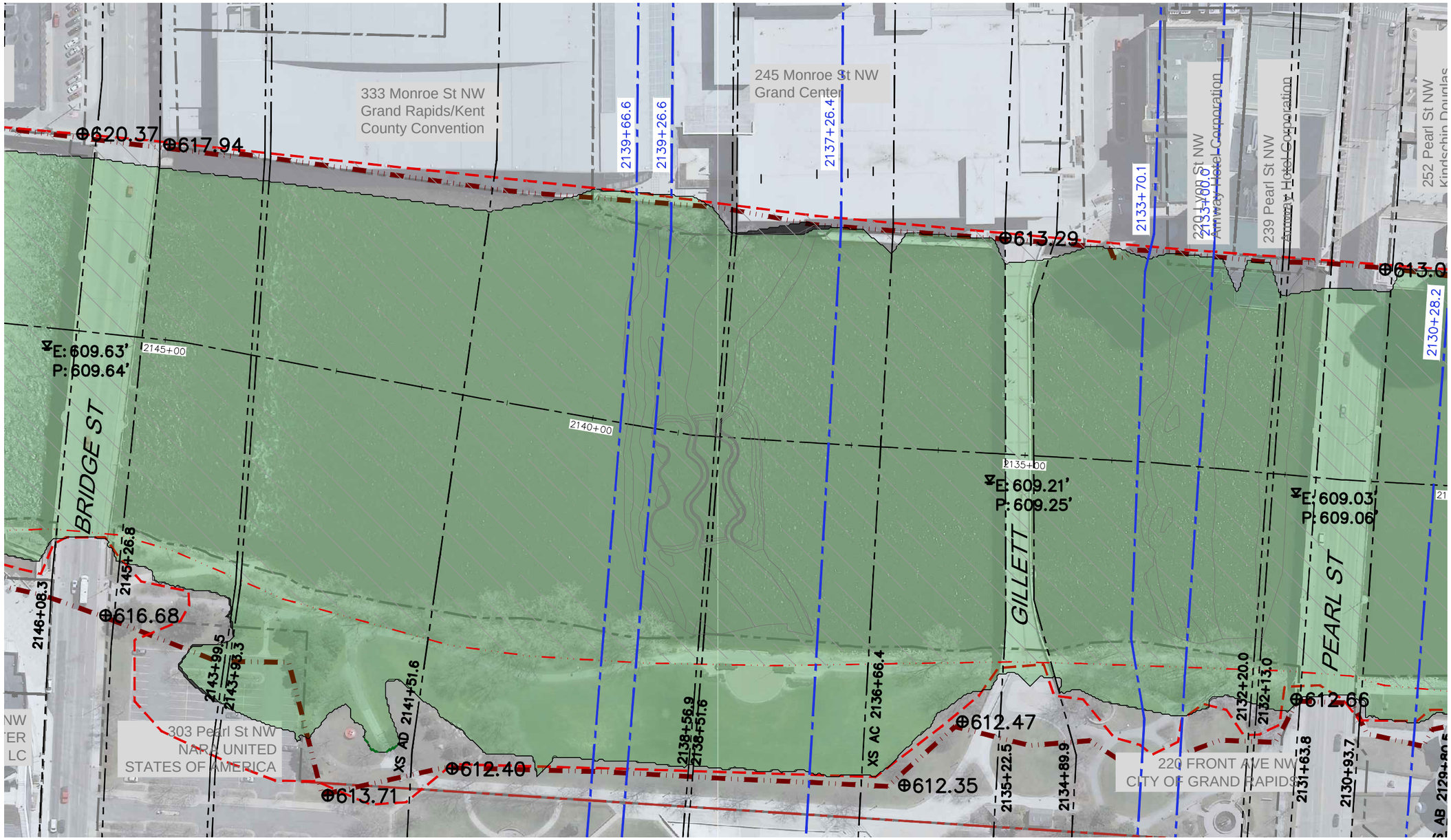
Sheet 1



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- CORRECTED EFFECTIVE SECTION
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- ⧩ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

N

0 60' 120'
SCALE: 1" = 60'

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
BRIDGE ST TO GILLETT
50 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand Rapids, Kent County MI

Project 02.MI01.001
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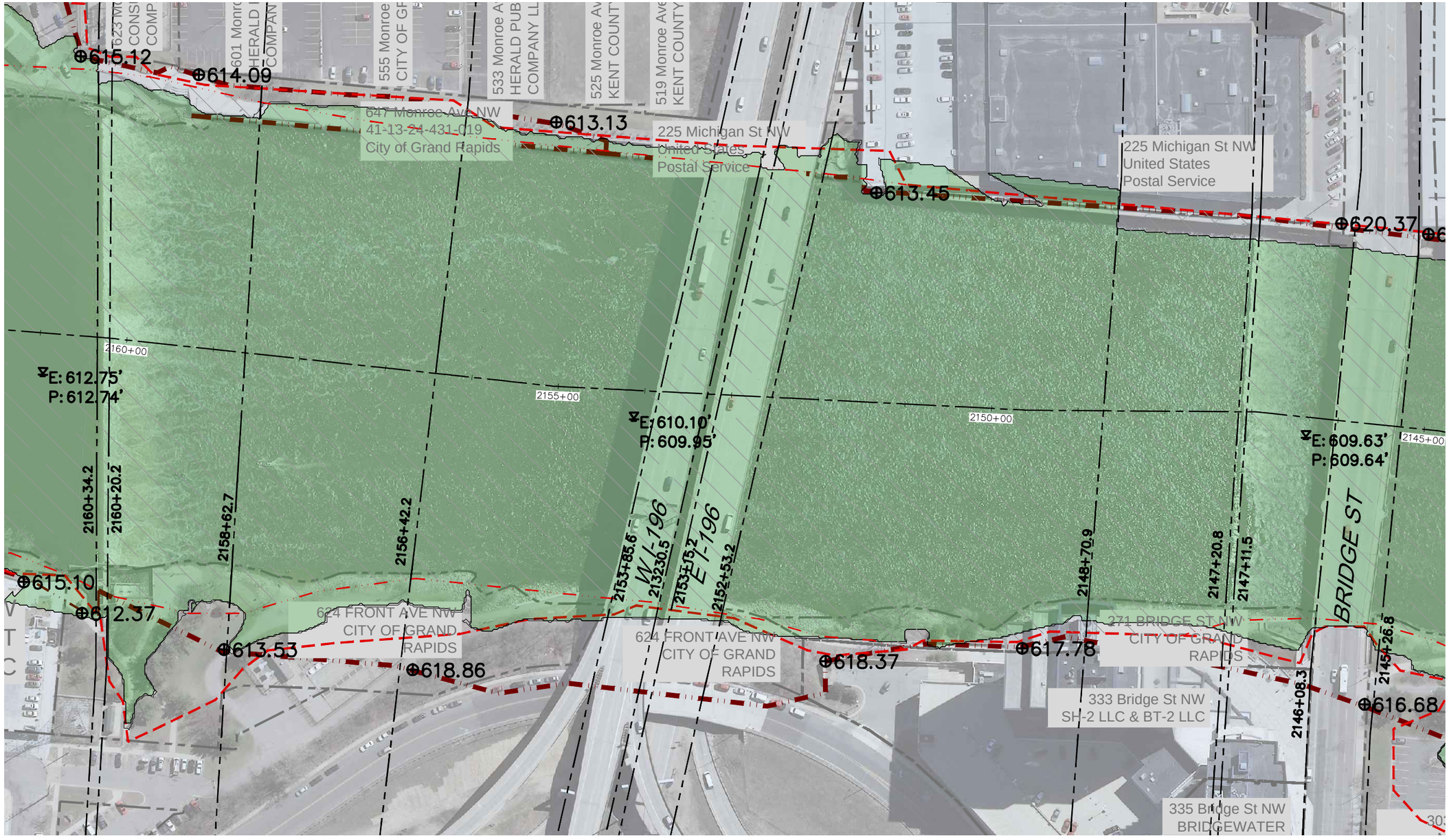

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- CORRECTED EFFECTIVE SECTION
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- ⧩ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION HARMFUL INTERFERENCE EVALUATION 6TH ST DAM TO BRIDGE ST 50 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand Rapids, Kent County MI

Project	Sheet
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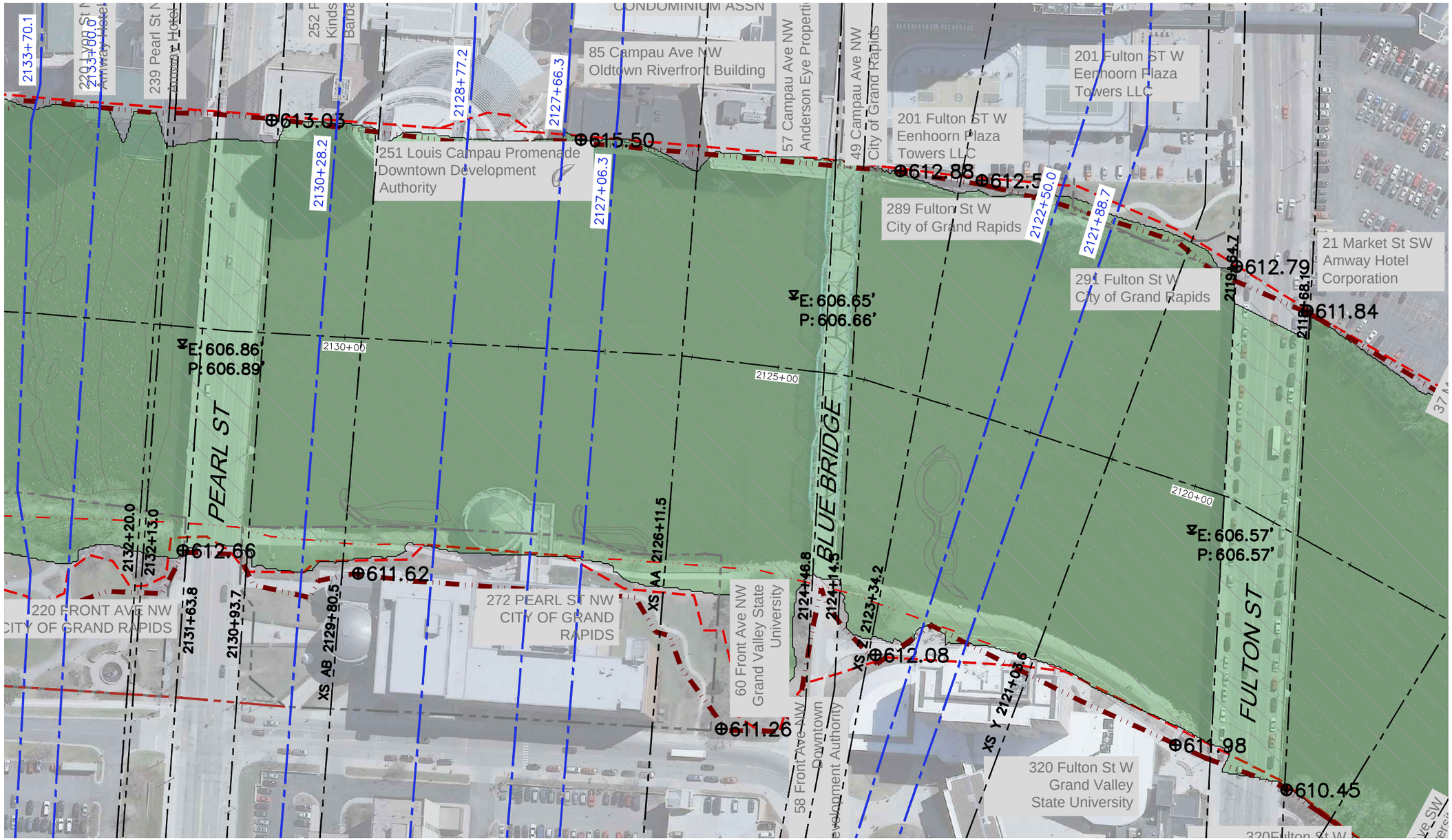

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- CORRECTED EFFECTIVE SECTION
- ⊕ ELEV. FLOOD PROTECTION ELEVATION
- ⧩ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION HARMFUL INTERFERENCE EVALUATION PEARL ST TO US-131 25 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand Rapids, Kent County MI

Project 02.MI01.001
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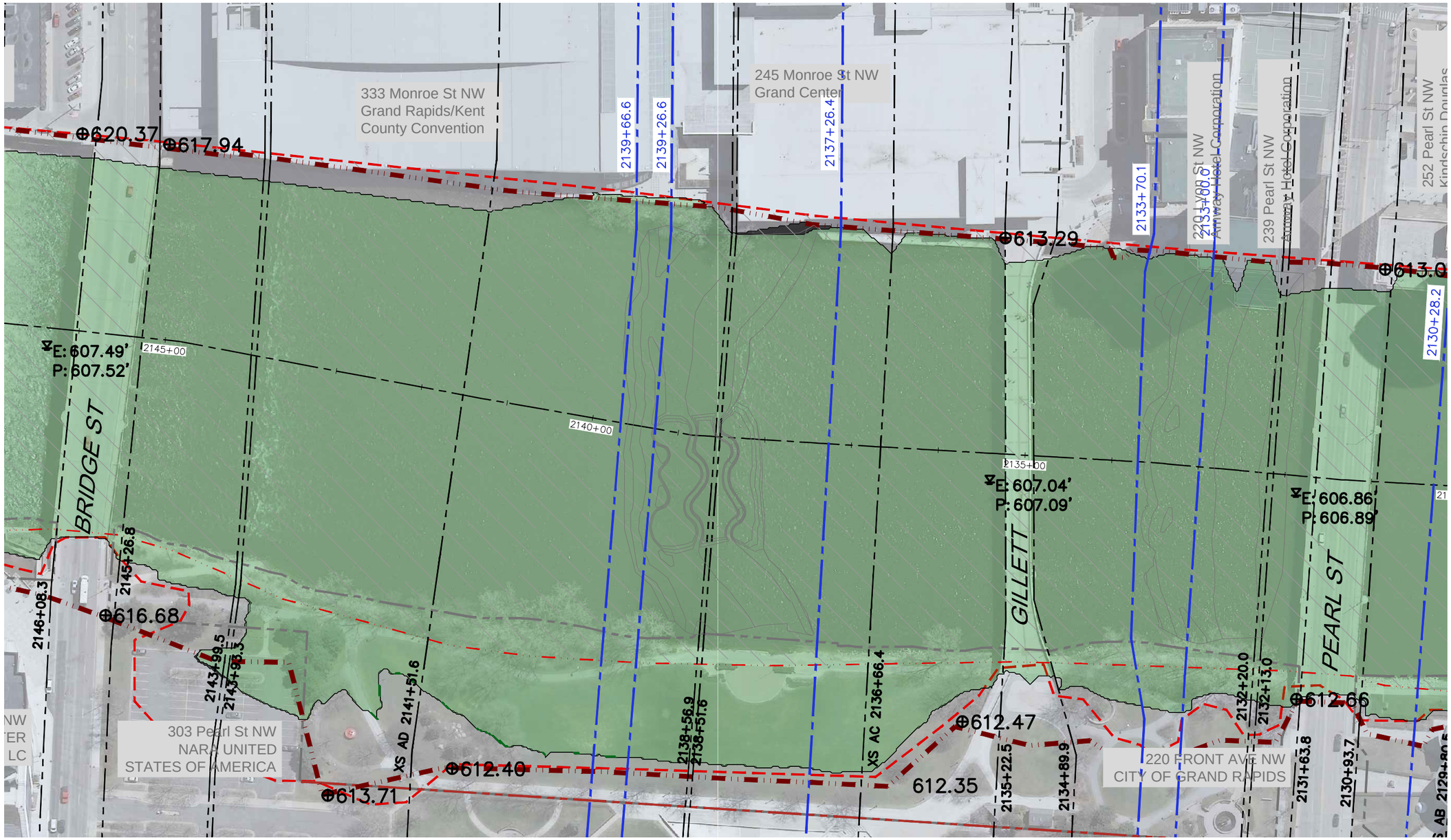

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
BRIDGE ST TO GILLETT
25 YEAR FLOOD

NOT FOR CONSTRUCTION

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Grand River Revitalization
Grand Rapids, Kent County MI

Project 02.MI01.001
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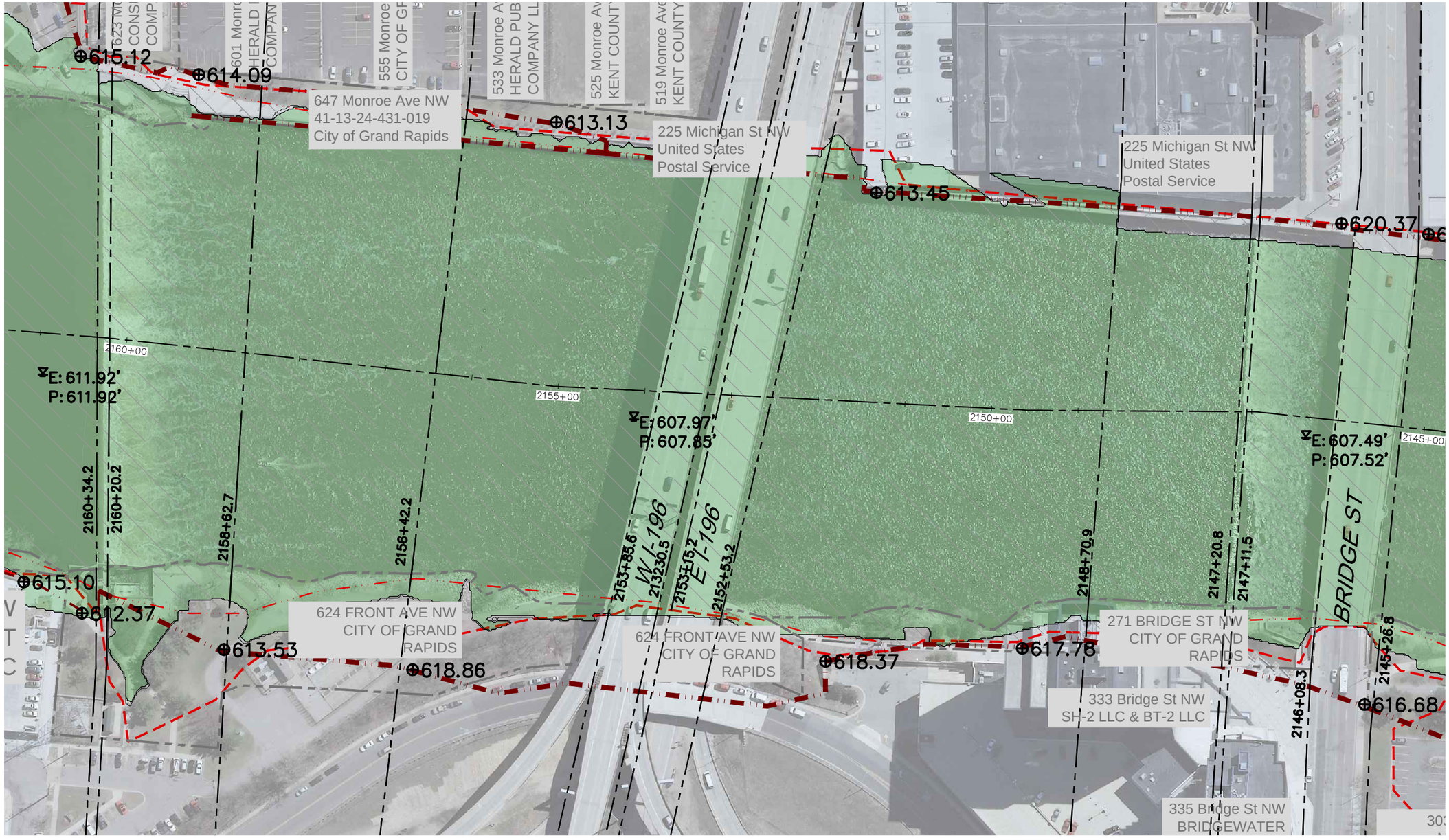

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- CORRECTED EFFECTIVE SECTION
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- ⧖ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

N

0 60' 120'
SCALE: 1" = 60'

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
6TH ST DAM TO BRIDGE ST
25 YEAR FLOOD

NOT FOR CONSTRUCTION

No.	REVISION/UPDATE	Date

CLIENT NAME AND ADDRESS

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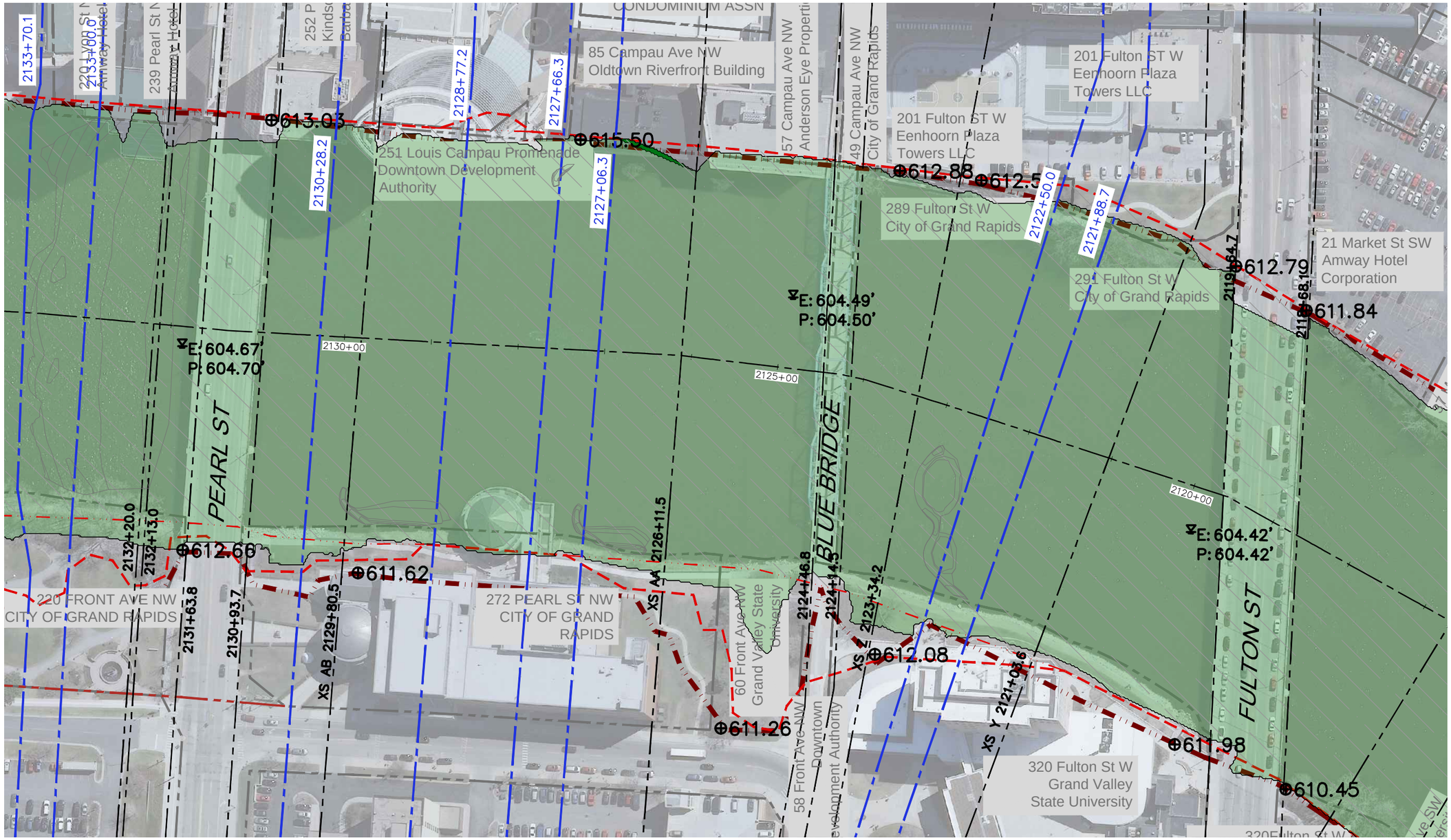
PROJECT NAME AND ADDRESS

Grand River Revitalization
Grand Rapids, Kent County MI

Project 02.MI01.001
Date APR 2024
Scale 1" = 60'
Sheet 3



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N

0 60' 120'
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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
PEARL ST TO US-131
10 YEAR FLOOD

NOT FOR CONSTRUCTION

No.	REVISION/UPDATE	Date

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Grand Rapids WhiteWater
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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
BRIDGE ST TO GILLETT
10 YEAR FLOOD

NOT FOR CONSTRUCTION

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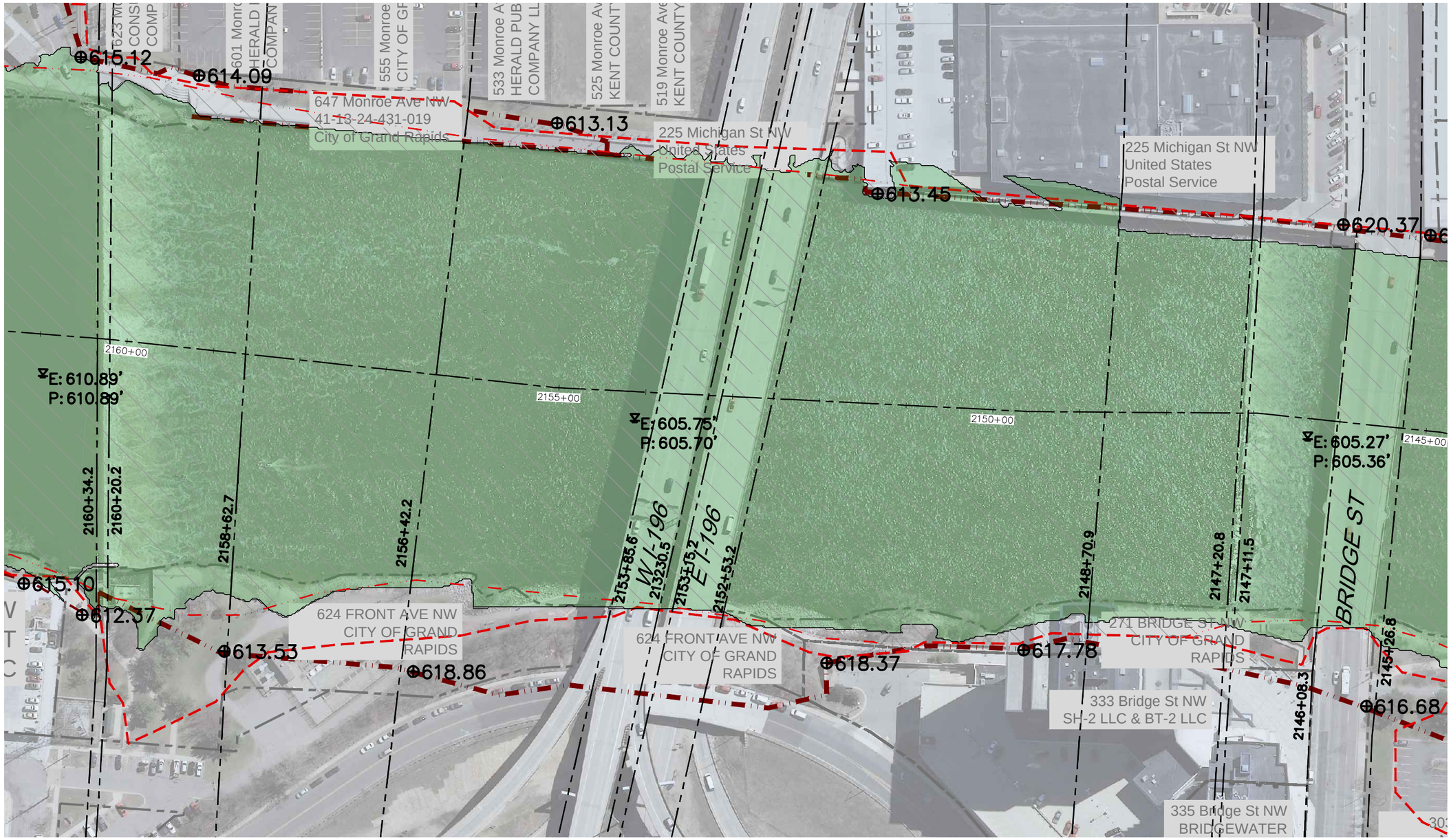

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
6TH ST DAM TO BRIDGE ST
10 YEAR FLOOD

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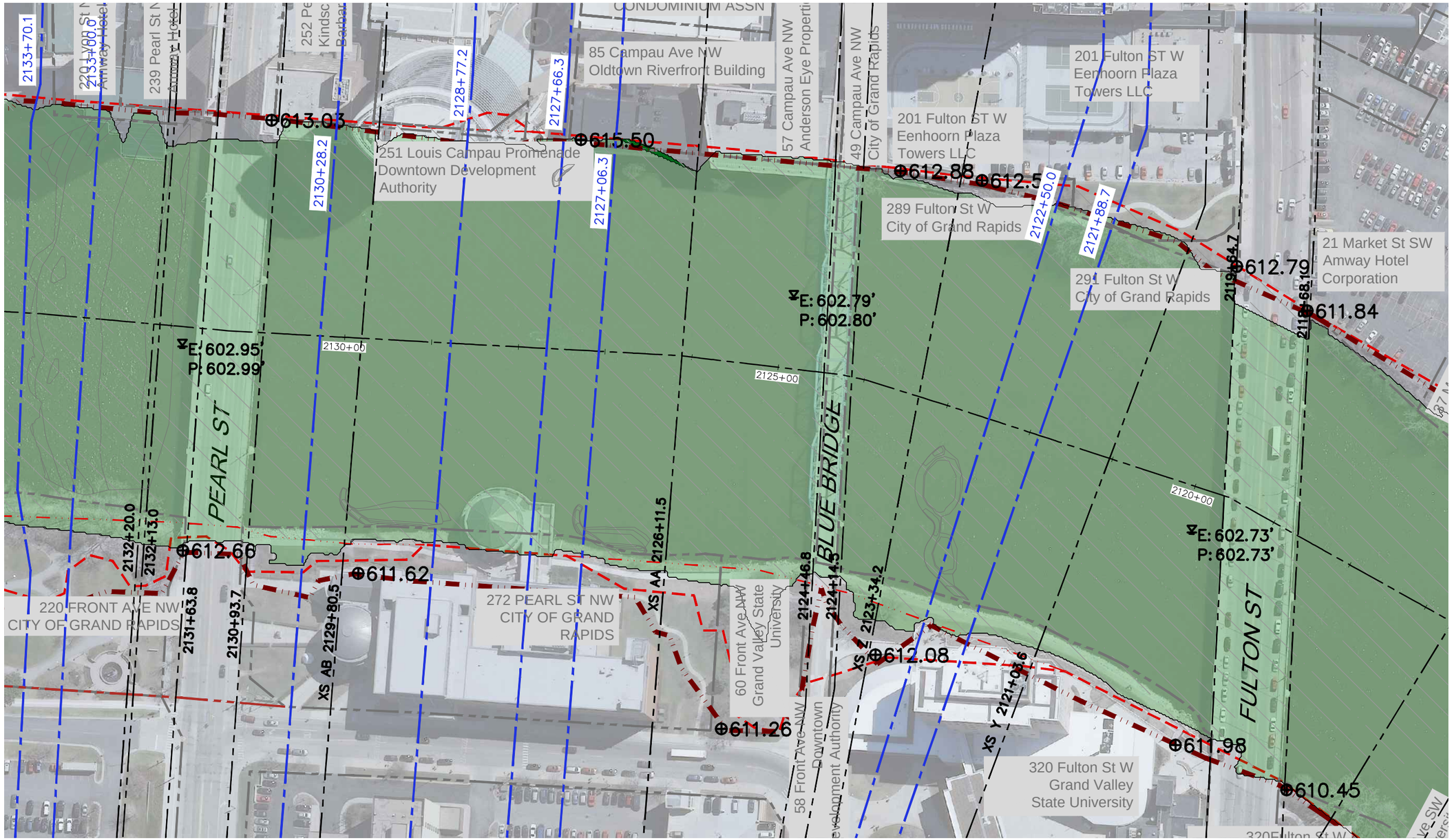

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
PEARL ST TO US-131
5 YEAR FLOOD

NOT FOR CONSTRUCTION

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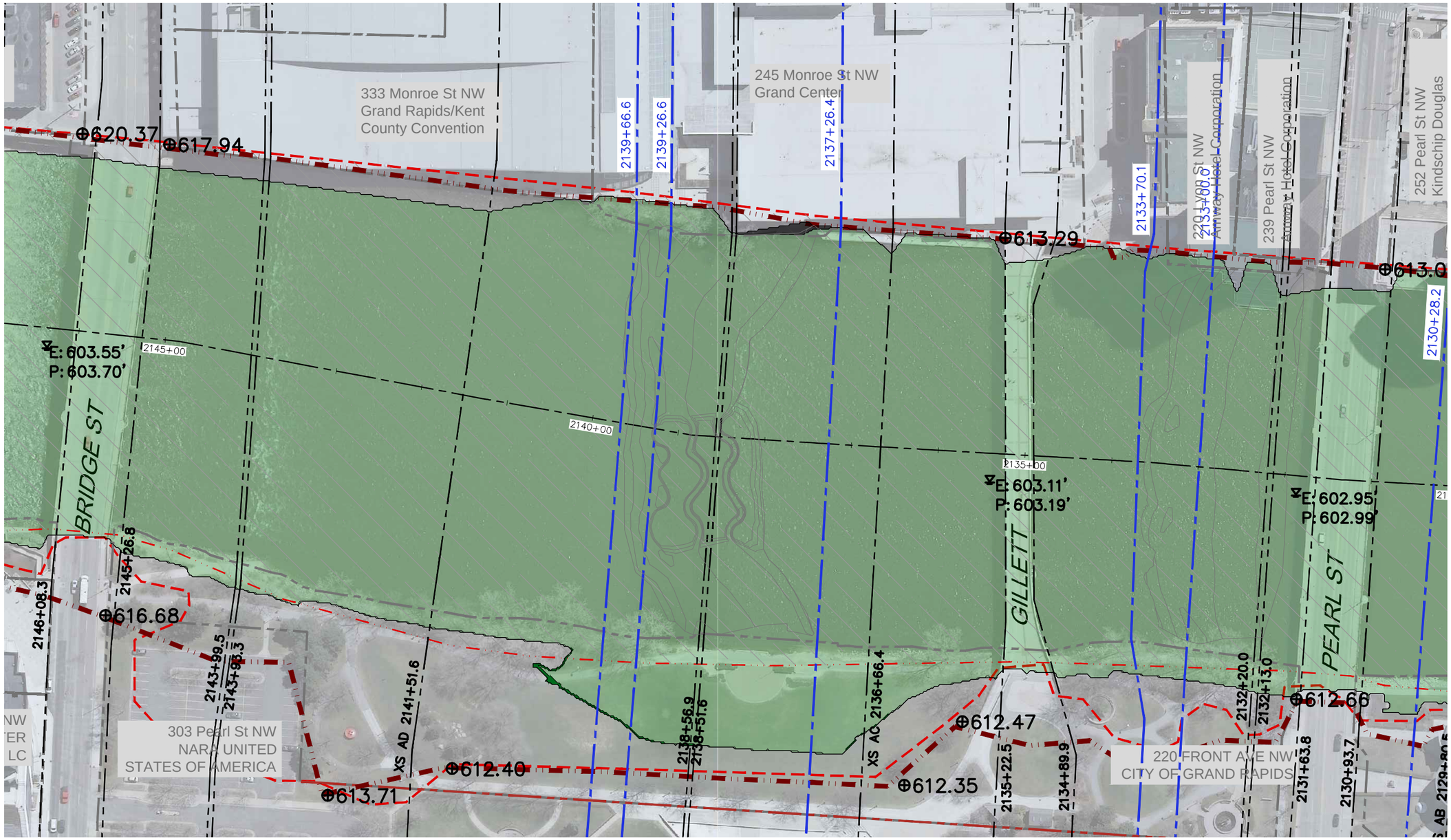

LEGEND

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N

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
BRIDGE ST TO GILLETT
5 YEAR FLOOD

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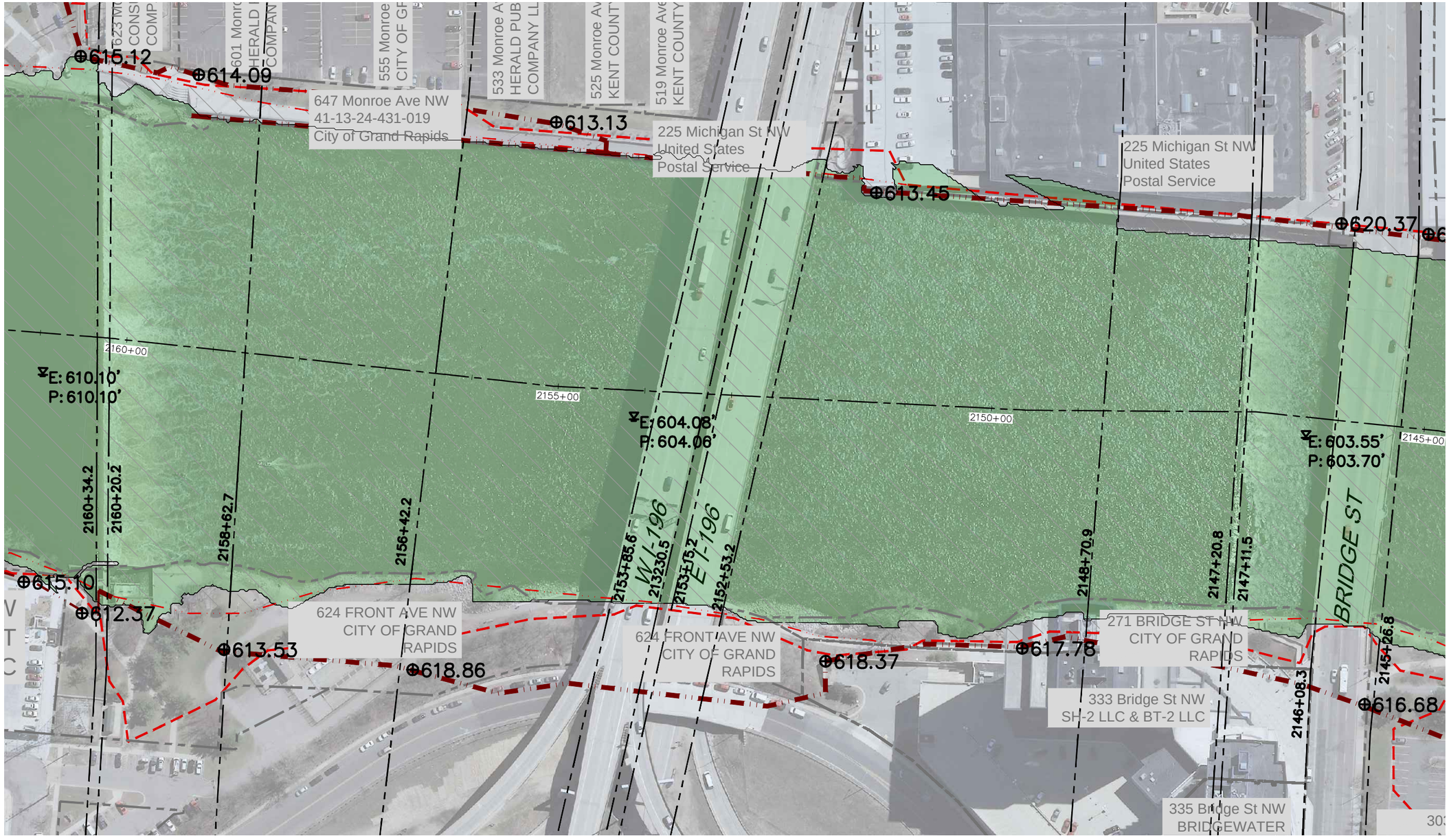

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

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6TH ST DAM TO BRIDGE ST
5 YEAR FLOOD

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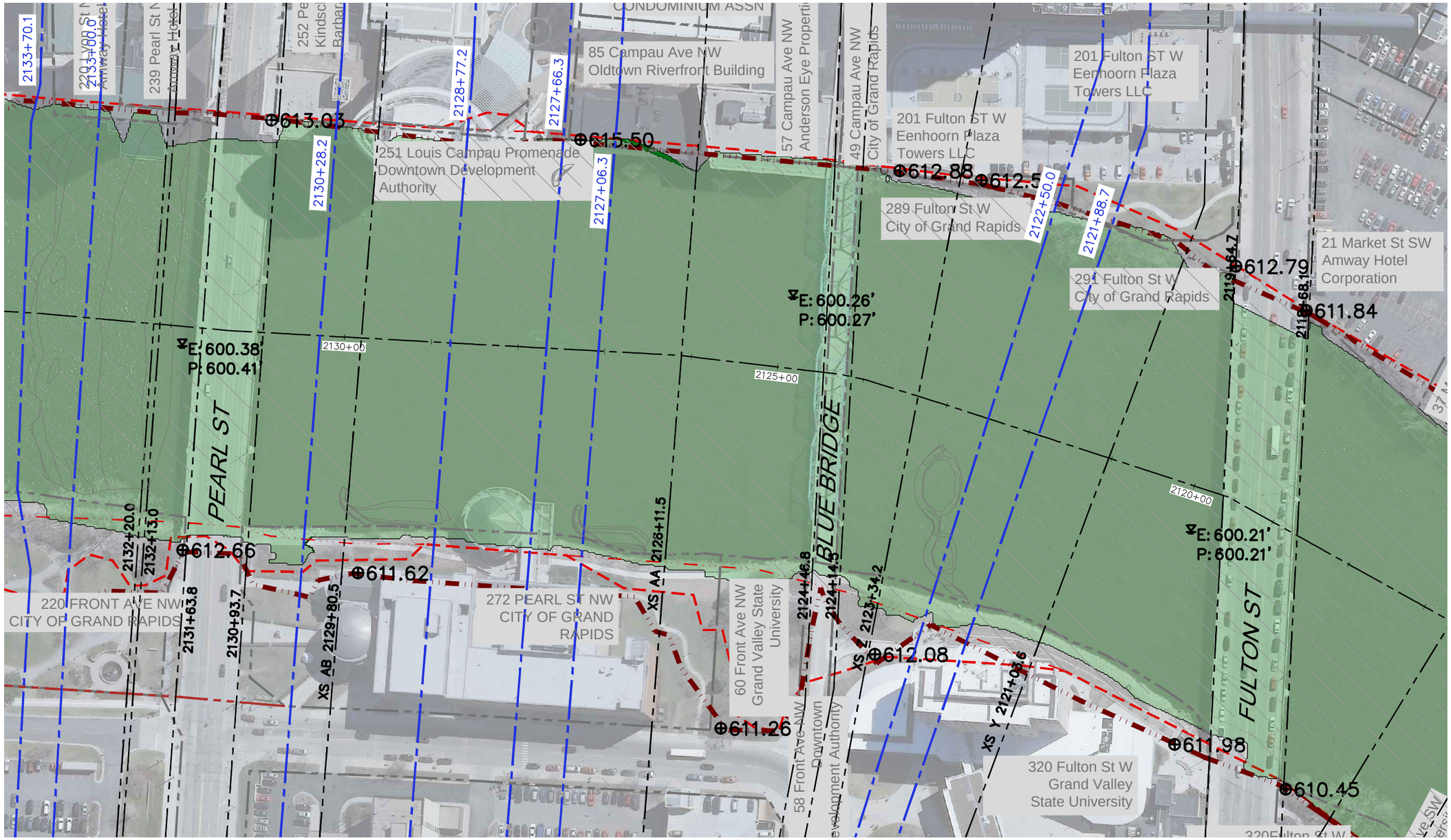

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PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION HARMFUL INTERFERENCE EVALUATION PEARL ST TO US-131 2 YEAR FLOOD

NOT FOR CONSTRUCTION

No.	REVISION/UPDATE	Date

CLIENT NAME AND ADDRESS

Grand Rapids WhiteWater
502 Second Street NW Suite 300
Grand Rapids, MI 49504
grandrapidswhitewater.org

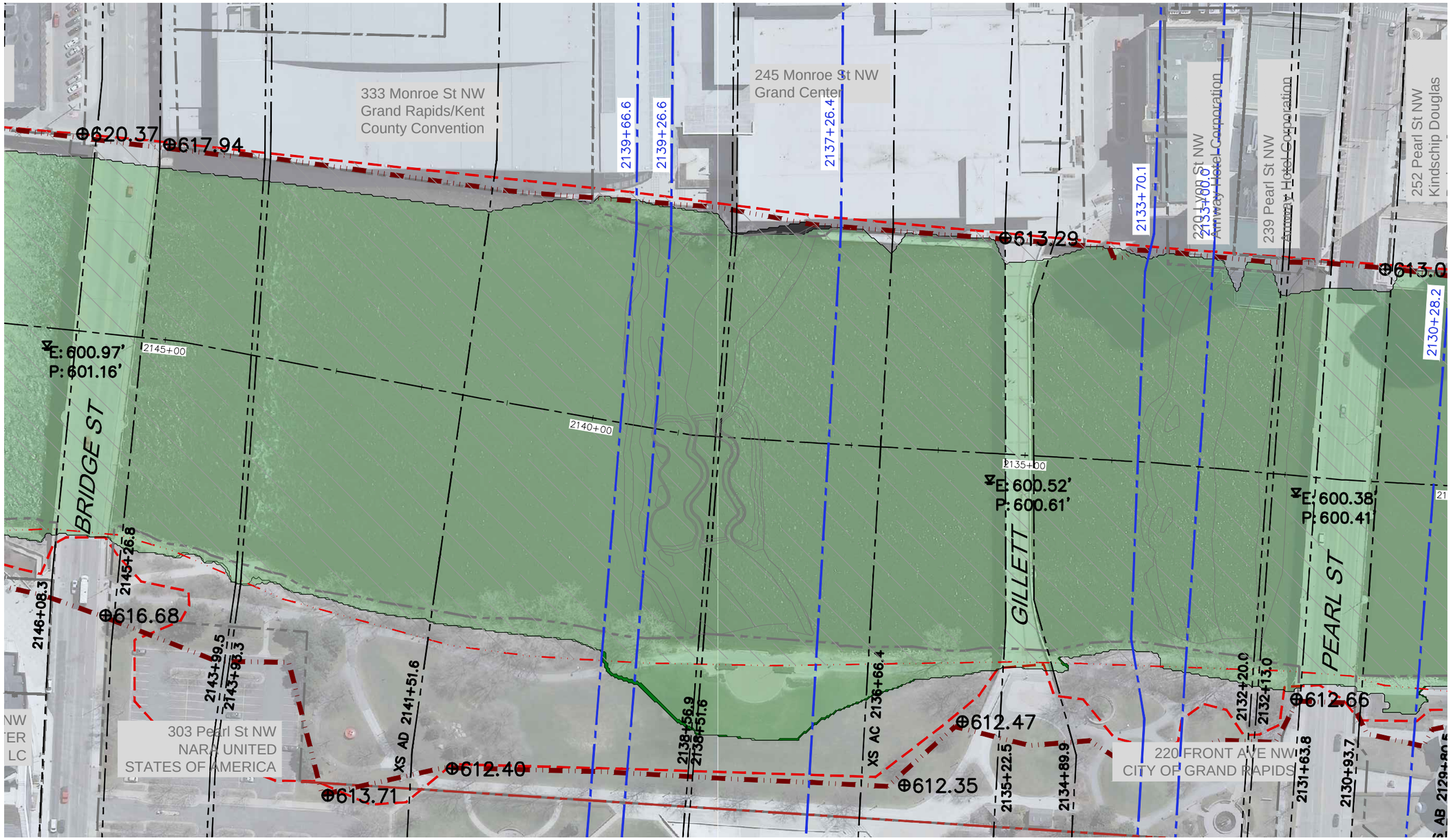
DESIGN FIRM NAME AND ADDRESS

P.O. Box 248
Carbondale, CO 81623
www.RiverRestoration.org

PROJECT NAME AND ADDRESS

Grand River Revitalization
Grand Rapids, Kent County MI

Project 02.MI01.001
Date APR 2024
Scale 1" = 60'
Sheet 1



LEGEND

- PROPOSED EFFECTIVE IMPACT AREA
- AREA OF INCREASED IMPACT
- AREA OF DECREASED IMPACT
- EXISTING FLOOD EMBANKMENT
- EXISTING FLOODWALL
- EFFECTIVE FEMA FIS 100 YEAR LIMITS OF IMPACT
- FEMA FLOODWAY BOUNDARY
- PROPERTY PARCEL BOUNDARY
- EFFECTIVE SECTION
- CORRECTED EFFECTIVE SECTION
- ⊕ ELEV. — FLOOD PROTECTION ELEVATION
- ⧩ ELEV. — MODELED 100 YEAR FLOOD ELEVATIONS

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
BRIDGE ST TO GILLETT
2 YEAR FLOOD

NOT FOR CONSTRUCTION

No.	REVISION/UPDATE	Date

CLIENT NAME AND ADDRESS

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Grand Rapids, MI 49504
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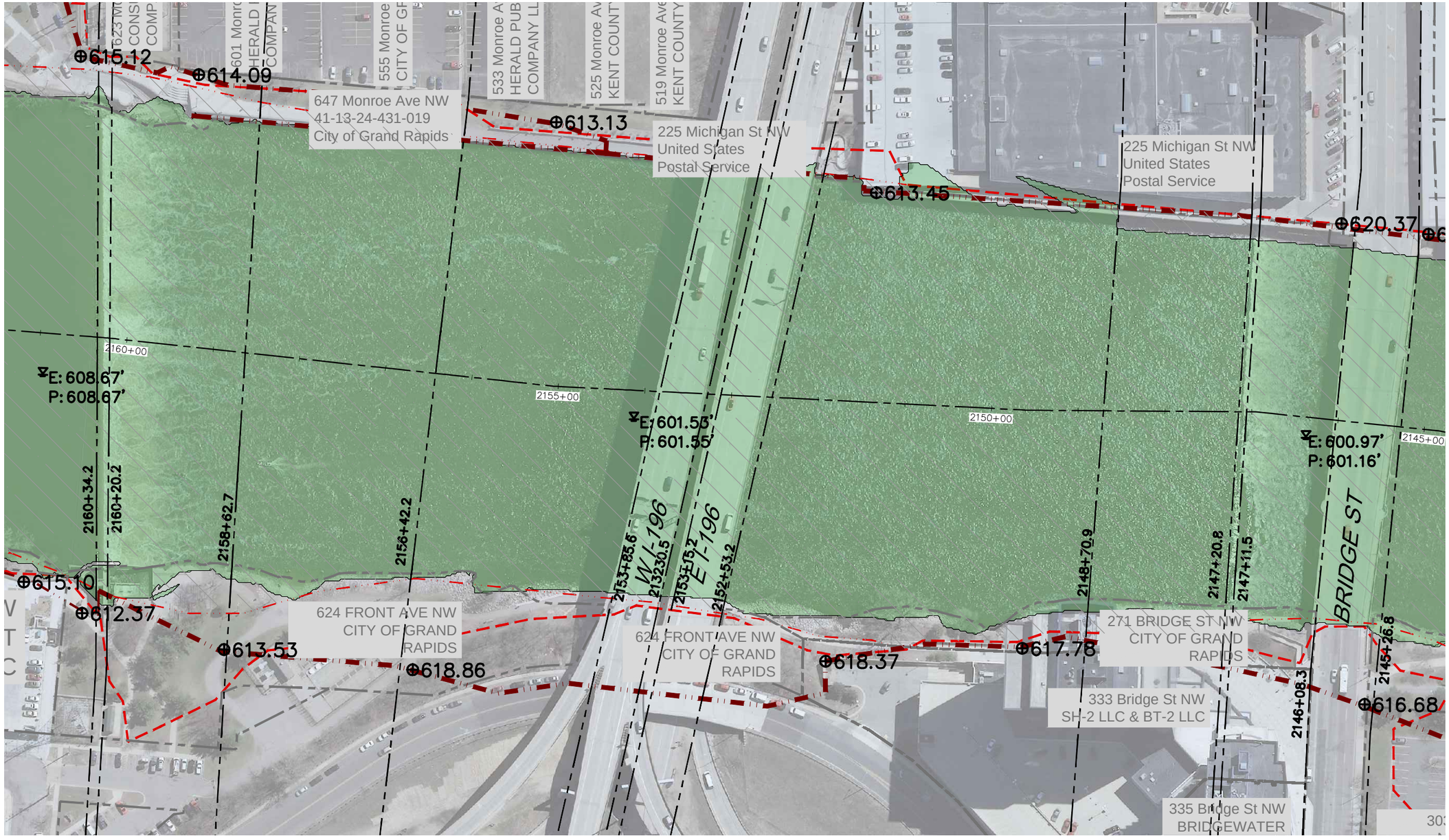
PROJECT NAME AND ADDRESS

Grand River Revitalization
Grand Rapids, Kent County MI

Project	Sheet
02.MI01.001	2
Date: APR 2024	
Scale: 1" = 60'	



N

0 60' 120'

SCALE: 1" = 60'

LEGEND

- PROPOSED EFFECTIVE IMPACT AREA
- AREA OF INCREASED IMPACT
- AREA OF DECREASED IMPACT
- EXISTING FLOOD EMBANKMENT
- EXISTING FLOODWALL
- EFFECTIVE FEMA FIS 100 YEAR LIMITS OF IMPACT
- FEMA FLOODWAY BOUNDARY
- PROPERTY PARCEL BOUNDARY
- EFFECTIVE SECTION
- CORRECTED EFFECTIVE SECTION
- ⊕ ELEV. FLOOD PROTECTION ELEVATION
- ⧖ ELEV. MODELED 100 YEAR FLOOD ELEVATIONS

PROFESSIONAL ENGINEER STAMP

PRELIMINARY

GRAND RIVER REVITALIZATION
HARMFUL INTERFERENCE EVALUATION
6TH ST DAM TO BRIDGE ST
2 YEAR FLOOD

NOT FOR CONSTRUCTION

No.	REVISION/UPDATE	Date

CLIENT NAME AND ADDRESS

Grand Rapids WhiteWater

502 Second Street NW Suite 300
Grand Rapids, MI 49504
grandrapidswhitewater.org

DESIGN FIRM NAME AND ADDRESS

P.O. Box 248
Carbondale, CO 81623
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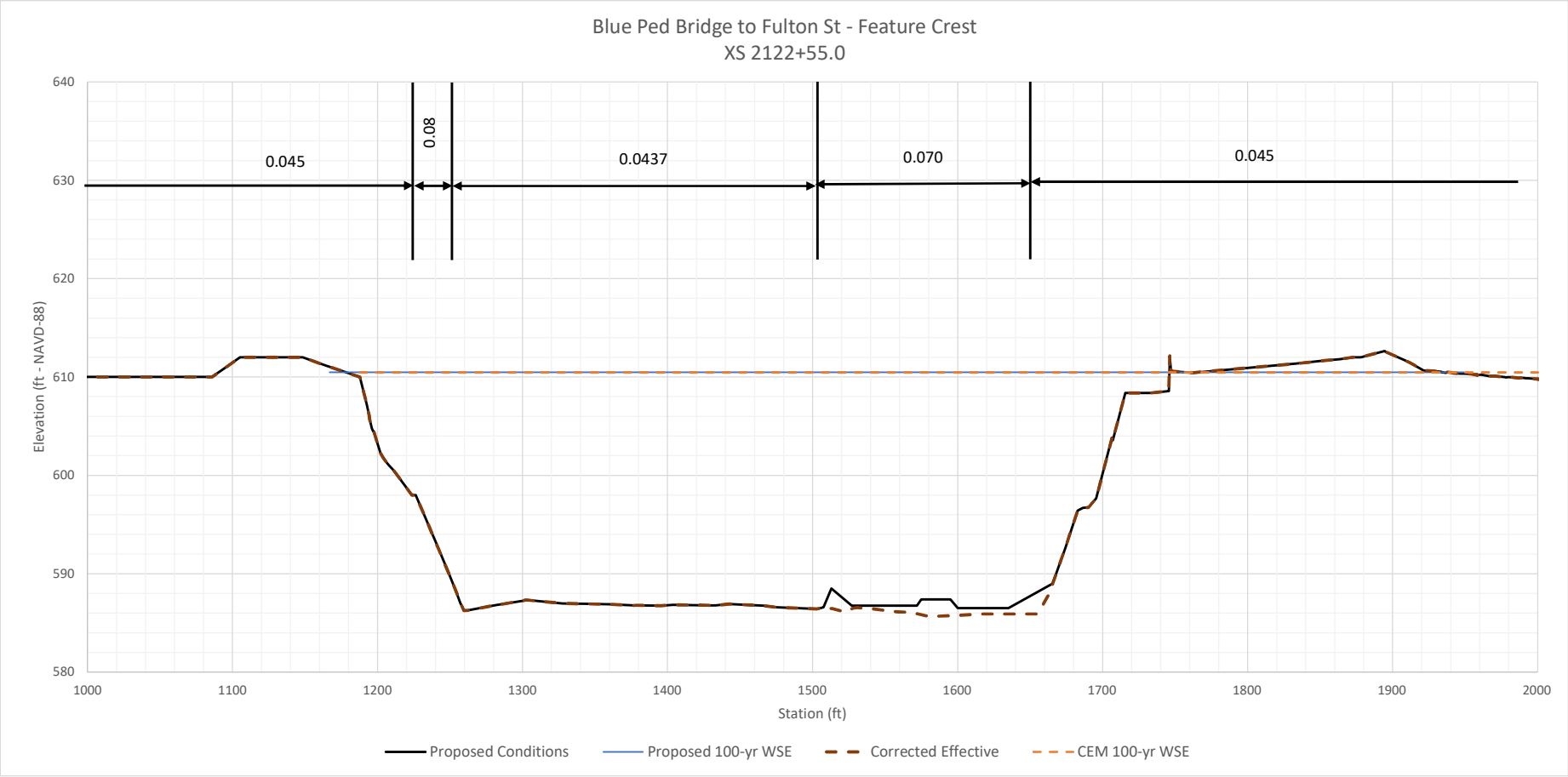
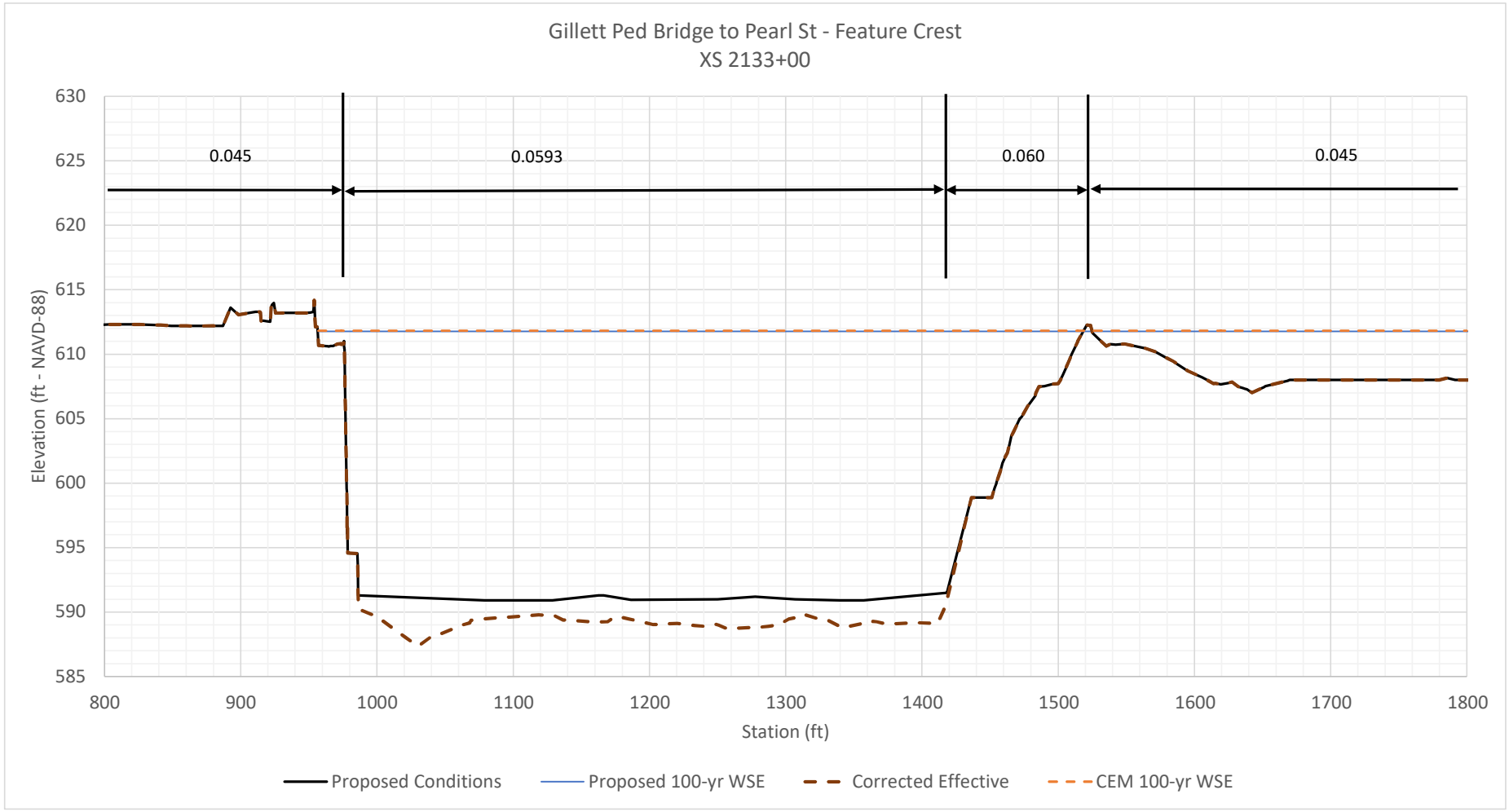
PROJECT NAME AND ADDRESS

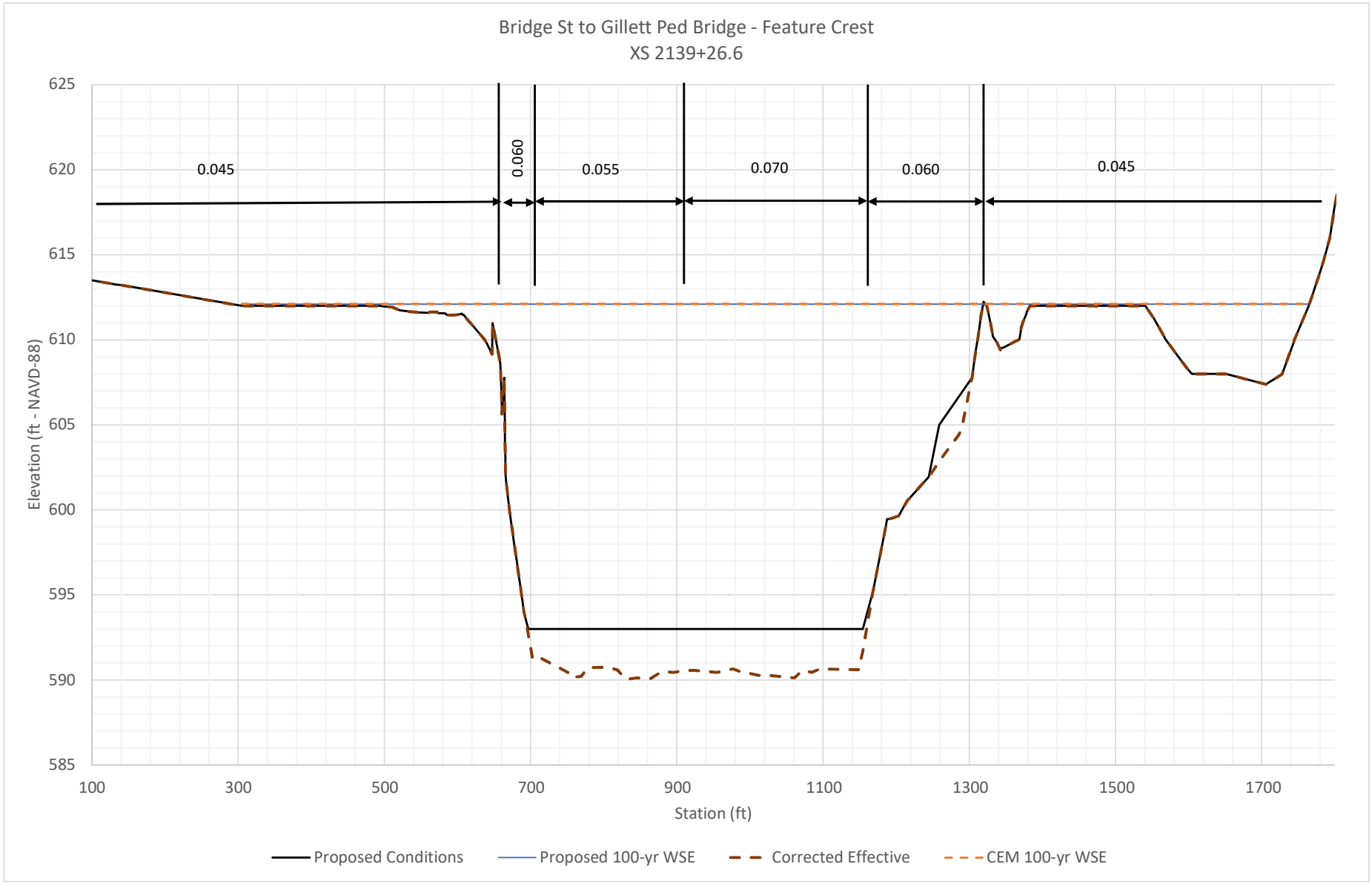
Grand River Revitalization
Grand Rapids, Kent County MI

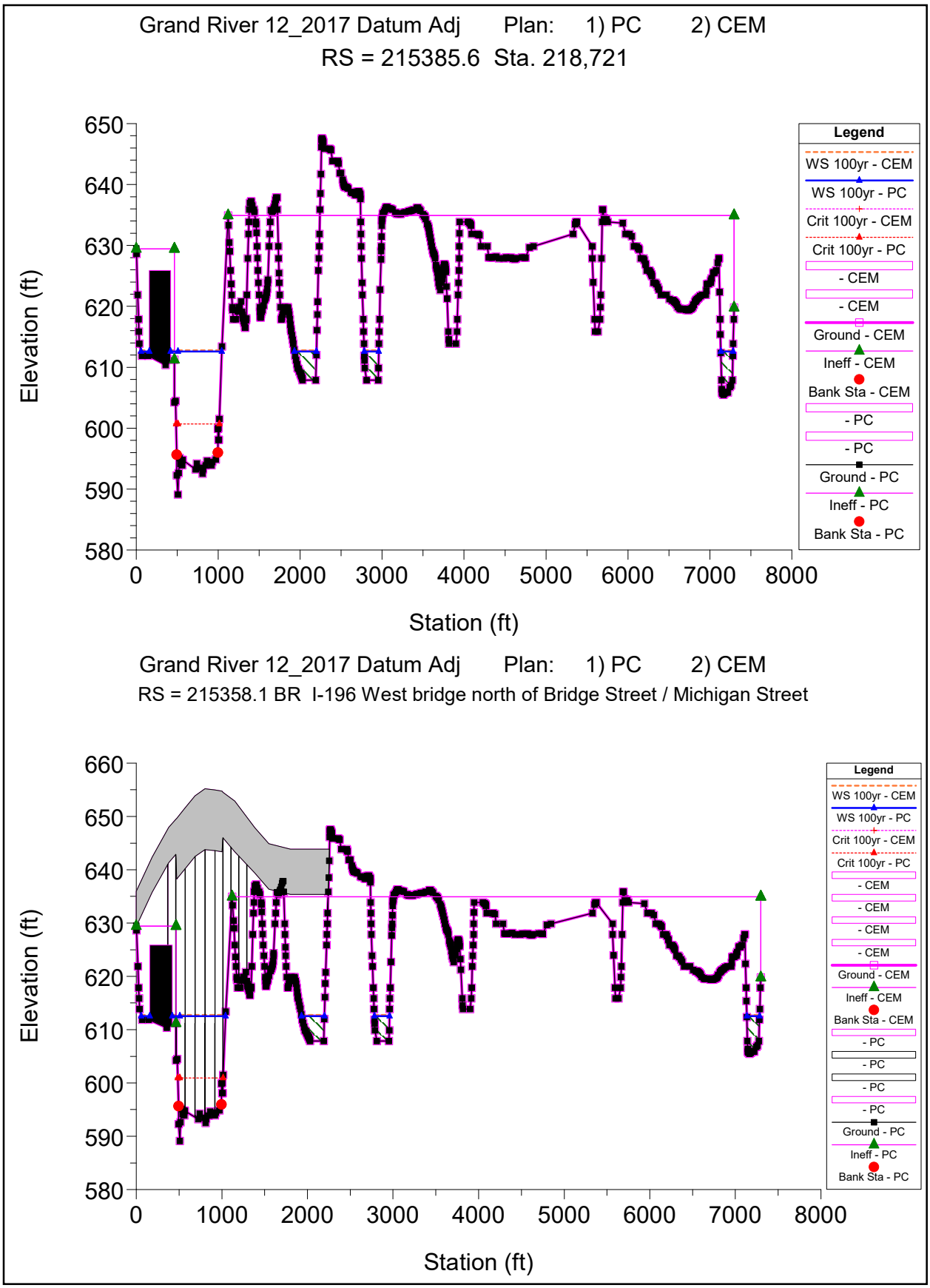
Project	Sheet
02.MI01.001	3
Date: APR 2024	
Scale: 1" = 60'	

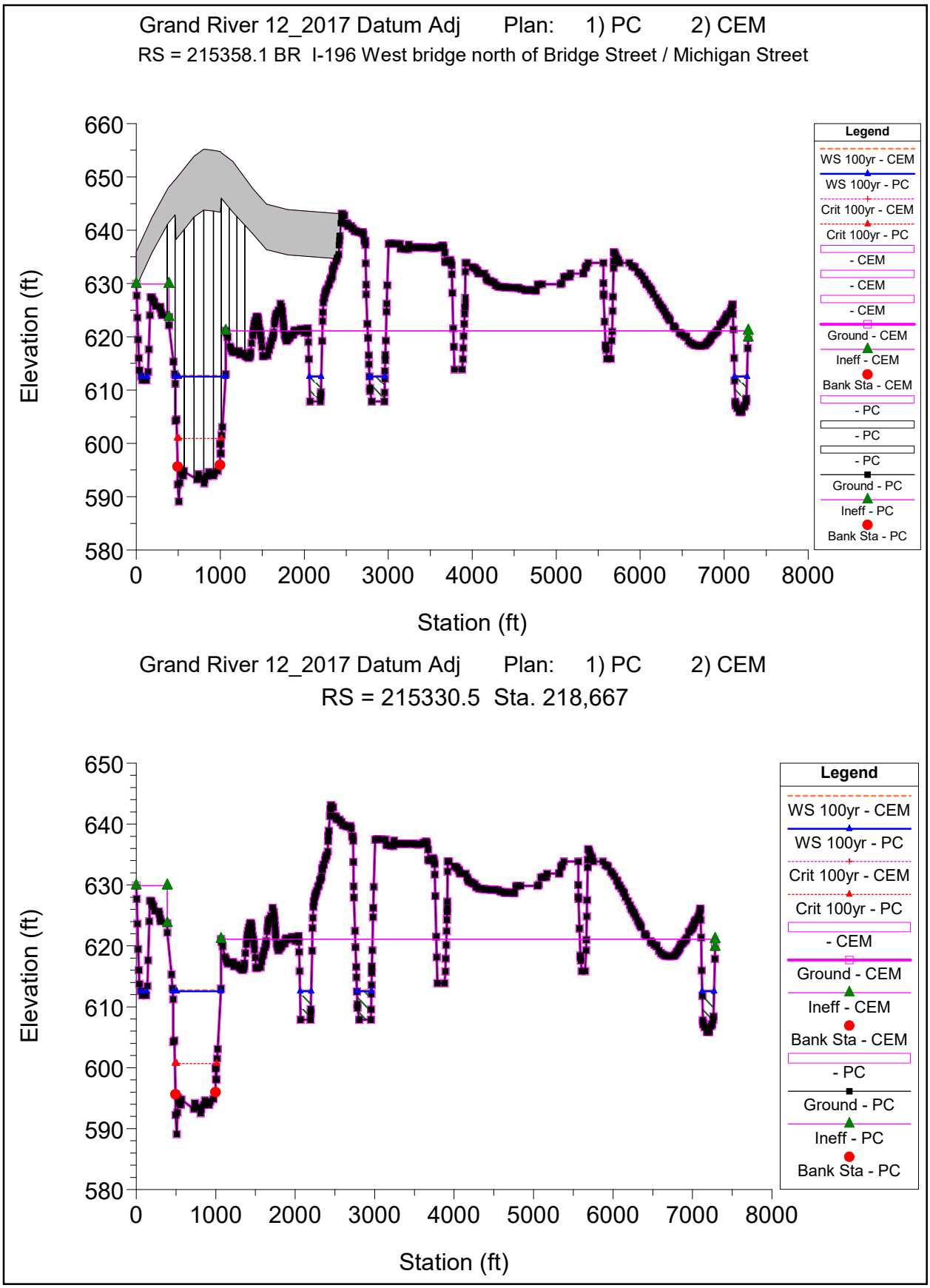
ATTACHMENT 10:
HYDRAULIC MODEL – CROSS SECTION OUTPUT

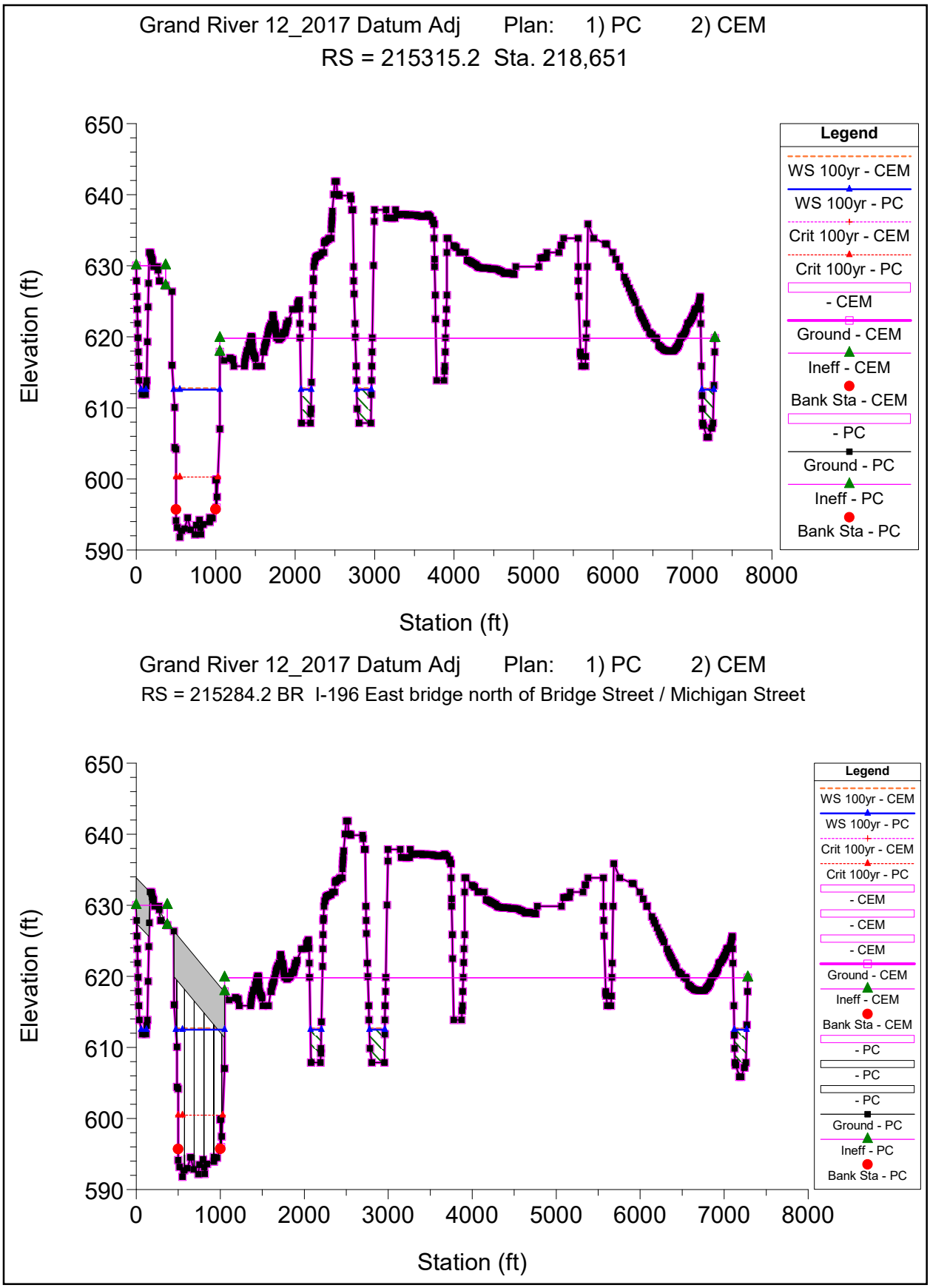

Blue Ped Bridge to Fulton St - Feature Crest
XS 2122+55.0
0.045
0.08
0.0437
0.070
0.045
Elevation (ft - NAVD-88)
640
630
620
610
600
590
580
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Station (ft)
Proposed Conditions
Proposed 100-yr WSE
Corrected Effective
CEM 100-yr WSE

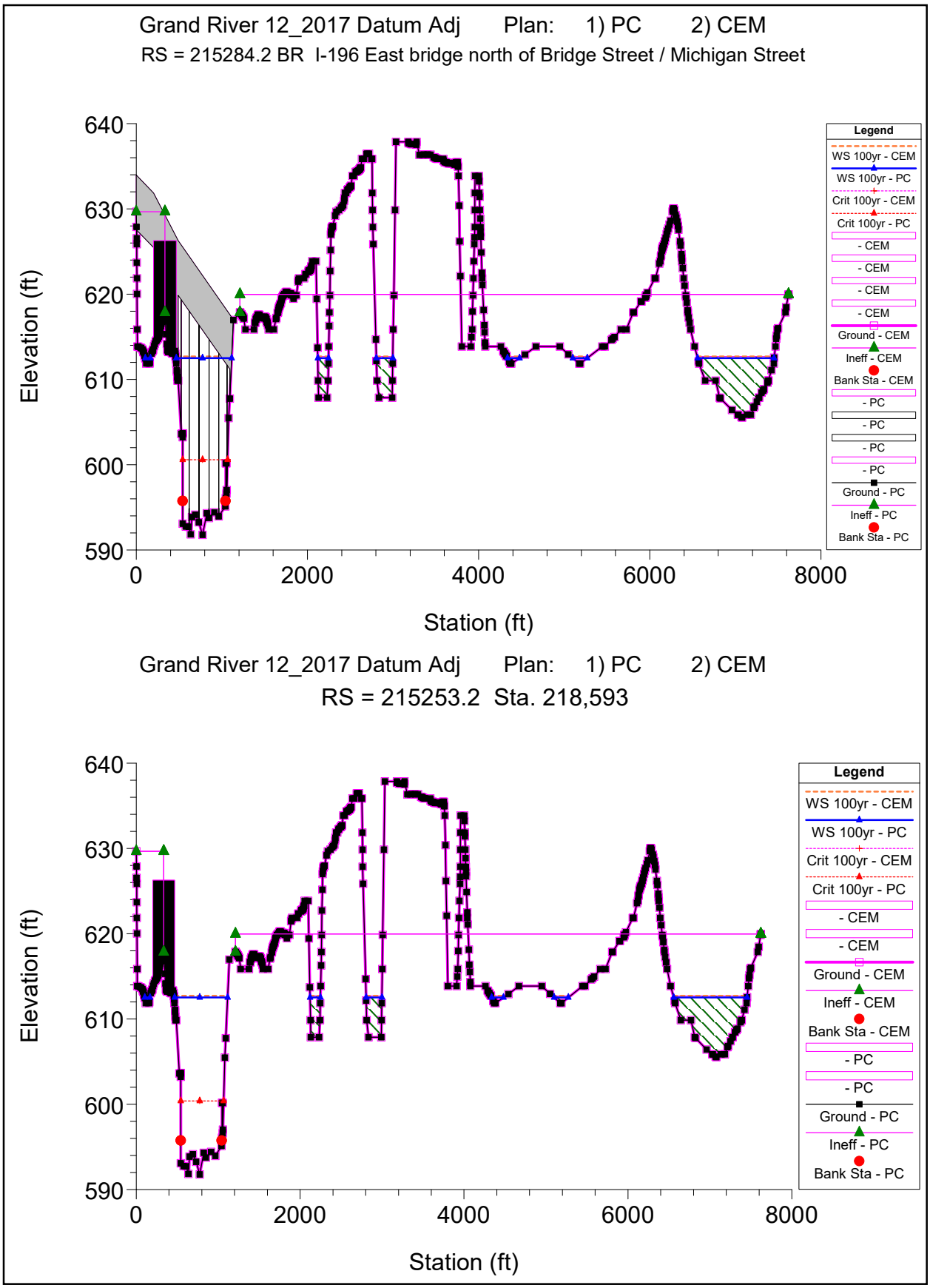

Gillett Ped Bridge to Pearl St - Feature Crest
XS 2133+00
0.045
0.0593
0.060
0.045
Elevation (ft - NAVD-88)
630
625
620
615
610
605
600
595
590
585
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
Station (ft)
Proposed Conditions
Proposed 100-yr WSE
Corrected Effective
CEM 100-yr WSE

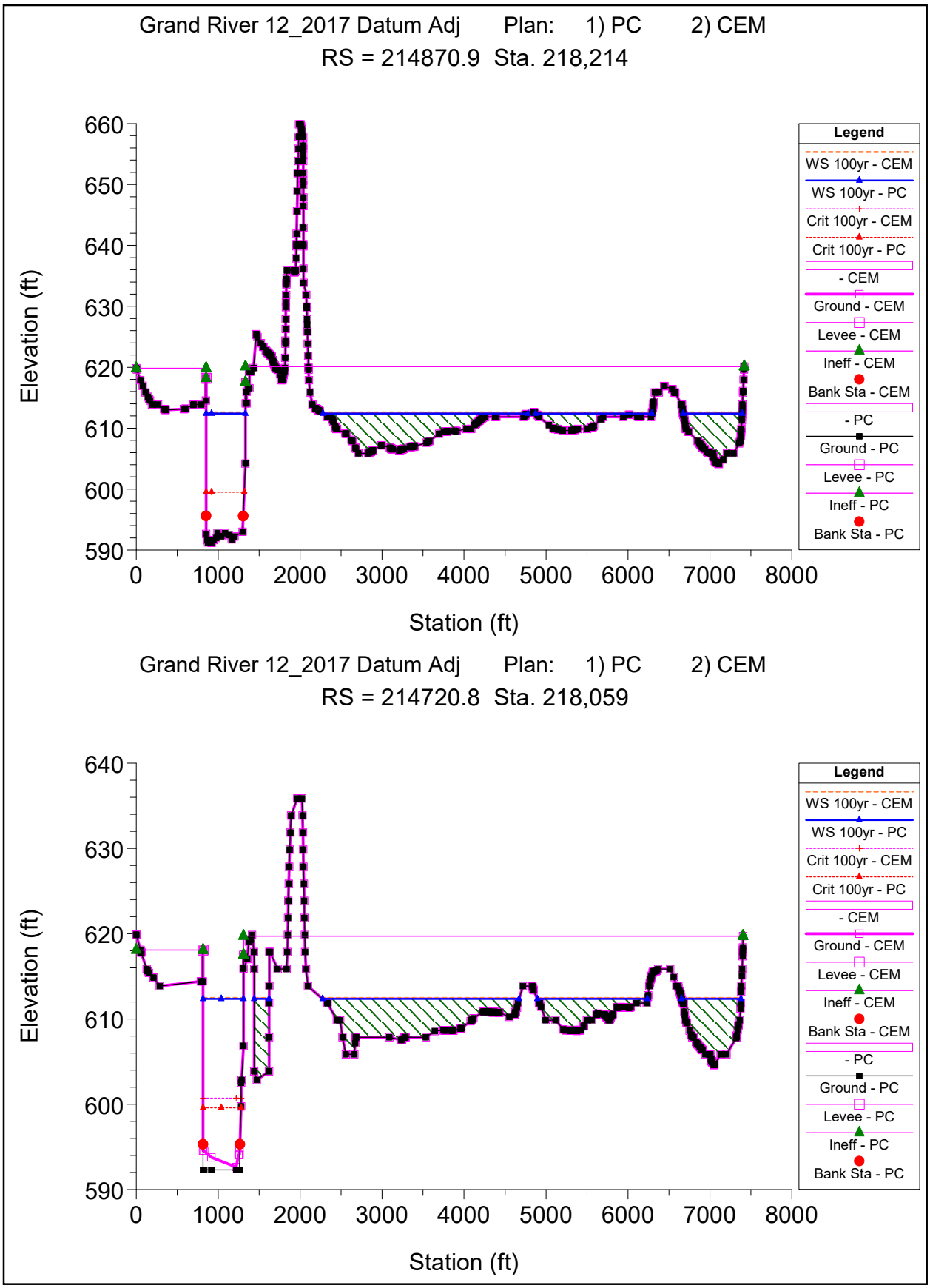

Bridge St to Gillett Ped Bridge - Feature Crest
XS 2139+26.6
0.045
0.060
0.055
0.070
0.060
0.045
Elevation (ft - NAVD-88)
625
620
615
610
605
600
595
590
585
100
300
500
700
900
1100
1300
1500
1700
Station (ft)
Proposed Conditions
Proposed 100-yr WSE
Corrected Effective
CEM 100-yr WSE

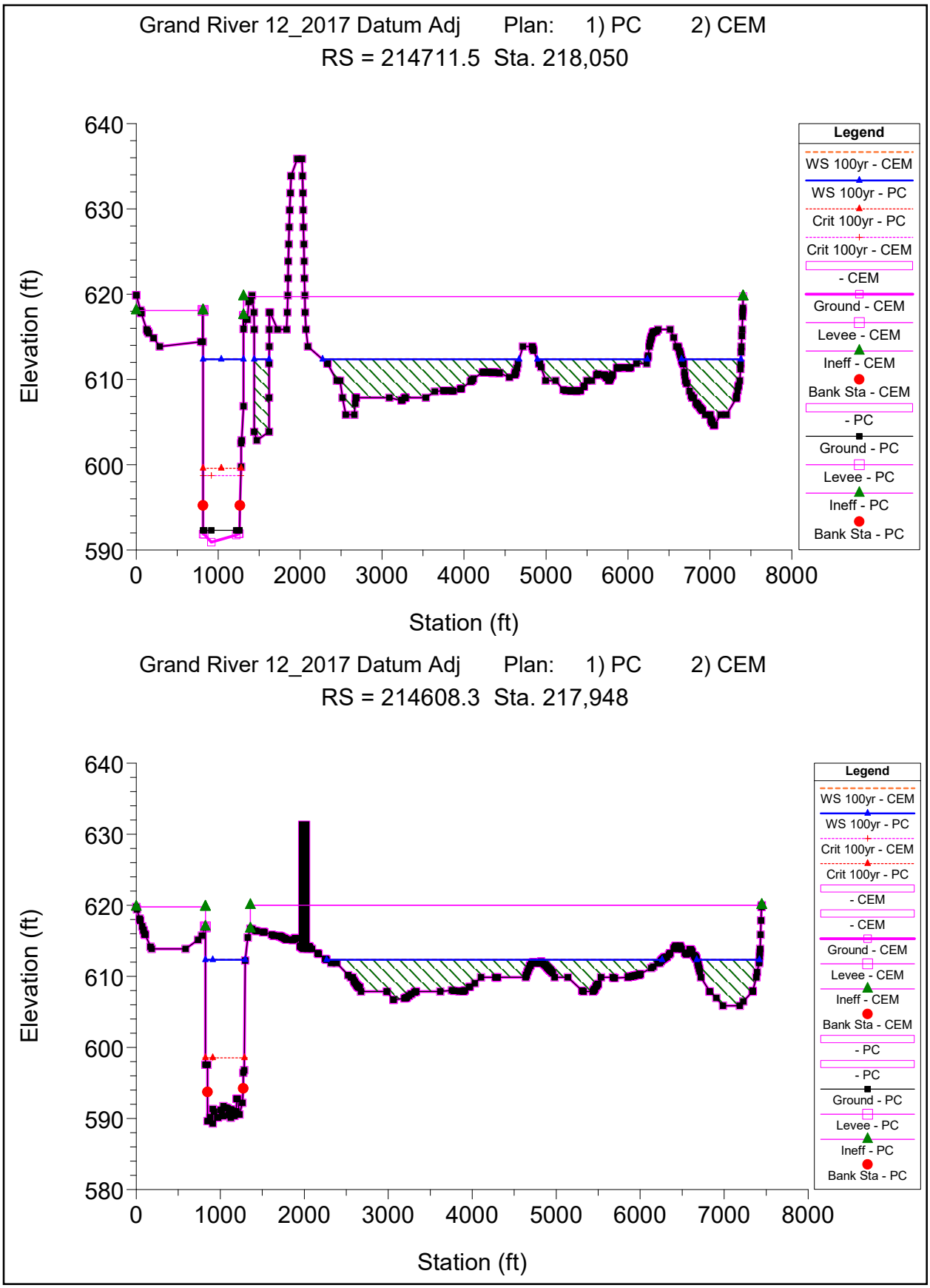

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215385.6 Sta. 218,721
Elevation (ft)
650
640
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215358.1 BR I-196 West bridge north of Bridge Street / Michigan Street
Elevation (ft)
660
650
640
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
Ground - PC
Ineff - PC
Bank Sta - PC

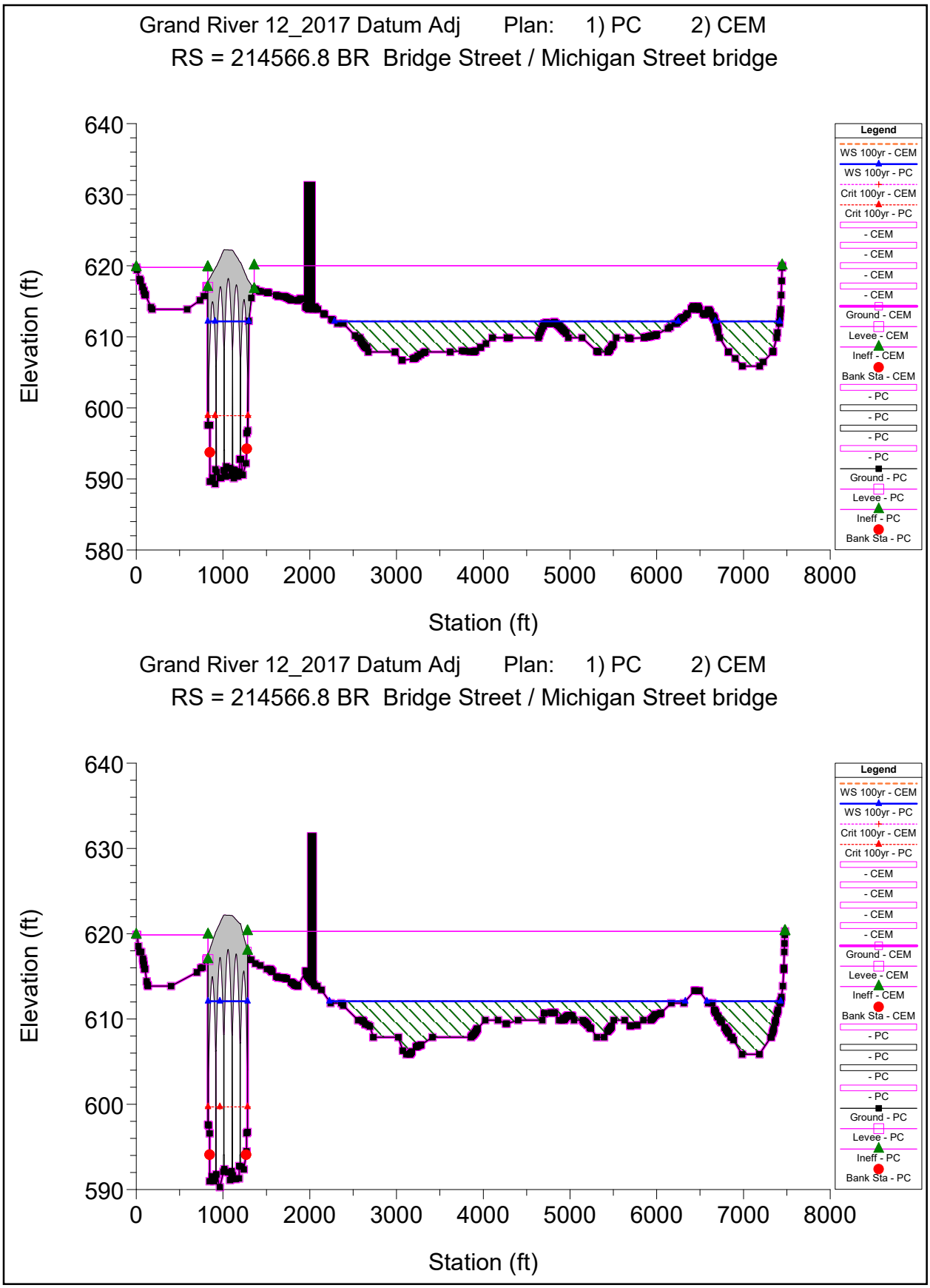

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215358.1 BR I-196 West bridge north of Bridge Street / Michigan Street
Elevation (ft)
660
650
640
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
Ground - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215330.5 Sta. 218,667
Elevation (ft)
650
640
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Ineff - PC
Bank Sta - PC

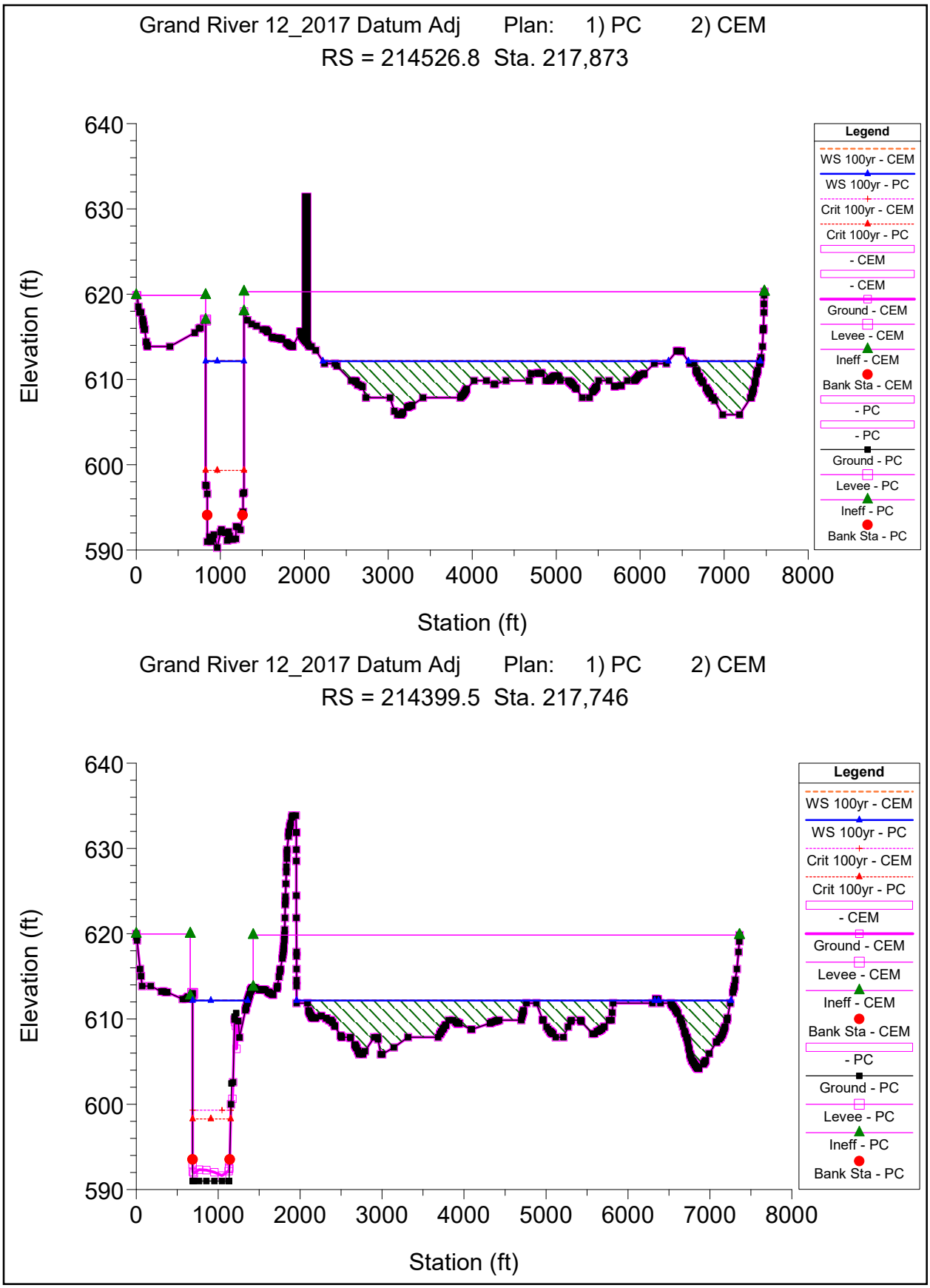

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215315.2 Sta. 218,651
Elevation (ft)
650
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215284.2 BR I-196 East bridge north of Bridge Street / Michigan Street
Elevation (ft)
650
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
Ground - PC
Ineff - PC
Bank Sta - PC

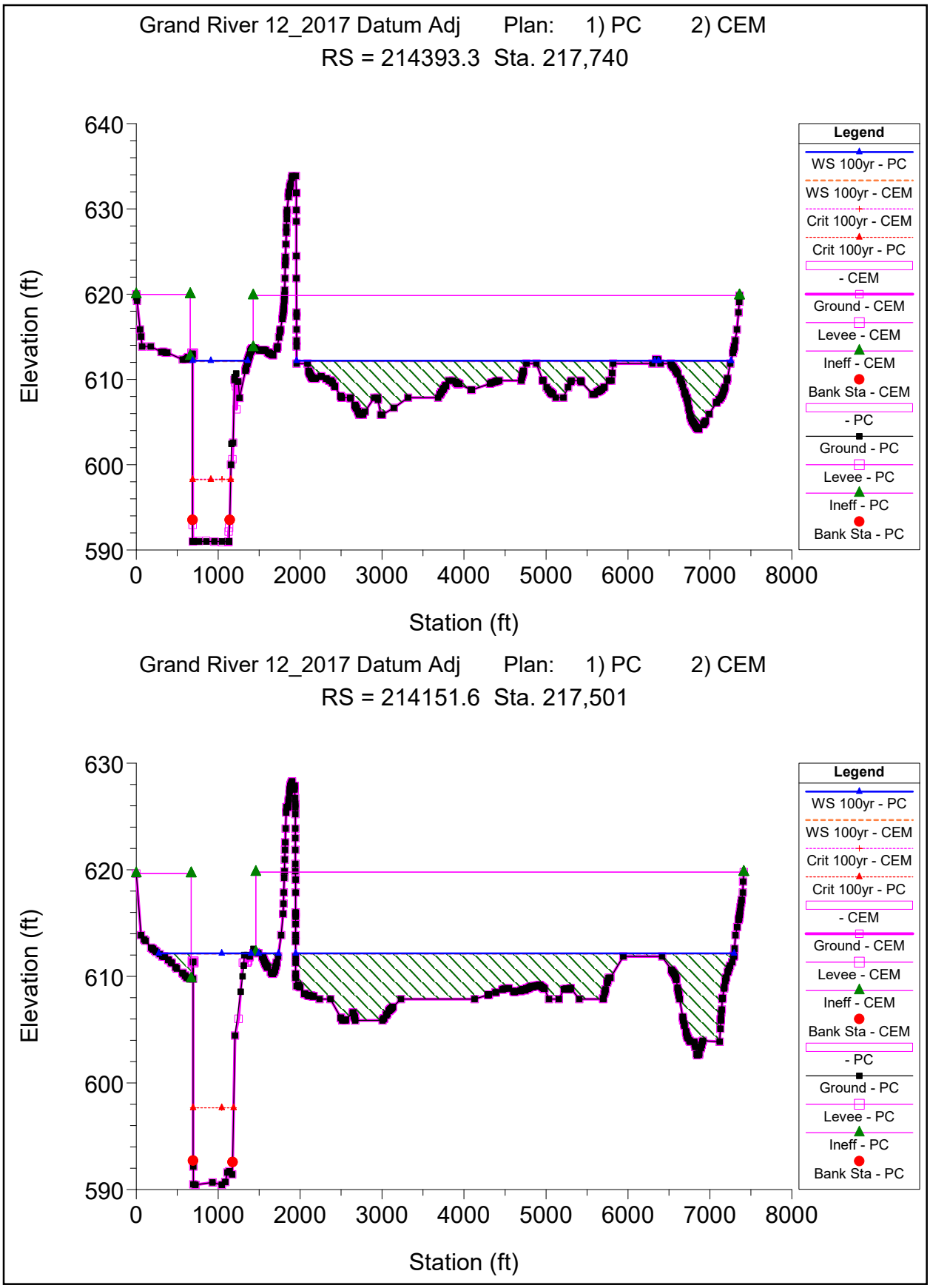

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215284.2 BR I-196 East bridge north of Bridge Street / Michigan Street
Elevation (ft)
640
630
620
610
600
590
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
Ground - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 215253.2 Sta. 218,593
Elevation (ft)
640
630
620
610
600
590
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Ineff - PC
Bank Sta - PC

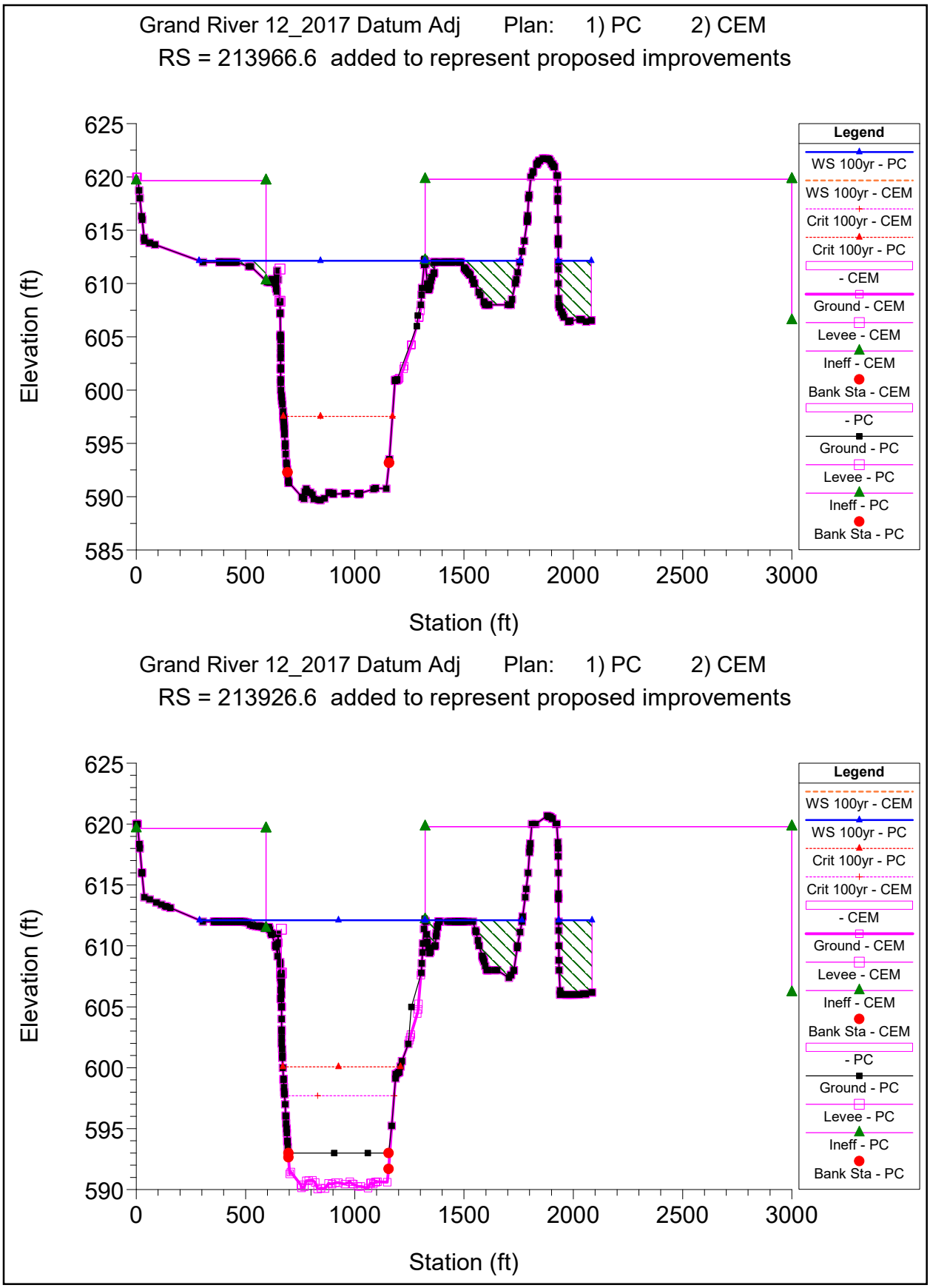

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214870.9 Sta. 218,214
Elevation (ft)
660
650
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214720.8 Sta. 218,059
Elevation (ft)
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

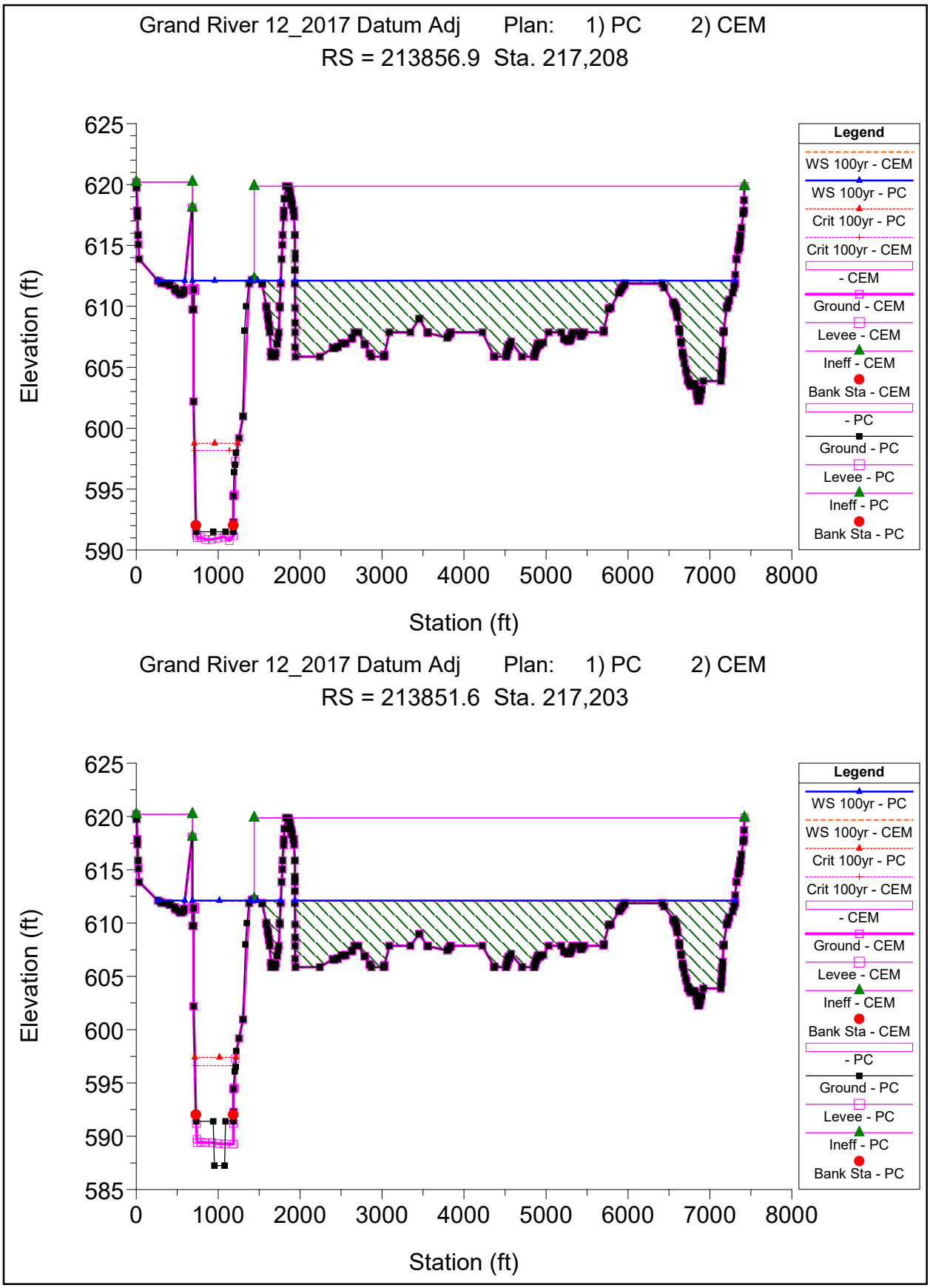

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214711.5 Sta. 218,050
Elevation (ft)
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214608.3 Sta. 217,948
Elevation (ft)
640
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

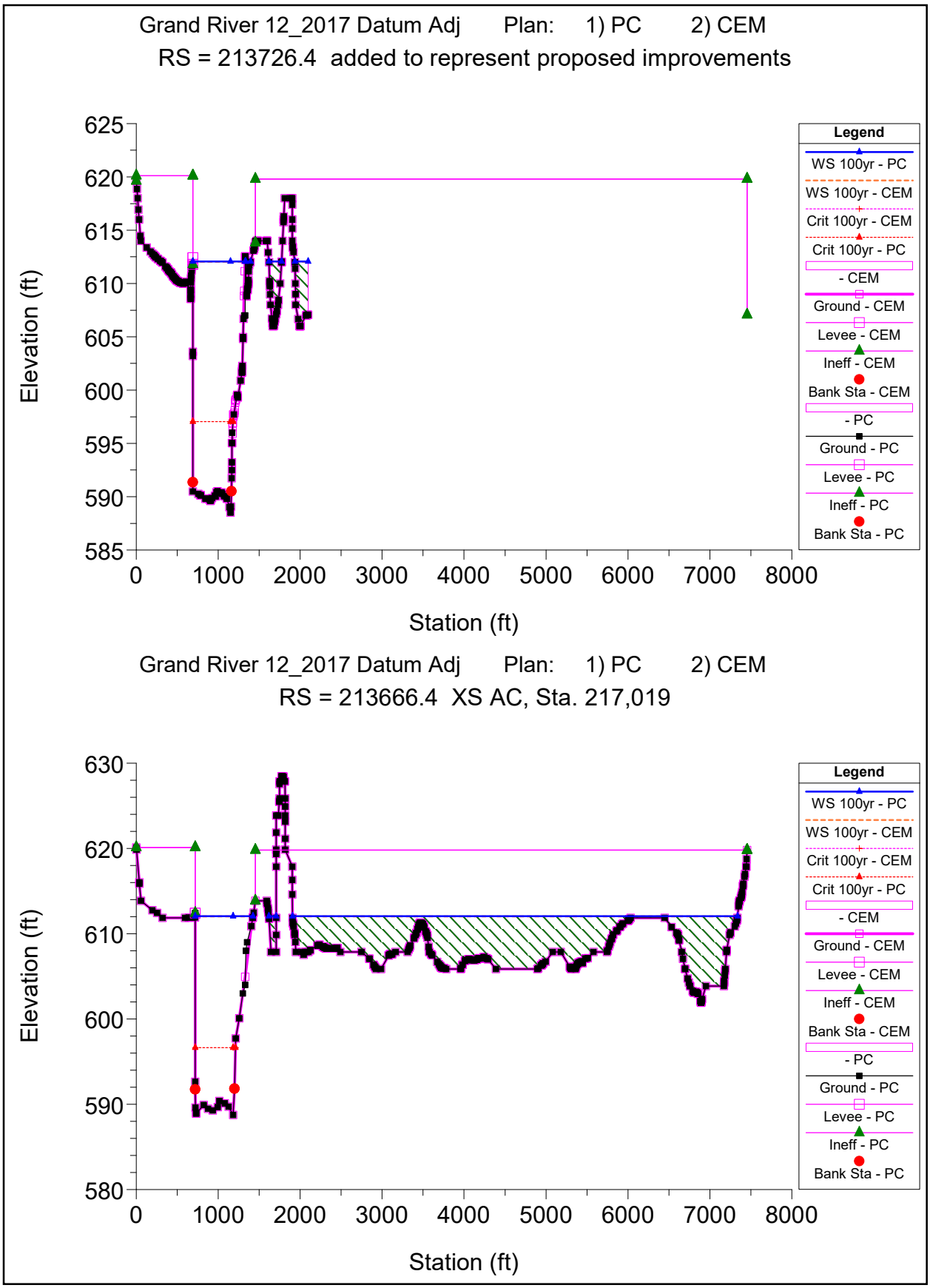

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214566.8 BR Bridge Street / Michigan Street bridge
Elevation (ft)
640
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214566.8 BR Bridge Street / Michigan Street bridge
Elevation (ft)
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

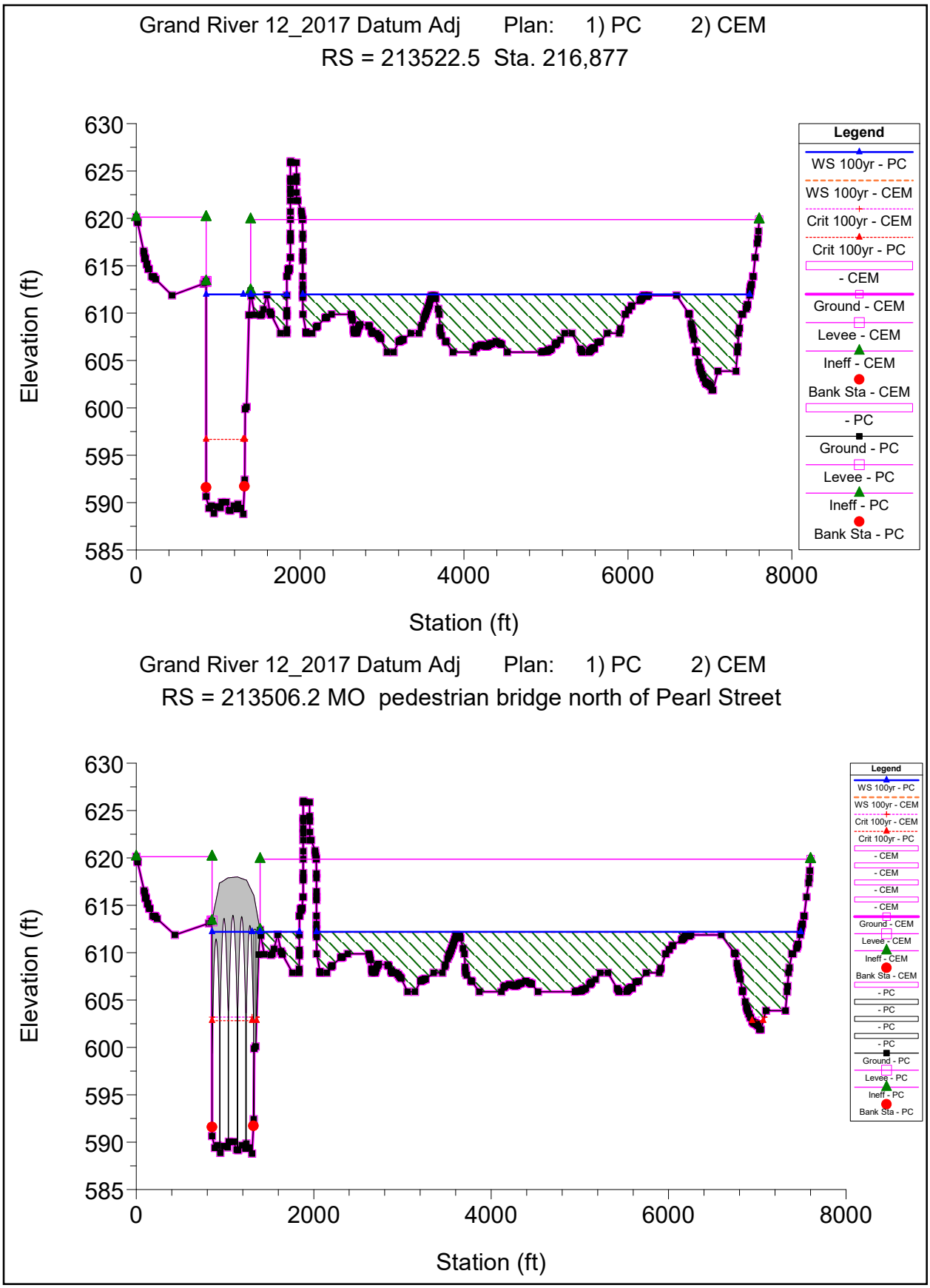

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214526.8 Sta. 217,873
Elevation (ft)
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214399.5 Sta. 217,746
Elevation (ft)
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

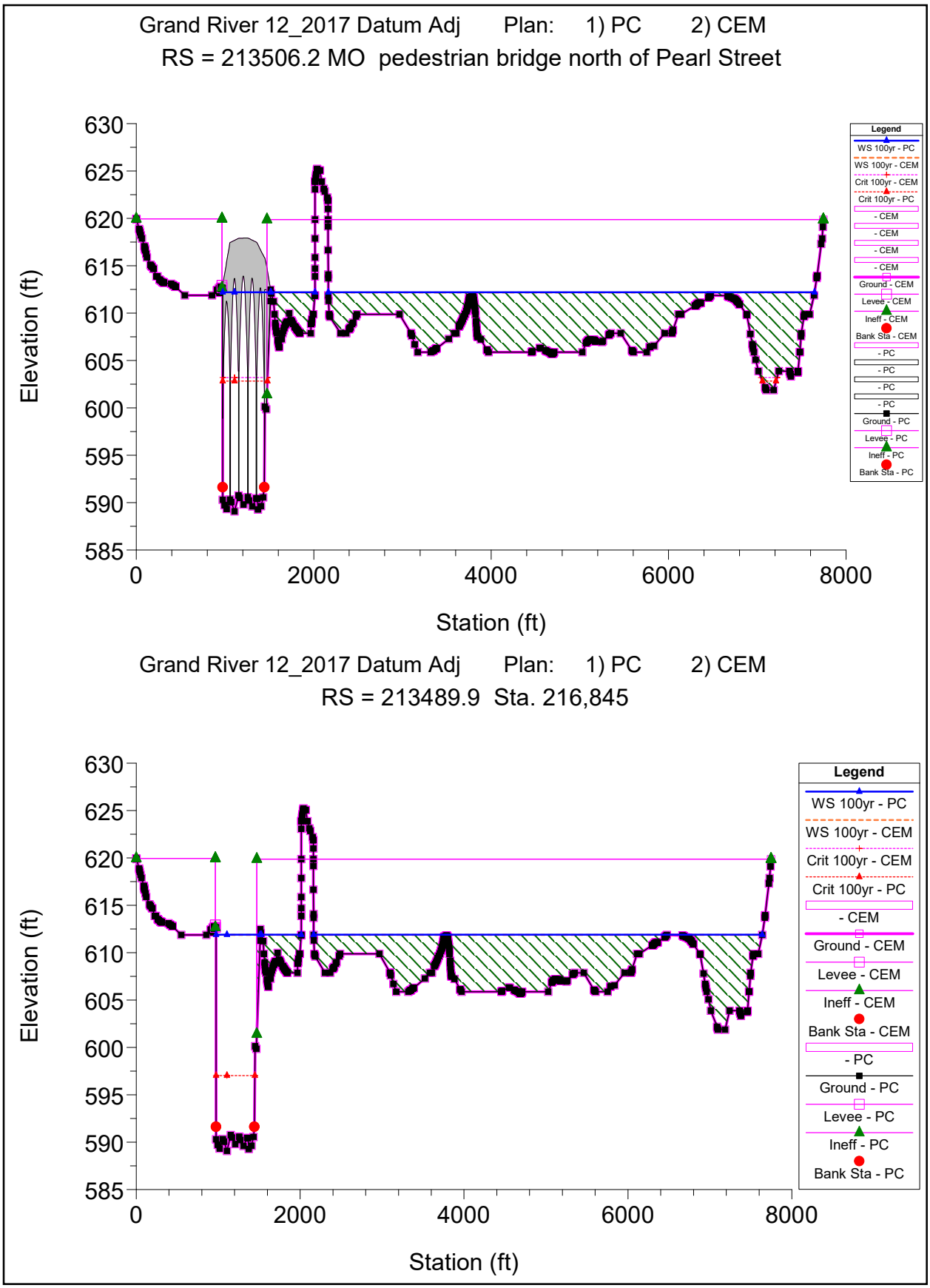

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214393.3 Sta. 217,740
Elevation (ft)
640
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 214151.6 Sta. 217,501
Elevation (ft)
630
620
610
600
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

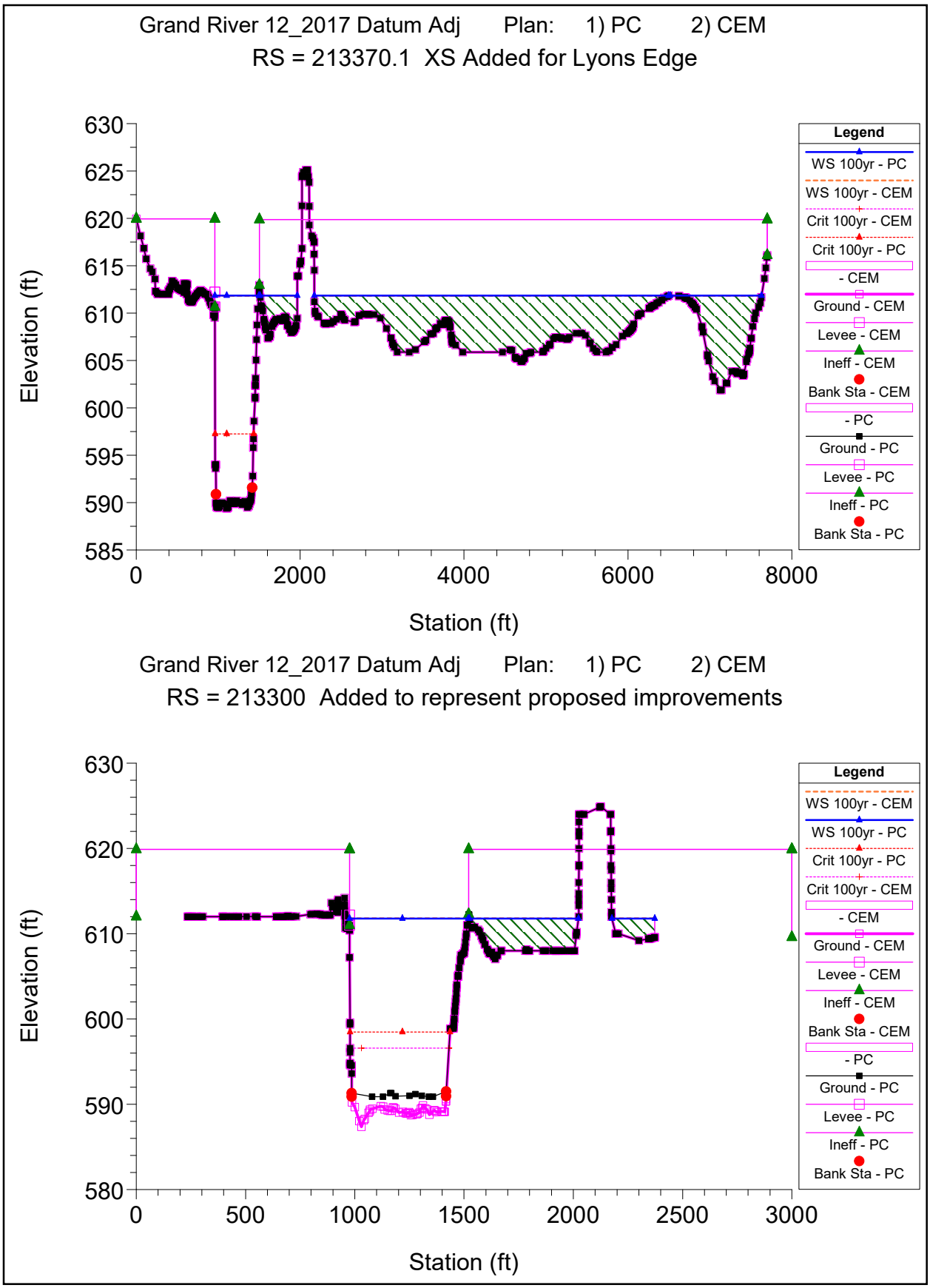

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213966.6 added to represent proposed improvements
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213926.6 added to represent proposed improvements
Elevation (ft)
625
620
615
610
605
600
595
590
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

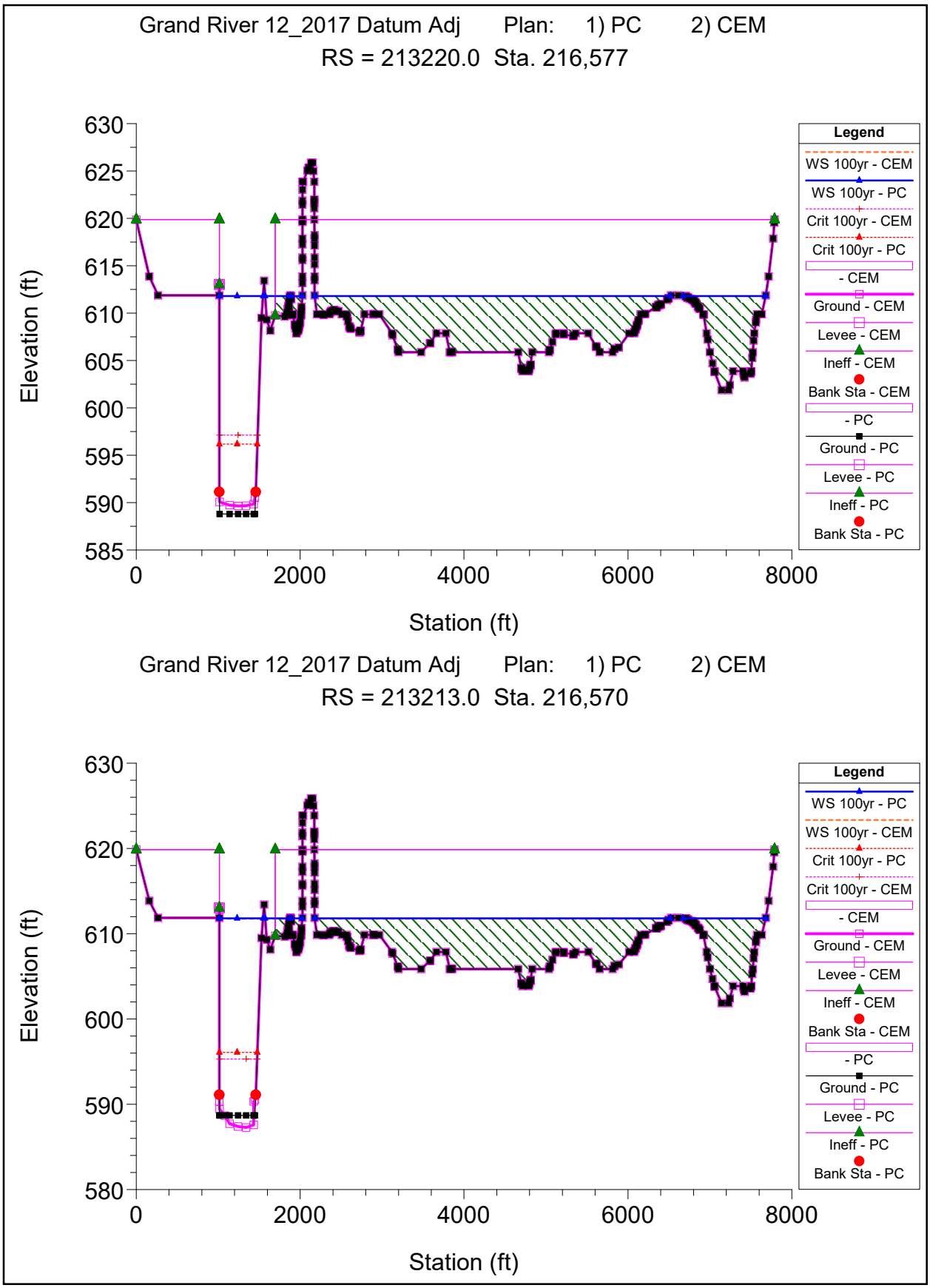

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213856.9 Sta. 217,208
Elevation (ft)
625
620
615
610
605
600
595
590
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213851.6 Sta. 217,203
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

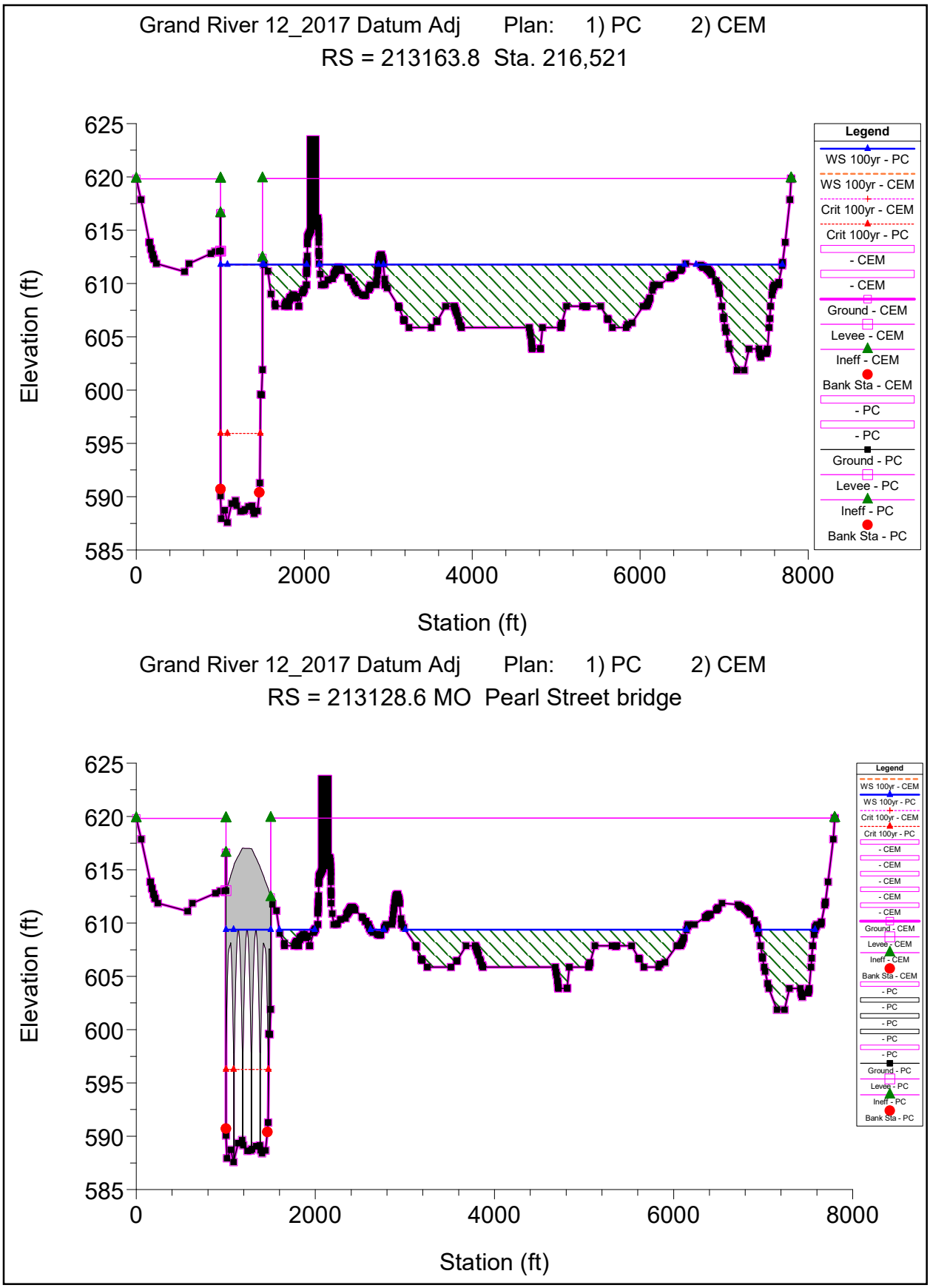

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213726.4 added to represent proposed improvements
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213666.4 XS AC, Sta. 217,019
Elevation (ft)
630
620
610
600
590
580
0
1000
2000
3000
4000
5000
6000
7000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

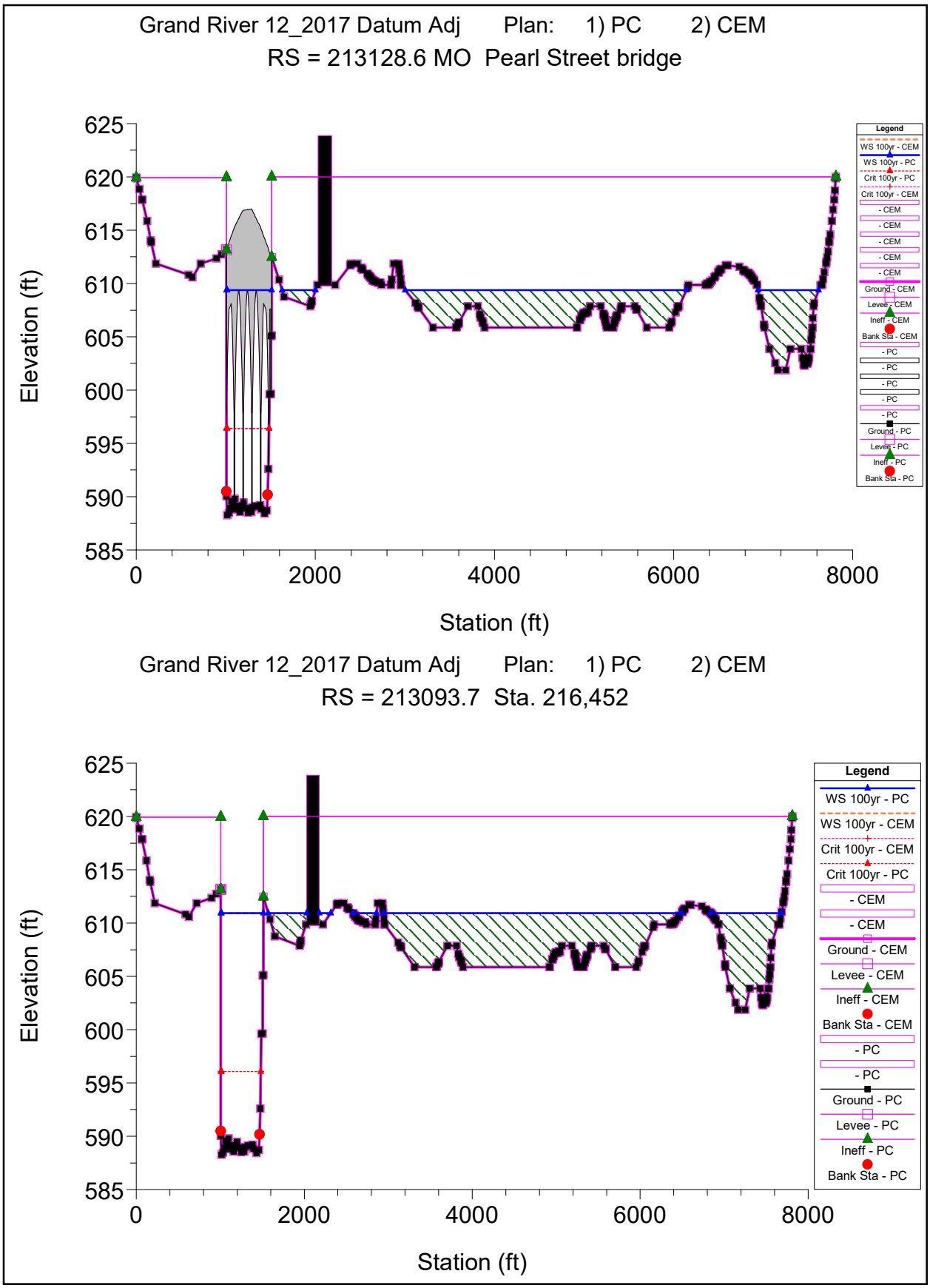

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213522.5 Sta. 216,877
Elevation (ft)
630
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213506.2 MO pedestrian bridge north of Pearl Street
Elevation (ft)
630
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

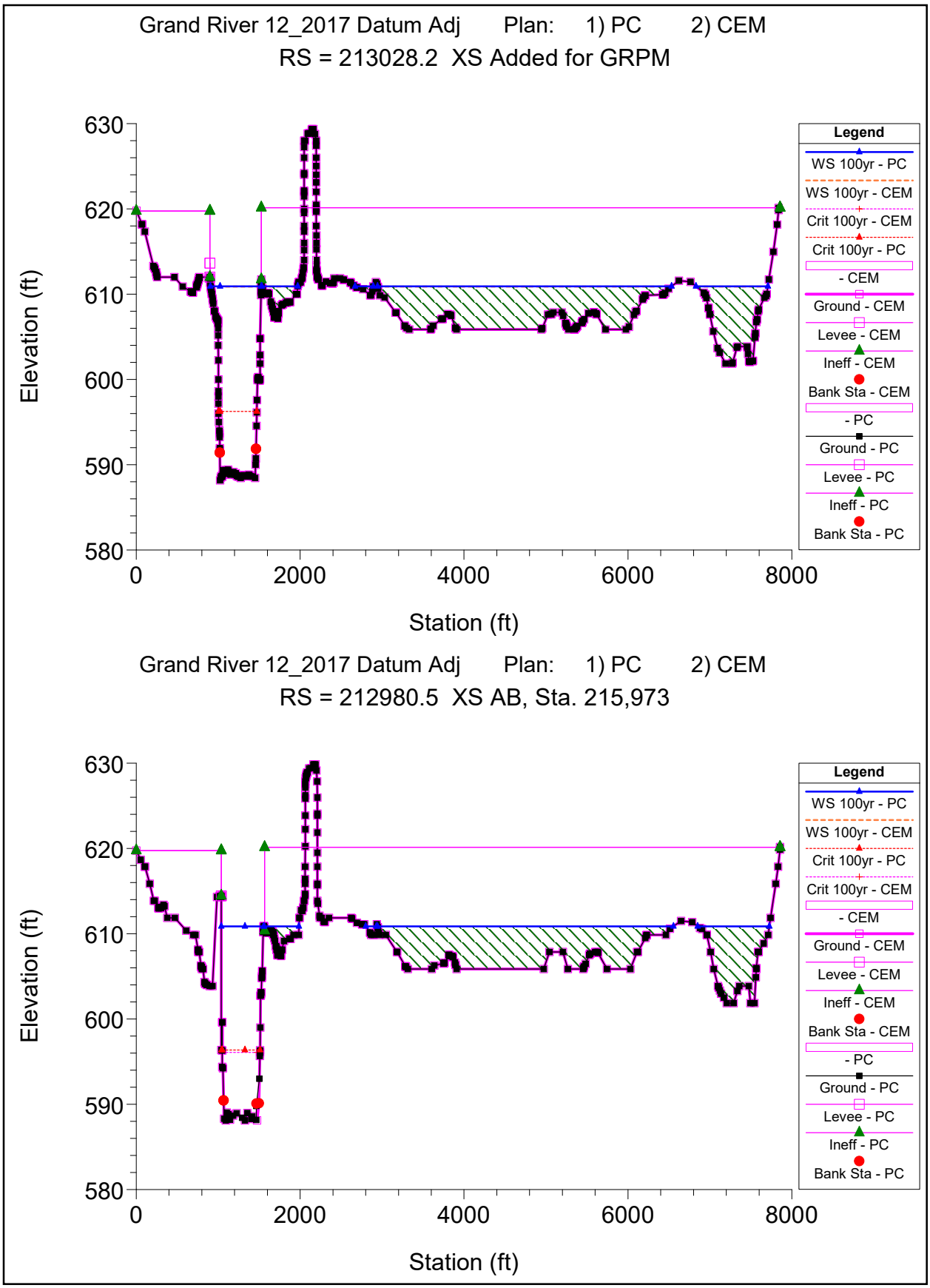

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213506.2 MO pedestrian bridge north of Pearl Street
Elevation (ft)
630
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213489.9 Sta. 216,845
Elevation (ft)
630
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

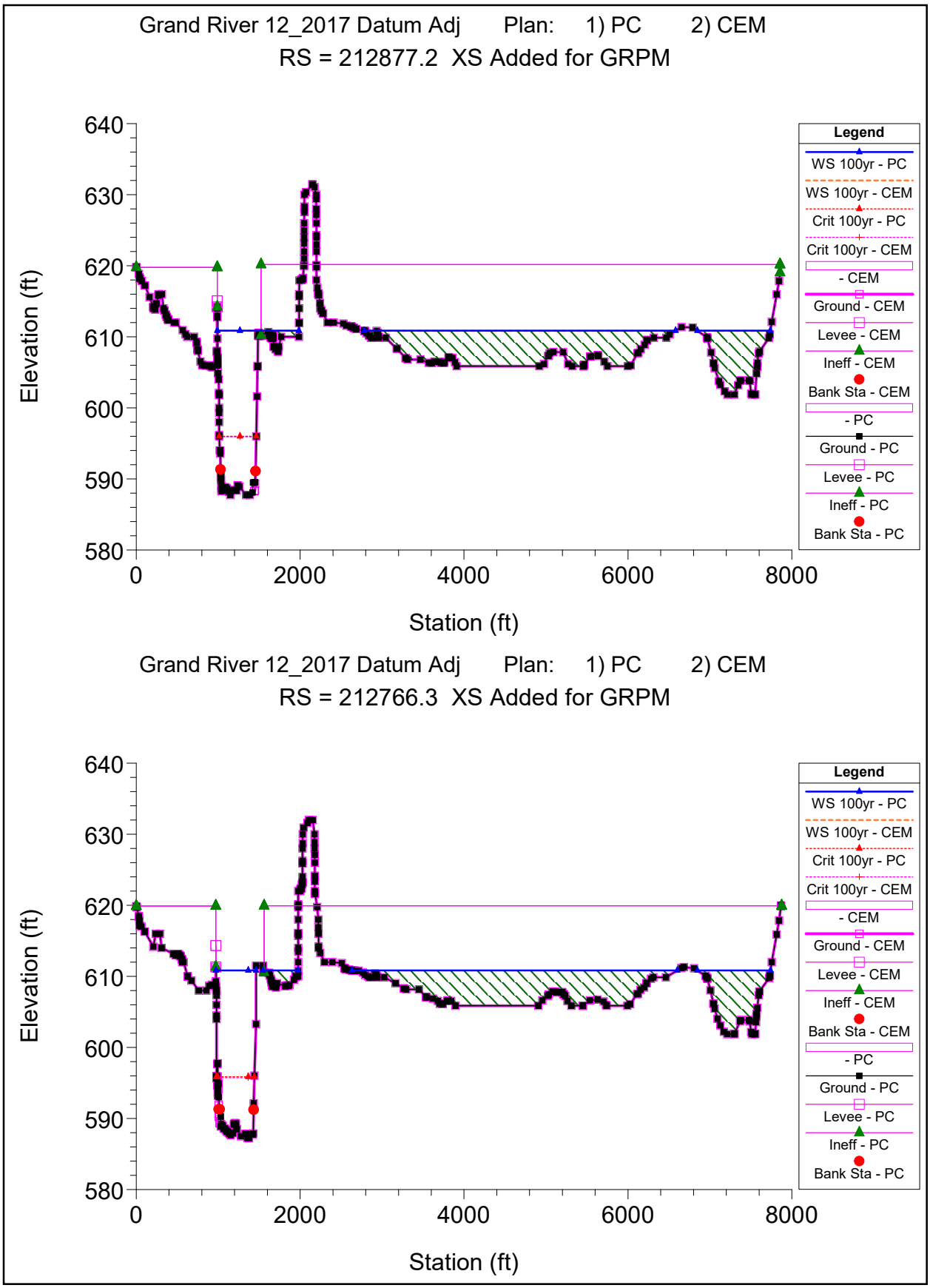

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213370.1 XS Added for Lyons Edge
Elevation (ft)
630
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213300 Added to represent proposed improvements
Elevation (ft)
630
620
610
600
590
580
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

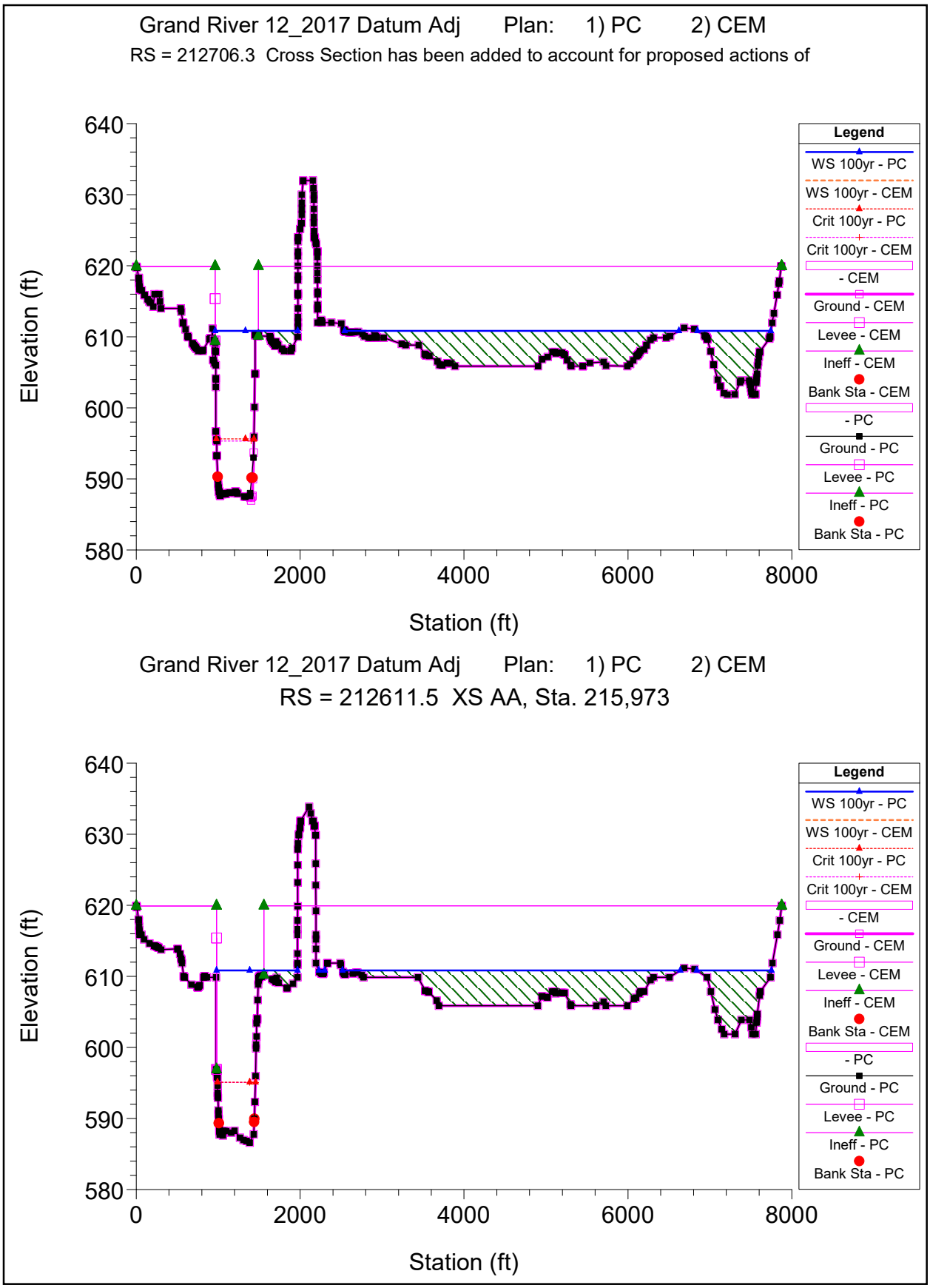

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213220.0 Sta. 216,577
Elevation (ft)
630
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213213.0 Sta. 216,570
Elevation (ft)
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

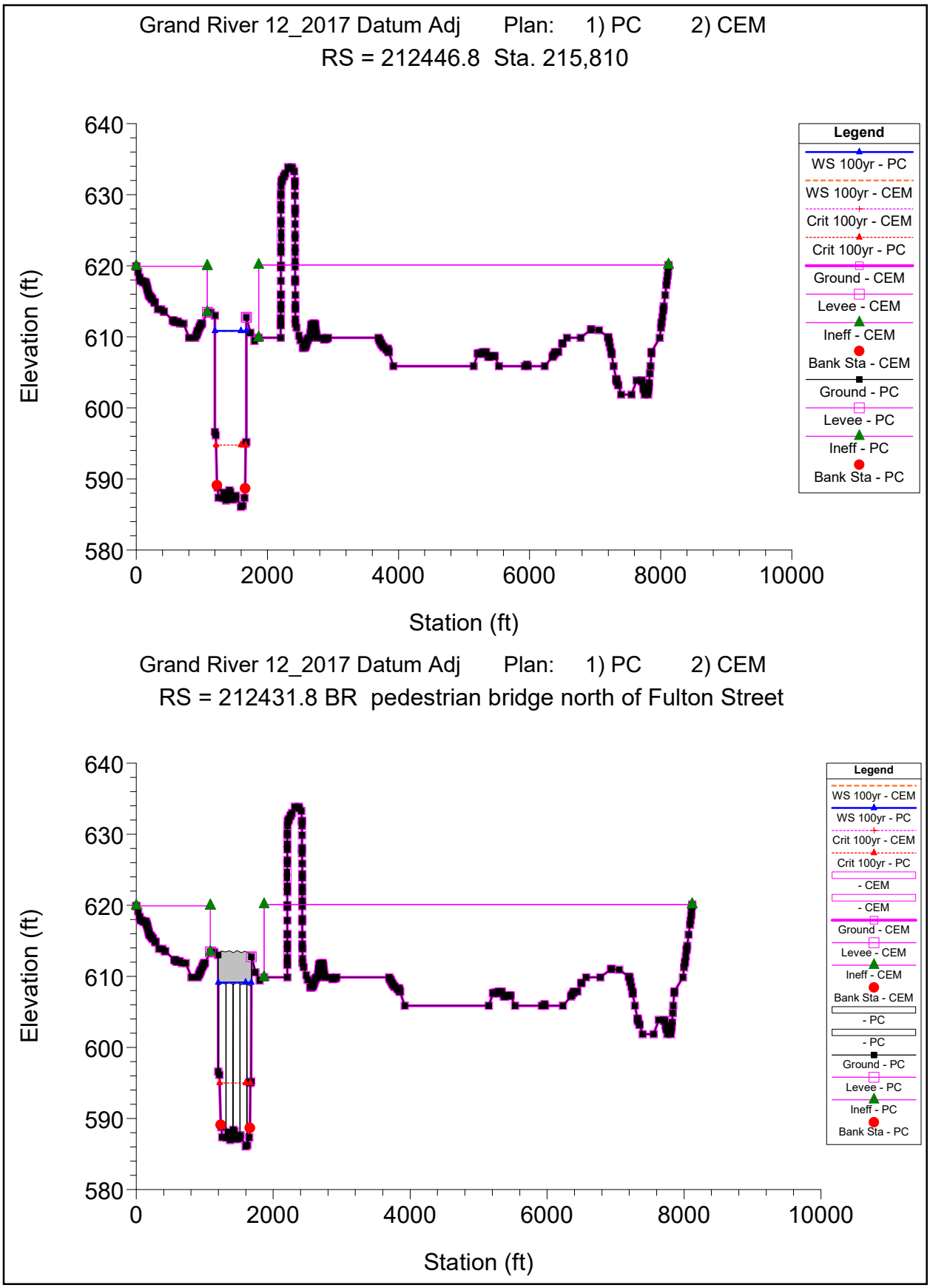

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213163.8 Sta. 216,521
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213128.6 MO Pearl Street bridge
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend

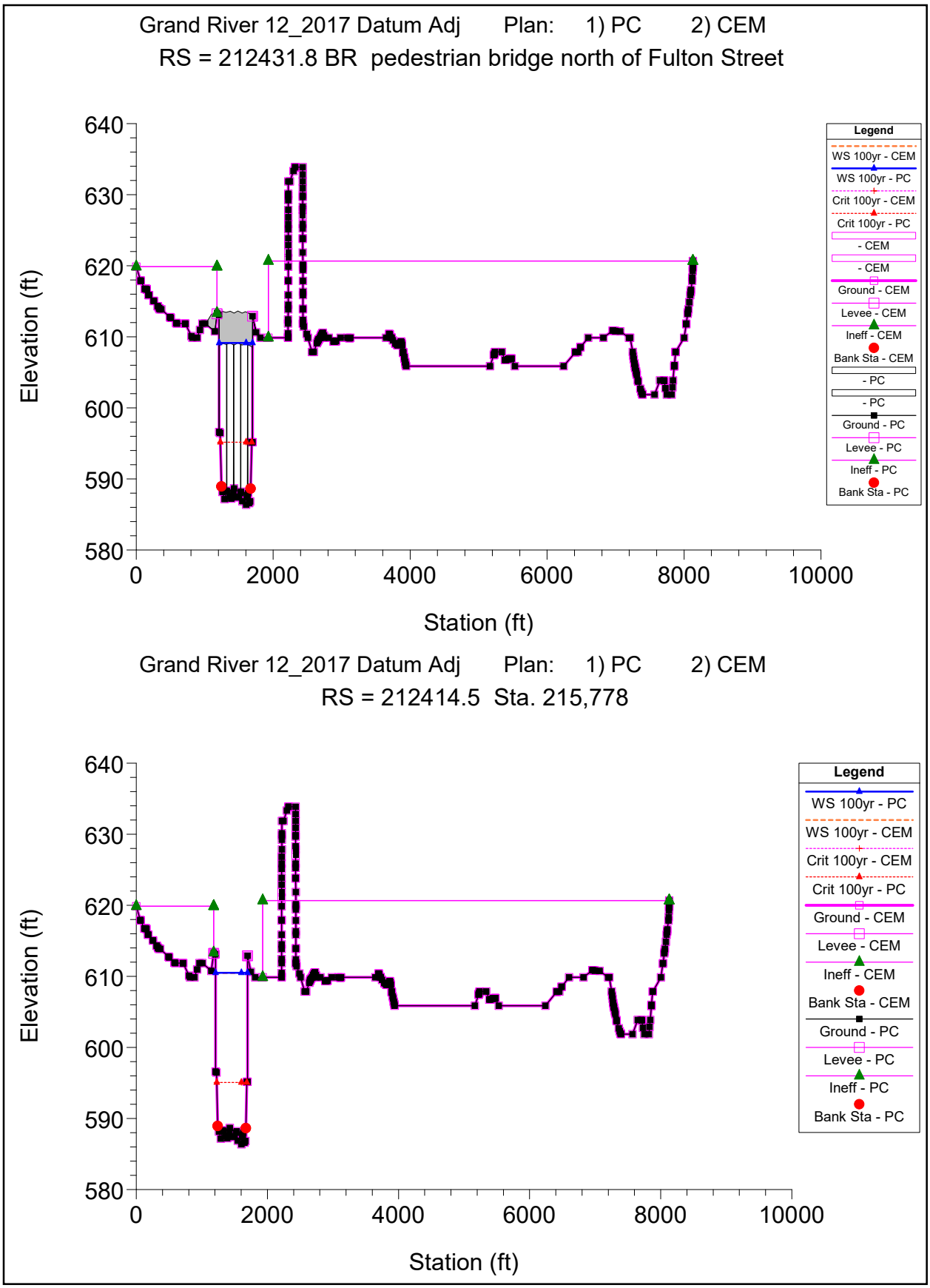

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213128.6 MO Pearl Street bridge
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - PC
Crit 100yr - CEM
- CEM
- CEM
- CEM
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
- PC
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213093.7 Sta. 216,452
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

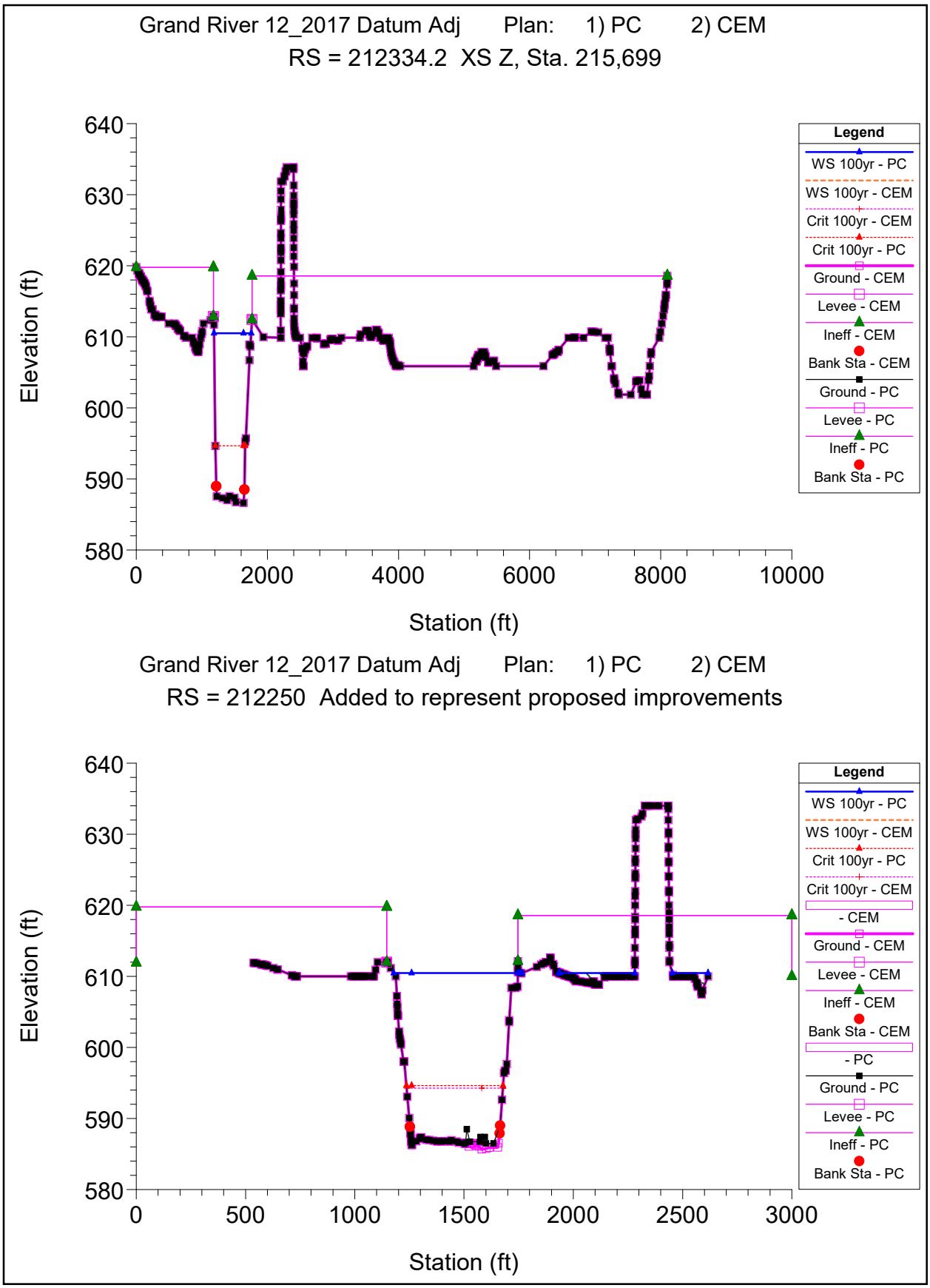

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 213028.2 XS Added for GRPM
Elevation (ft)
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212980.5 XS AB, Sta. 215,973
Elevation (ft)
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

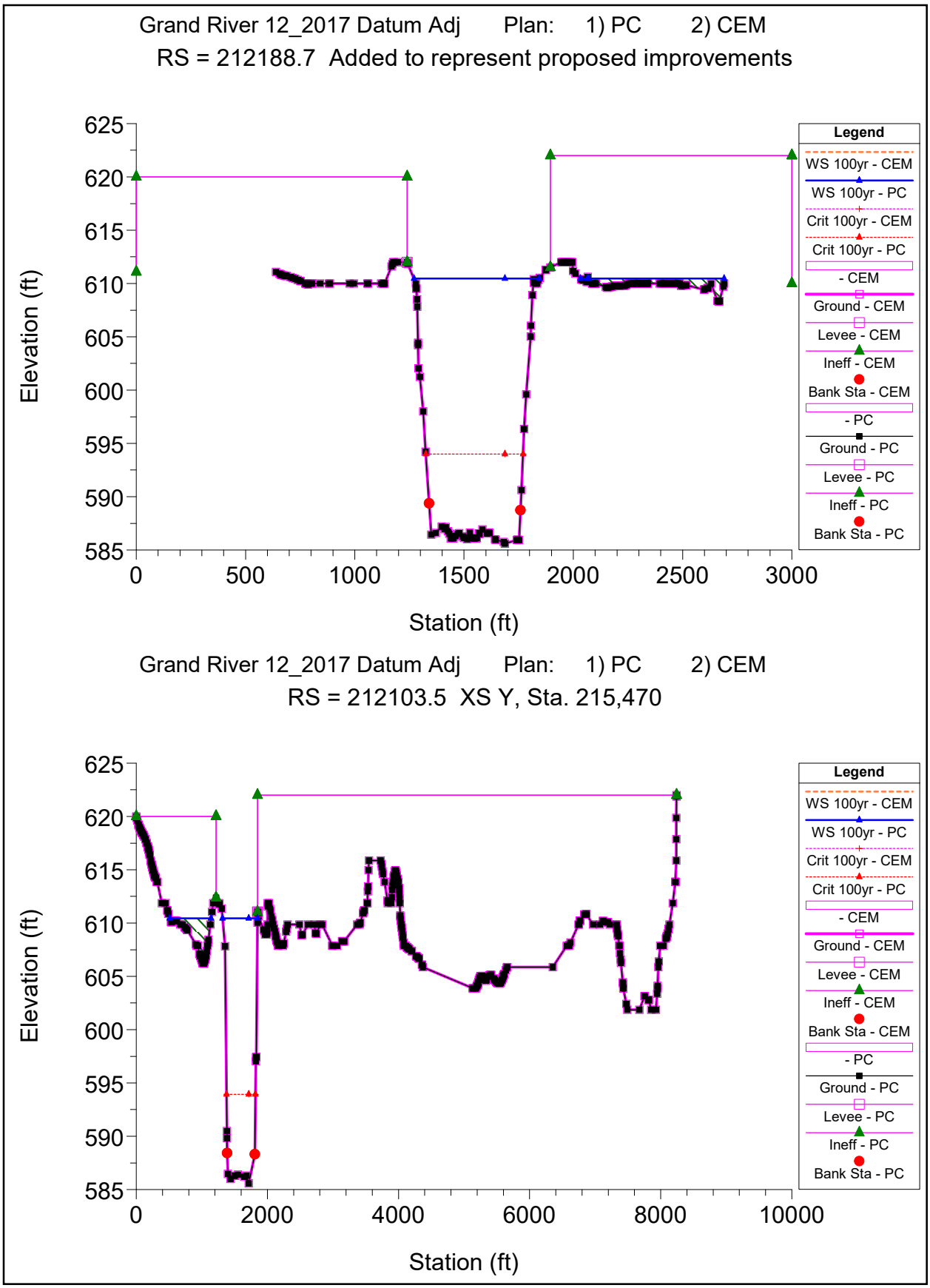

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212877.2 XS Added for GRPM
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212766.3 XS Added for GRPM
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

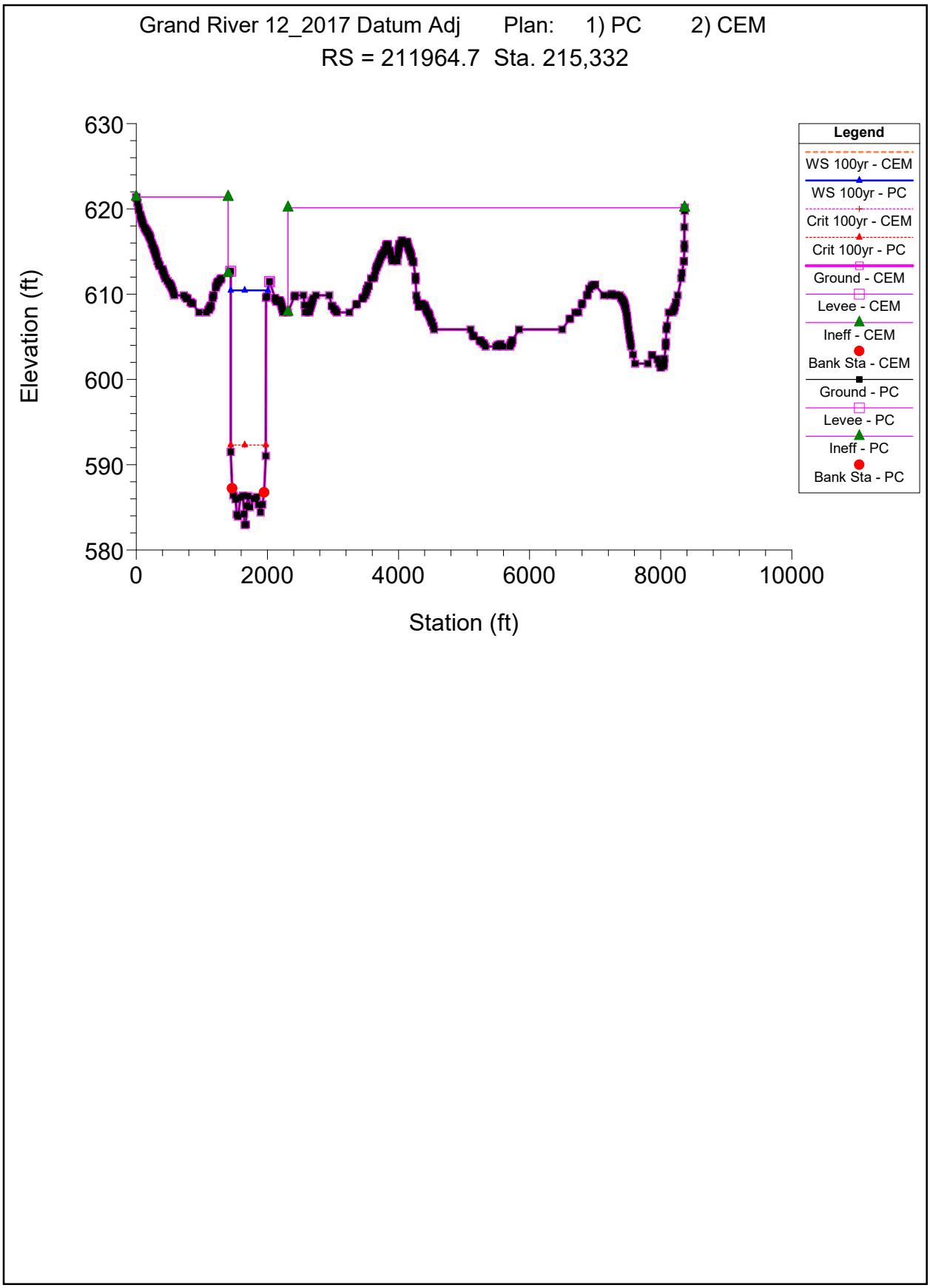

Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212706.3 Cross Section has been added to account for proposed actions of
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212611.5 XS AA, Sta. 215,973
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC


Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212446.8 Sta. 215,810
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212431.8 BR pedestrian bridge north of Fulton Street
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC


Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212431.8 BR pedestrian bridge north of Fulton Street
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212414.5 Sta. 215,778
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC


Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212334.2 XS Z, Sta. 215,699
Elevation (ft)
640
630
620
610
600
590
580
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - CEM
Crit 100yr - PC
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212250 Added to represent proposed improvements
Elevation (ft)
640
630
620
610
600
590
580
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - PC
WS 100yr - CEM
Crit 100yr - PC
Crit 100yr - CEM
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC


Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212188.7 Added to represent proposed improvements
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC
Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 212103.5 XS Y, Sta. 215,470
Elevation (ft)
625
620
615
610
605
600
595
590
585
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
- CEM
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
- PC
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC


Grand River 12_2017 Datum Adj Plan: 1) PC 2) CEM
RS = 211964.7 Sta. 215,332
Elevation (ft)
630
620
610
600
590
580
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 100yr - CEM
WS 100yr - PC
Crit 100yr - CEM
Crit 100yr - PC
Ground - CEM
Levee - CEM
Ineff - CEM
Bank Sta - CEM
Ground - PC
Levee - PC
Ineff - PC
Bank Sta - PC

ATTACHMENT 11:
HYDRAULIC MODEL – TABULAR RESULTS

100-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
244283.5 XS 44	619.61	619.59	-0.02	619.79	619.78	-0.01
241690.0 XS 43	619.35	619.33	-0.02	619.52	619.50	-0.02
239160.3 XS 42	619.09	619.07	-0.02	619.25	619.24	-0.01
237272.0 XS 41	618.89	618.87	-0.02	619.06	619.04	-0.02
236330.2 XS 40	618.74	618.72	-0.02	618.95	618.93	-0.02
235474.7 XS 46	618.63	618.61	-0.02	618.85	618.83	-0.02
235157.2 N Park St U/S	618.55	618.53	-0.02	618.80	618.78	-0.02
235082.5 N Park St D/S	618.48	618.46	-0.02	618.73	618.71	-0.02
234804.6 XS 45	618.37	618.34	-0.03	618.68	618.66	-0.02
234551.4 I-96 West U/S	618.34	618.32	-0.02	618.63	618.61	-0.02
234504.4 I-96 West D/S	618.27	618.25	-0.02	618.55	618.53	-0.02
234457.4 I-96 East U/S	618.27	618.25	-0.02	618.54	618.52	-0.02
234410.5 I-96 East D/S	618.12	618.09	-0.03	618.39	618.37	-0.02
233807.3 XS 39	617.99	617.96	-0.03	618.29	618.27	-0.02
231462.9 XS 38	617.75	617.73	-0.02	617.90	617.88	-0.02
228851.2 XS 37	617.46	617.44	-0.02	617.61	617.59	-0.02
227668.5 XS 36	617.28	617.25	-0.03	617.45	617.43	-0.02
225261.3 XS 35	616.71	616.68	-0.03	617.02	616.99	-0.03
224424.1 XS 34	616.50	616.47	-0.03	616.83	616.80	-0.03
223798.2 Ann St U/S	616.36	616.33	-0.03	616.69	616.66	-0.03
223733.8 Ann St D/S	616.31	616.28	-0.03	616.66	616.62	-0.04
223275.7 XS 33	616.24	616.20	-0.04	616.53	616.50	-0.03
222995.3 XS 32	616.20	616.17	-0.03	616.46	616.43	-0.03
222730.9 RR3 U/S	616.04	616.01	-0.03	616.39	616.35	-0.04
222717.4 RR3 D/S	615.97	615.94	-0.03	616.33	616.30	-0.03
222516.4 XS 31	615.96	615.92	-0.04	616.27	616.24	-0.03
221221.6 XS 30	615.45	615.41	-0.04	615.95	615.91	-0.04
220387.9 XS 29	615.05	615.01	-0.04	615.65	615.61	-0.04
219837.8 Leonard St U/S	614.91	614.86	-0.05	615.43	615.39	-0.04
219767.8 Leonard St D/S	614.85	614.81	-0.04	615.36	615.32	-0.04
219354.2 XS 28	614.77	614.73	-0.04	615.22	615.18	-0.04
218588.5 XS 27	614.59	614.55	-0.04	615.02	614.97	-0.05
217611.5 XS 26	614.23	614.18	-0.05	614.75	614.70	-0.05
216869.4 Sixth St U/S	614.07	614.01	-0.06	614.53	614.48	-0.05
216832.0 Sixth St D/S	614.03	613.97	-0.06	614.50	614.45	-0.05
216378.8 XS 25	613.96	613.90	-0.06	614.38	614.32	-0.06
216034.2 Dam No. 5 U/S	613.81	613.75	-0.06	614.25	614.20	-0.05
216020.2 Dam No. 5 D/S	612.92	612.73	-0.19	613.32	613.14	-0.18
215862.7 XS 24	612.89	612.70	-0.19	613.29	613.11	-0.18
215642.2 XS 23	612.86	612.67	-0.19	613.24	613.06	-0.18
215385.6 I-196 West U/S	612.79	612.60	-0.19	613.19	613.01	-0.18
215330.5 I-196 West D/S	612.75	612.56	-0.19	613.15	612.97	-0.18
215315.2 I-196 East U/S	612.75	612.56	-0.19	613.14	612.96	-0.18
215253.2 I-196 East D/S	612.71	612.52	-0.19	613.10	612.92	-0.18
214870.9 XS 22	612.58	612.39	-0.19	613.02	612.84	-0.18
214720.8 Dam No. 4 U/S	612.47	612.35	-0.12	612.98	612.81	-0.17
214711.5 Dam No. 4 D/S	612.40	612.35	-0.05	612.82	612.80	-0.02
214608.3 Bridge St U/S	612.36	612.32	-0.04	612.79	612.76	-0.03
214526.8 Bridge St D/S	612.18	612.15	-0.03	612.68	612.64	-0.04
214399.5 Dam No. 3 U/S	612.19	612.18	-0.01	612.63	612.57	-0.06
214393.3 Dam No. 3 D/S	612.14	612.18	0.04	612.53	612.56	0.03
214151.6 XS 21	612.13	612.15	0.02	612.48	612.50	0.02
213966.6	612.13	612.14	0.01	612.45	612.47	0.02
213926.6	612.12	612.11	-0.01	612.45	612.45	0.00
213856.9 Dam No. 2 U/S	612.11	612.10	-0.01	612.43	612.39	-0.04
213851.6 Dam No. 2 D/S	612.06	612.11	0.05	612.35	612.38	0.03
213726.4	612.04	612.06	0.02	612.34	612.35	0.01
213666.4 XS 20	612.03	612.05	0.02	612.33	612.34	0.01
213522.5 ped bridge U/S	611.97	611.98	0.01	612.31	612.33	0.02

100-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
213489.9 ped bridge D/S	611.87	611.89	0.02	612.23	612.24	0.01
213370.1	611.82	611.84	0.02	612.21	612.22	0.01
213300	611.82	611.79	-0.03	612.19	612.20	0.01
213220.0 Dam No. 1 U/S	611.81	611.81	0.00	612.18	612.13	-0.05
213213.0 Dam No. 1 D/S	611.76	611.81	0.05	612.08	612.12	0.04
213163.8 Pearl St U/S	611.74	611.78	0.04	612.08	612.11	0.03
213093.7 Pearl St D/S	610.91	610.94	0.03	611.27	611.30	0.03
213028.2	610.88	610.91	0.03	611.26	611.29	0.03
212980.5 XS 19	610.86	610.87	0.01	611.25	611.28	0.03
212877.2	610.83	610.86	0.03	611.23	611.26	0.03
212766.3	610.82	610.83	0.01	611.21	611.23	0.02
212706.3	610.82	610.82	0.00	611.20	611.22	0.02
212611.5 XS 18	610.83	610.84	0.01	611.18	611.19	0.01
212446.8 ped bridge U/S	610.81	610.82	0.01	611.16	611.17	0.01
212414.5 ped bridge D/S	610.48	610.49	0.01	610.84	610.85	0.01
212334.2 XS 17	610.48	610.50	0.02	610.83	610.84	0.01
212250	610.46	610.48	0.02	610.81	610.82	0.01
212188.7	610.46	610.46	0.00	610.80	610.80	0.00
212103.5 XS 16	610.44	610.44	0.00	610.79	610.79	0.00
211964.7 Fulton St U/S	610.44	610.44	0.00	610.68	610.68	0.00
211868.1 Fulton St D/S	609.91	609.91	0.00	610.15	610.15	0.00
211664.8 XS 15	609.81	609.81	0.00	610.13	610.13	0.00
211561.3 XS 14	609.80	609.80	0.00	610.12	610.12	0.00
211348.6 US Hwy 131 U/S	609.71	609.71	0.00	610.09	610.09	0.00
211144.8 US Hwy 131 D/S	609.55	609.55	0.00	610.02	610.02	0.00
210918.9 XS 13	609.56	609.56	0.00	609.86	609.86	0.00
210676.0 XS 12B	609.57	609.57	0.00	609.84	609.84	0.00
209996.9 XS 12A	609.44	609.44	0.00	609.77	609.77	0.00
209711.4 RR2 U/S	609.44	609.44	0.00	609.62	609.62	0.00
209656.6 RR2 D/S	609.21	609.21	0.00	609.40	609.40	0.00
209422.2 XS 11	609.12	609.12	0.00	609.37	609.37	0.00
209175.5 XS 10	608.89	608.89	0.00	609.33	609.33	0.00
208859.8 Wealthy St U/S	608.64	608.64	0.00	609.26	609.26	0.00
208777.1 Wealthy St D/S	608.59	608.59	0.00	609.20	609.20	0.00
208327.8 XS 9	608.60	608.60	0.00	609.01	609.01	0.00
207340.5 RR1 U/S	608.54	608.54	0.00	608.88	608.88	0.00
207324.2 RR1 D/S	608.51	608.51	0.00	608.84	608.84	0.00
206988	608.41	608.41	0.00	608.80	608.80	0.00
206651.9	608.34	608.34	0.00	608.75	608.75	0.00
206315.8 XS 8	608.33	608.33	0.00	608.70	608.70	0.00
205904	608.26	608.26	0.00	608.63	608.63	0.00
205492.2	608.10	608.10	0.00	608.54	608.54	0.00
205080.5	607.96	607.96	0.00	608.45	608.45	0.00
204668.7 XS 7	607.83	607.83	0.00	608.35	608.35	0.00
204250.5	607.62	607.62	0.00	608.23	608.23	0.00
203832.4 XS 6	607.48	607.48	0.00	608.11	608.11	0.00
203398.8	607.41	607.41	0.00	607.97	607.97	0.00
202965.1	607.32	607.32	0.00	607.85	607.85	0.00
202531.5	607.23	607.23	0.00	607.73	607.73	0.00
202097.9 XS 5	607.15	607.15	0.00	607.62	607.62	0.00
201740	607.15	607.15	0.00	607.51	607.51	0.00
201382.2	607.12	607.12	0.00	607.43	607.43	0.00
201024.4 XS 4	607.09	607.09	0.00	607.36	607.36	0.00
200751	607.02	607.02	0.00	607.32	607.32	0.00
200477.6 I-196 East U/S	607.01	607.01	0.00	607.27	607.27	0.00
200408.8 I-196 East D/S	606.99	606.99	0.00	607.25	607.25	0.00
200340.0 I-196 West U/S	606.99	606.99	0.00	607.24	607.24	0.00
200271.2 I-196 West D/S	606.98	606.98	0.00	607.21	607.21	0.00
200063.8 XS 3	606.69	606.69	0.00	607.15	607.15	0.00

100-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
199857.4	606.64	606.64	0.00	607.10	607.10	0.00
199651.1	606.58	606.58	0.00	607.04	607.04	0.00
199444.7	606.47	606.47	0.00	606.98	606.98	0.00
199238.3	606.36	606.36	0.00	606.92	606.92	0.00
199031.9 XS 2	606.30	606.30	0.00	606.85	606.85	0.00
198803.4	606.29	606.29	0.00	606.76	606.76	0.00
198574.8	606.31	606.31	0.00	606.67	606.67	0.00
198346.3	606.34	606.34	0.00	606.60	606.60	0.00
198117.8 XS 1	606.34	606.34	0.00	606.53	606.53	0.00
196113.4	605.62	605.62	0.00	606.05	606.05	0.00
195990.1	605.76	605.76	0.00	605.95	605.95	0.00
195958.1	605.68	605.68	0.00	605.87	605.87	0.00
195867.6	605.50	605.50	0.00	605.84	605.84	0.00
195493.9	605.45	605.45	0.00	605.75	605.75	0.00
194983.9	605.43	605.43	0.00	605.67	605.67	0.00
192633.9	605.17	605.17	0.00	605.38	605.38	0.00
190233.9	604.51	604.51	0.00	604.97	604.97	0.00
183733.9	604.29	604.29	0.00	604.34	604.34	0.00
180433.9	603.82	603.82	0.00	604.10	604.10	0.00
180333.9	603.58	603.58	0.00	603.95	603.95	0.00
180191.9	603.62	603.62	0.00	603.90	603.90	0.00
180190.9	603.58	603.58	0.00	603.89	603.89	0.00
180134.9	603.56	603.56	0.00	603.88	603.88	0.00
180133.9	603.58	603.58	0.00	603.86	603.86	0.00
177683.9	603.26	603.26	0.00	603.51	603.51	0.00
176303.9	602.87	602.87	0.00	603.25	603.25	0.00
175383.9	602.88	602.88	0.00	603.04	603.04	0.00
174783.9	602.84	602.84	0.00	602.97	602.97	0.00
172643.9	602.75	602.75	0.00	602.82	602.82	0.00
171243.9	602.57	602.57	0.00	602.71	602.71	0.00
169743.9	602.39	602.39	0.00	602.58	602.58	0.00
167243.9	602.13	602.13	0.00	602.24	602.24	0.00
165443.9	601.88	601.88	0.00	602.08	602.08	0.00
163763.9	601.74	601.74	0.00	601.84	601.84	0.00
162163.9	601.65	601.65	0.00	601.74	601.74	0.00
161233.9	601.58	601.58	0.00	601.67	601.67	0.00
159383.9	601.47	601.47	0.00	601.56	601.56	0.00
157683.9	601.30	601.30	0.00	601.42	601.42	0.00
155083.9	601.14	601.14	0.00	601.30	601.30	0.00
153553.9	601.07	601.07	0.00	601.20	601.20	0.00
152203.9	600.82	600.82	0.00	601.02	601.02	0.00

50-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
244283.5 XS 44	618.44	618.44	0.00	618.62	618.62	0.00
241690.0 XS 43	618.18	618.18	0.00	618.34	618.34	0.00
239160.3 XS 42	617.91	617.91	0.00	618.07	618.07	0.00
237272.0 XS 41	617.71	617.71	0.00	617.87	617.87	0.00
236330.2 XS 40	617.57	617.57	0.00	617.76	617.76	0.00
235474.7 XS 46	617.47	617.47	0.00	617.66	617.66	0.00
235157.2 N Park St U/S	617.39	617.39	0.00	617.61	617.61	0.00
235082.5 N Park St D/S	617.34	617.34	0.00	617.57	617.56	-0.01
234804.6 XS 45	617.24	617.24	0.00	617.52	617.52	0.00
234551.4 I-96 West U/S	617.22	617.22	0.00	617.47	617.47	0.00
234504.4 I-96 West D/S	617.14	617.14	0.00	617.39	617.39	0.00
234457.4 I-96 East U/S	617.14	617.14	0.00	617.38	617.38	0.00
234410.5 I-96 East D/S	616.99	616.99	0.00	617.23	617.23	0.00
233807.3 XS 39	616.85	616.85	0.00	617.14	617.13	-0.01
231462.9 XS 38	616.59	616.59	0.00	616.74	616.74	0.00
228851.2 XS 37	616.29	616.29	0.00	616.43	616.43	0.00
227668.5 XS 36	616.10	616.10	0.00	616.27	616.27	0.00
225261.3 XS 35	615.55	615.55	0.00	615.83	615.83	0.00
224424.1 XS 34	615.36	615.36	0.00	615.65	615.64	-0.01
223798.2 Ann St U/S	615.22	615.22	0.00	615.51	615.51	0.00
223733.8 Ann St D/S	615.18	615.17	-0.01	615.48	615.48	0.00
223275.7 XS 33	615.10	615.10	0.00	615.36	615.36	0.00
222995.3 XS 32	615.06	615.06	0.00	615.30	615.30	0.00
222730.9 RR3 U/S	614.91	614.91	0.00	615.22	615.22	0.00
222717.4 RR3 D/S	614.85	614.85	0.00	615.17	615.17	0.00
222516.4 XS 31	614.84	614.83	-0.01	615.11	615.11	0.00
221221.6 XS 30	614.35	614.35	0.00	614.80	614.79	-0.01
220387.9 XS 29	613.96	613.96	0.00	614.50	614.50	0.00
219837.8 Leonard St U/S	613.81	613.81	0.00	614.28	614.28	0.00
219767.8 Leonard St D/S	613.76	613.76	0.00	614.21	614.21	0.00
219354.2 XS 28	613.68	613.67	-0.01	614.08	614.07	-0.01
218588.5 XS 27	613.50	613.50	0.00	613.88	613.88	0.00
217611.5 XS 26	613.15	613.15	0.00	613.61	613.61	0.00
216869.4 Sixth St U/S	612.99	612.99	0.00	613.40	613.40	0.00
216832.0 Sixth St D/S	612.96	612.95	-0.01	613.38	613.37	-0.01
216378.8 XS 25	612.88	612.87	-0.01	613.26	613.26	0.00
216034.2 Dam No. 5 U/S	612.75	612.74	-0.01	613.14	613.14	0.00
216020.2 Dam No. 5 D/S	610.26	610.12	-0.14	610.68	610.55	-0.13
215862.7 XS 24	610.23	610.09	-0.14	610.64	610.51	-0.13
215642.2 XS 23	610.18	610.04	-0.14	610.59	610.46	-0.13
215385.6 I-196 West U/S	610.10	609.95	-0.15	610.53	610.39	-0.14
215330.5 I-196 West D/S	610.05	609.91	-0.14	610.48	610.34	-0.14
215315.2 I-196 East U/S	610.05	609.91	-0.14	610.47	610.33	-0.14
215253.2 I-196 East D/S	610.00	609.86	-0.14	610.42	610.29	-0.13
214870.9 XS 22	609.87	609.72	-0.15	610.33	610.19	-0.14
214720.8 Dam No. 4 U/S	609.73	609.67	-0.06	610.27	610.15	-0.12
214711.5 Dam No. 4 D/S	609.67	609.68	0.01	610.11	610.14	0.03
214608.3 Bridge St U/S	609.63	609.65	0.02	610.08	610.09	0.01
214526.8 Bridge St D/S	609.47	609.49	0.02	609.98	609.99	0.01
214399.5 Dam No. 3 U/S	609.47	609.51	0.04	609.93	609.91	-0.02
214393.3 Dam No. 3 D/S	609.39	609.51	0.12	609.81	609.90	0.09
214151.6 XS 21	609.39	609.47	0.08	609.75	609.82	0.07
213966.6	609.37	609.45	0.08	609.71	609.79	0.08
213926.6	609.36	609.39	0.03	609.70	609.77	0.07
213856.9 Dam No. 2 U/S	609.35	609.37	0.02	609.69	609.68	-0.01
213851.6 Dam No. 2 D/S	609.31	609.39	0.08	609.61	609.67	0.06
213726.4	609.28	609.33	0.05	609.59	609.64	0.05
213666.4 XS 20	609.28	609.32	0.04	609.58	609.63	0.05
213522.5 ped bridge U/S	609.21	609.26	0.05	609.56	609.61	0.05

50-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
213489.9 ped bridge D/S	609.14	609.19	0.05	609.50	609.55	0.05
213370.1	609.09	609.14	0.05	609.48	609.53	0.05
213300	609.08	609.06	-0.02	609.47	609.50	0.03
213220.0 Dam No. 1 U/S	609.07	609.08	0.01	609.45	609.41	-0.04
213213.0 Dam No. 1 D/S	609.05	609.08	0.03	609.37	609.40	0.03
213163.8 Pearl St U/S	609.03	609.06	0.03	609.36	609.39	0.03
213093.7 Pearl St D/S	608.86	608.89	0.03	609.20	609.23	0.03
213028.2	608.83	608.86	0.03	609.19	609.22	0.03
212980.5 XS 19	608.81	608.82	0.01	609.18	609.21	0.03
212877.2	608.79	608.81	0.02	609.17	609.18	0.01
212766.3	608.77	608.78	0.01	609.15	609.16	0.01
212706.3	608.77	608.77	0.00	609.13	609.14	0.01
212611.5 XS 18	608.78	608.78	0.00	609.11	609.12	0.01
212446.8 ped bridge U/S	608.76	608.77	0.01	609.09	609.09	0.00
212414.5 ped bridge D/S	608.73	608.74	0.01	609.06	609.06	0.00
212334.2 XS 17	608.73	608.74	0.01	609.04	609.05	0.01
212250	608.70	608.72	0.02	609.03	609.03	0.00
212188.7	608.70	608.70	0.00	609.02	609.02	0.00
212103.5 XS 16	608.69	608.69	0.00	609.00	609.00	0.00
211964.7 Fulton St U/S	608.68	608.68	0.00	608.90	608.90	0.00
211868.1 Fulton St D/S	608.30	608.30	0.00	608.51	608.51	0.00
211664.8 XS 15	608.21	608.21	0.00	608.49	608.49	0.00
211561.3 XS 14	608.20	608.20	0.00	608.48	608.48	0.00
211348.6 US Hwy 131 U/S	608.12	608.12	0.00	608.45	608.45	0.00
211144.8 US Hwy 131 D/S	607.98	607.98	0.00	608.39	608.39	0.00
210918.9 XS 13	607.99	607.99	0.00	608.26	608.26	0.00
210676.0 XS 12B	607.98	607.98	0.00	608.24	608.24	0.00
209996.9 XS 12A	607.89	607.89	0.00	608.18	608.18	0.00
209711.4 RR2 U/S	607.88	607.88	0.00	608.04	608.04	0.00
209656.6 RR2 D/S	607.72	607.72	0.00	607.88	607.88	0.00
209422.2 XS 11	607.63	607.63	0.00	607.86	607.86	0.00
209175.5 XS 10	607.43	607.43	0.00	607.82	607.82	0.00
208859.8 Wealthy St U/S	607.21	607.21	0.00	607.75	607.75	0.00
208777.1 Wealthy St D/S	607.16	607.16	0.00	607.70	607.70	0.00
208327.8 XS 9	607.17	607.17	0.00	607.53	607.53	0.00
207340.5 RR1 U/S	607.11	607.11	0.00	607.40	607.40	0.00
207324.2 RR1 D/S	607.08	607.08	0.00	607.37	607.37	0.00
206988	607.00	607.00	0.00	607.33	607.33	0.00
206651.9	606.93	606.93	0.00	607.29	607.29	0.00
206315.8 XS 8	606.89	606.89	0.00	607.25	607.25	0.00
205904	606.83	606.83	0.00	607.18	607.18	0.00
205492.2	606.68	606.68	0.00	607.10	607.10	0.00
205080.5	606.57	606.57	0.00	607.01	607.01	0.00
204668.7 XS 7	606.46	606.46	0.00	606.92	606.92	0.00
204250.5	606.26	606.26	0.00	606.81	606.81	0.00
203832.4 XS 6	606.14	606.14	0.00	606.70	606.70	0.00
203398.8	606.08	606.08	0.00	606.56	606.56	0.00
202965.1	605.99	605.99	0.00	606.45	606.45	0.00
202531.5	605.90	605.90	0.00	606.34	606.34	0.00
202097.9 XS 5	605.83	605.83	0.00	606.24	606.24	0.00
201740	605.82	605.82	0.00	606.14	606.14	0.00
201382.2	605.78	605.78	0.00	606.07	606.07	0.00
201024.4 XS 4	605.75	605.75	0.00	606.00	606.00	0.00
200751	605.69	605.69	0.00	605.96	605.96	0.00
200477.6 I-196 East U/S	605.68	605.68	0.00	605.91	605.91	0.00
200408.8 I-196 East D/S	605.67	605.67	0.00	605.89	605.89	0.00
200340.0 I-196 West U/S	605.66	605.66	0.00	605.88	605.88	0.00
200271.2 I-196 West D/S	605.65	605.65	0.00	605.86	605.86	0.00
200063.8 XS 3	605.39	605.39	0.00	605.80	605.80	0.00

50-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
199857.4	605.34	605.34	0.00	605.75	605.75	0.00
199651.1	605.28	605.28	0.00	605.70	605.70	0.00
199444.7	605.18	605.18	0.00	605.64	605.64	0.00
199238.3	605.07	605.07	0.00	605.58	605.58	0.00
199031.9 XS 2	605.01	605.01	0.00	605.52	605.52	0.00
198803.4	604.98	604.98	0.00	605.43	605.43	0.00
198574.8	605.00	605.00	0.00	605.35	605.35	0.00
198346.3	605.02	605.02	0.00	605.28	605.28	0.00
198117.8 XS 1	605.02	605.02	0.00	605.20	605.20	0.00
196113.4	604.35	604.35	0.00	604.74	604.74	0.00
195990.1	604.48	604.48	0.00	604.65	604.65	0.00
195958.1	604.42	604.42	0.00	604.59	604.59	0.00
195867.6	604.26	604.26	0.00	604.56	604.56	0.00
195493.9	604.21	604.21	0.00	604.49	604.49	0.00
194983.9	604.19	604.19	0.00	604.41	604.41	0.00
192633.9	603.93	603.93	0.00	604.13	604.13	0.00
190233.9	603.30	603.30	0.00	603.73	603.73	0.00
183733.9	603.07	603.07	0.00	603.12	603.12	0.00
180433.9	602.64	602.64	0.00	602.88	602.88	0.00
180333.9	602.42	602.42	0.00	602.74	602.74	0.00
180191.9	602.46	602.46	0.00	602.70	602.70	0.00
180190.9	602.42	602.42	0.00	602.69	602.69	0.00
180134.9	602.40	602.40	0.00	602.68	602.68	0.00
180133.9	602.42	602.42	0.00	602.66	602.66	0.00
177683.9	602.11	602.11	0.00	602.34	602.34	0.00
176303.9	601.74	601.74	0.00	602.09	602.09	0.00
175383.9	601.74	601.74	0.00	601.89	601.89	0.00
174783.9	601.70	601.70	0.00	601.83	601.83	0.00
172643.9	601.59	601.59	0.00	601.67	601.67	0.00
171243.9	601.42	601.42	0.00	601.56	601.56	0.00
169743.9	601.27	601.27	0.00	601.44	601.44	0.00
167243.9	601.01	601.01	0.00	601.11	601.11	0.00
165443.9	600.75	600.75	0.00	600.94	600.94	0.00
163763.9	600.60	600.60	0.00	600.70	600.70	0.00
162163.9	600.50	600.50	0.00	600.59	600.59	0.00
161233.9	600.43	600.43	0.00	600.52	600.52	0.00
159383.9	600.32	600.32	0.00	600.41	600.41	0.00
157683.9	600.16	600.16	0.00	600.27	600.27	0.00
155083.9	600.02	600.02	0.00	600.16	600.16	0.00
153553.9	599.95	599.95	0.00	600.07	600.07	0.00
152203.9	599.71	599.71	0.00	599.89	599.89	0.00

25-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
244283.5 XS 44	617.29	617.29	0.00	617.46	617.46	0.00
241690.0 XS 43	617.03	617.03	0.00	617.18	617.18	0.00
239160.3 XS 42	616.76	616.76	0.00	616.91	616.91	0.00
237272.0 XS 41	616.56	616.56	0.00	616.71	616.71	0.00
236330.2 XS 40	616.43	616.43	0.00	616.60	616.60	0.00
235474.7 XS 46	616.34	616.34	0.00	616.50	616.50	0.00
235157.2 N Park St U/S	616.28	616.28	0.00	616.46	616.46	0.00
235082.5 N Park St D/S	616.24	616.24	0.00	616.43	616.43	0.00
234804.6 XS 45	616.15	616.15	0.00	616.38	616.38	0.00
234551.4 I-96 West U/S	616.13	616.13	0.00	616.34	616.34	0.00
234504.4 I-96 West D/S	616.05	616.05	0.00	616.26	616.26	0.00
234457.4 I-96 East U/S	616.05	616.05	0.00	616.25	616.25	0.00
234410.5 I-96 East D/S	615.90	615.90	0.00	616.11	616.11	0.00
233807.3 XS 39	615.76	615.76	0.00	616.02	616.02	0.00
231462.9 XS 38	615.48	615.48	0.00	615.63	615.63	0.00
228851.2 XS 37	615.18	615.18	0.00	615.315	615.315	0.00
227668.5 XS 36	614.99	614.99	0.00	615.15	615.15	0.00
225261.3 XS 35	614.49	614.49	0.00	614.72	614.72	0.00
224424.1 XS 34	614.31	614.31	0.00	614.55	614.55	0.00
223798.2 Ann St U/S	614.18	614.18	0.00	614.43	614.43	0.00
223733.8 Ann St D/S	614.14	614.14	0.00	614.40	614.40	0.00
223275.7 XS 33	614.07	614.07	0.00	614.29	614.29	0.00
222995.3 XS 32	614.03	614.03	0.00	614.23	614.23	0.00
222730.9 RR3 U/S	613.90	613.90	0.00	614.16	614.16	0.00
222717.4 RR3 D/S	613.84	613.84	0.00	614.12	614.12	0.00
222516.4 XS 31	613.83	613.83	0.00	614.06	614.06	0.00
221221.6 XS 30	613.385	613.385	0.00	613.77	613.77	0.00
220387.9 XS 29	613.024	613.025	0.00	613.49	613.49	0.00
219837.8 Leonard St U/S	612.88	612.88	0.00	613.29	613.29	0.00
219767.8 Leonard St D/S	612.83	612.83	0.00	613.22	613.22	0.00
219354.2 XS 28	612.754	612.755	0.00	613.095	613.095	0.00
218588.5 XS 27	612.59	612.59	0.00	612.91	612.91	0.00
217611.5 XS 26	612.28	612.28	0.00	612.67	612.67	0.00
216869.4 Sixth St U/S	612.14	612.14	0.00	612.48	612.48	0.00
216832.0 Sixth St D/S	612.11	612.11	0.00	612.46	612.46	0.00
216378.8 XS 25	612.03	612.03	0.00	612.35	612.35	0.00
216034.2 Dam No. 5 U/S	611.92	611.92	0.00	612.25	612.25	0.00
216020.2 Dam No. 5 D/S	608.17	608.06	-0.11	608.59	608.49	-0.10
215862.7 XS 24	608.13	608.02	-0.11	608.54	608.44	-0.10
215642.2 XS 23	608.08	607.97	-0.11	608.48	608.37	-0.11
215385.6 I-196 West U/S	607.97	607.86	-0.11	608.40	608.29	-0.11
215330.5 I-196 West D/S	607.92	607.80	-0.12	608.35	608.24	-0.11
215315.2 I-196 East U/S	607.92	607.80	-0.12	608.33	608.22	-0.11
215253.2 I-196 East D/S	607.87	607.75	-0.12	608.29	608.18	-0.11
214870.9 XS 22	607.74	607.61	-0.13	608.18	608.06	-0.12
214720.8 Dam No. 4 U/S	607.57	607.55	-0.02	608.11	608.02	-0.09
214711.5 Dam No. 4 D/S	607.52	607.56	0.03	607.94	608.01	0.07
214608.3 Bridge St U/S	607.49	607.53	0.04	607.91	607.95	0.04
214526.8 Bridge St D/S	607.33	607.37	0.04	607.82	607.86	0.04
214399.5 Dam No. 3 U/S	607.32	607.38	0.07	607.77	607.77	0.00
214393.3 Dam No. 3 D/S	607.23	607.38	0.15	607.63	607.77	0.13
214151.6 XS 21	607.22	607.34	0.12	607.57	607.68	0.11
213966.6	607.20	607.31	0.11	607.53	607.64	0.11
213926.6	607.18	607.22	0.04	607.52	607.62	0.10
213856.9 Dam No. 2 U/S	607.17	607.20	0.03	607.51	607.51	0.00
213851.6 Dam No. 2 D/S	607.14	607.22	0.09	607.43	607.50	0.07
213726.4	607.10	607.16	0.05	607.41	607.46	0.05
213666.4 XS 20	607.10	607.16	0.06	607.39	607.45	0.05
213522.5 ped bridge U/S	607.04	607.10	0.06	607.37	607.42	0.05

25-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
213489.9 ped bridge D/S	606.99	607.04	0.06	607.33	607.38	0.05
213370.1	606.93	606.99	0.06	607.30	607.36	0.05
213300	606.93	606.90	-0.03	607.29	607.32	0.04
213220.0 Dam No. 1 U/S	606.91	606.91	0.00	607.27	607.23	-0.04
213213.0 Dam No. 1 D/S	606.88	606.91	0.03	607.18	607.22	0.04
213163.8 Pearl St U/S	606.86	606.90	0.04	607.17	607.21	0.04
213093.7 Pearl St D/S	606.75	606.79	0.04	607.07	607.11	0.03
213028.2	606.71	606.75	0.04	607.06	607.09	0.03
212980.5 XS 19	606.70	606.72	0.01	607.05	607.08	0.03
212877.2	606.68	606.70	0.02	607.03	607.05	0.02
212766.3	606.66	606.67	0.01	607.01	607.03	0.02
212706.3	606.66	606.66	0.00	606.99	607.01	0.02
212611.5 XS 18	606.66	606.67	0.01	606.97	606.98	0.01
212446.8 ped bridge U/S	606.65	606.66	0.01	606.95	606.96	0.01
212414.5 ped bridge D/S	606.62	606.63	0.01	606.92	606.93	0.01
212334.2 XS 17	606.61	606.62	0.01	606.90	606.92	0.01
212250	606.60	606.61	0.01	606.89	606.89	0.00
212188.7	606.59	606.59	0.00	606.88	606.88	0.00
212103.5 XS 16	606.58	606.58	0.00	606.87	606.87	0.00
211964.7 Fulton St U/S	606.57	606.57	0.00	606.76	606.76	0.00
211868.1 Fulton St D/S	606.50	606.50	0.00	606.68	606.68	0.00
211664.8 XS 15	606.42	606.42	0.00	606.66	606.66	0.00
211561.3 XS 14	606.41	606.41	0.00	606.65	606.65	0.00
211348.6 US Hwy 131 U/S	606.34	606.34	0.00	606.63	606.63	0.00
211144.8 US Hwy 131 D/S	606.21	606.21	0.00	606.57	606.57	0.00
210918.9 XS 13	606.22	606.22	0.00	606.46	606.46	0.00
210676.0 XS 12B	606.21	606.21	0.00	606.43	606.43	0.00
209996.9 XS 12A	606.12	606.12	0.00	606.38	606.38	0.00
209711.4 RR2 U/S	606.11	606.11	0.00	606.25	606.25	0.00
209656.6 RR2 D/S	606.09	606.09	0.00	606.23	606.23	0.00
209422.2 XS 11	606.02	606.02	0.00	606.21	606.21	0.00
209175.5 XS 10	605.84	605.84	0.00	606.17	606.17	0.00
208859.8 Wealthy St U/S	605.64	605.64	0.00	606.11	606.11	0.00
208777.1 Wealthy St D/S	605.60	605.60	0.00	606.06	606.06	0.00
208327.8 XS 9	605.61	605.61	0.00	605.91	605.91	0.00
207340.5 RR1 U/S	605.55	605.55	0.00	605.80	605.80	0.00
207324.2 RR1 D/S	605.52	605.52	0.00	605.77	605.77	0.00
206988	605.45	605.45	0.00	605.73	605.73	0.00
206651.9	605.38	605.38	0.00	605.70	605.70	0.00
206315.8 XS 8	605.34	605.34	0.00	605.66	605.66	0.00
205904	605.26	605.26	0.00	605.59	605.59	0.00
205492.2	605.15	605.15	0.00	605.51	605.51	0.00
205080.5	605.05	605.05	0.00	605.43	605.43	0.00
204668.7 XS 7	604.94	604.94	0.00	605.35	605.35	0.00
204250.5	604.78	604.78	0.00	605.25	605.25	0.00
203832.4 XS 6	604.67	604.67	0.00	605.14	605.14	0.00
203398.8	604.60	604.60	0.00	605.02	605.02	0.00
202965.1	604.52	604.52	0.00	604.92	604.92	0.00
202531.5	604.44	604.44	0.00	604.82	604.82	0.00
202097.9 XS 5	604.37	604.37	0.00	604.72	604.72	0.00
201740	604.35	604.35	0.00	604.64	604.64	0.00
201382.2	604.31	604.31	0.00	604.57	604.57	0.00
201024.4 XS 4	604.28	604.28	0.00	604.51	604.51	0.00
200751	604.24	604.24	0.00	604.47	604.47	0.00
200477.6 I-196 East U/S	604.22	604.22	0.00	604.42	604.42	0.00
200408.8 I-196 East D/S	604.21	604.21	0.00	604.40	604.40	0.00
200340.0 I-196 West U/S	604.20	604.20	0.00	604.40	604.40	0.00
200271.2 I-196 West D/S	604.19	604.19	0.00	604.38	604.38	0.00
200063.8 XS 3	603.96	603.96	0.00	604.32	604.32	0.00

25-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
199857.4	603.91	603.91	0.00	604.28	604.28	0.00
199651.1	603.85	603.85	0.00	604.23	604.23	0.00
199444.7	603.76	603.76	0.00	604.17	604.17	0.00
199238.3	603.65	603.65	0.00	604.11	604.11	0.00
199031.9 XS 2	603.58	603.58	0.00	604.05	604.05	0.00
198803.4	603.55	603.55	0.00	603.97	603.97	0.00
198574.8	603.55	603.55	0.00	603.89	603.89	0.00
198346.3	603.57	603.57	0.00	603.82	603.82	0.00
198117.8 XS 1	603.57	603.57	0.00	603.75	603.75	0.00
196113.4	602.94	602.94	0.00	603.29	603.29	0.00
195990.1	603.05	603.05	0.00	603.21	603.21	0.00
195958.1	603.02	603.02	0.00	603.18	603.18	0.00
195867.6	602.88	602.88	0.00	603.15	603.15	0.00
195493.9	602.83	602.83	0.00	603.08	603.08	0.00
194983.9	602.81	602.81	0.00	603.01	603.01	0.00
192633.9	602.55	602.55	0.00	602.74	602.74	0.00
190233.9	601.94	601.94	0.00	602.34	602.34	0.00
183733.9	601.69	601.69	0.00	601.74	601.74	0.00
180433.9	601.30	601.30	0.00	601.51	601.51	0.00
180333.9	601.10	601.10	0.00	601.38	601.38	0.00
180191.9	601.14	601.14	0.00	601.34	601.34	0.00
180190.9	601.10	601.10	0.00	601.34	601.34	0.00
180134.9	601.09	601.09	0.00	601.32	601.32	0.00
180133.9	601.11	601.11	0.00	601.31	601.31	0.00
177683.9	600.81	600.81	0.00	601.01	601.01	0.00
176303.9	600.44	600.44	0.00	600.76	600.76	0.00
175383.9	600.44	600.44	0.00	600.58	600.58	0.00
174783.9	600.40	600.40	0.00	600.52	600.52	0.00
172643.9	600.29	600.29	0.00	600.37	600.37	0.00
171243.9	600.12	600.12	0.00	600.25	600.25	0.00
169743.9	599.98	599.98	0.00	600.14	600.14	0.00
167243.9	599.70	599.70	0.00	599.81	599.81	0.00
165443.9	599.45	599.45	0.00	599.64	599.64	0.00
163763.9	599.30	599.30	0.00	599.39	599.39	0.00
162163.9	599.18	599.18	0.00	599.28	599.28	0.00
161233.9	599.11	599.11	0.00	599.20	599.20	0.00
159383.9	598.99	598.99	0.00	599.08	599.08	0.00
157683.9	598.85	598.85	0.00	598.95	598.95	0.00
155083.9	598.73	598.73	0.00	598.85	598.85	0.00
153553.9	598.66	598.66	0.00	598.77	598.77	0.00
152203.9	598.43	598.43	0.00	598.60	598.60	0.00

10-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
244283.5 XS 44	615.82	615.82	0.00	615.98	615.98	0.00
241690.0 XS 43	615.56	615.56	0.00	615.70	615.70	0.00
239160.3 XS 42	615.31	615.31	0.00	615.43	615.43	0.00
237272.0 XS 41	615.11	615.11	0.00	615.24	615.24	0.00
236330.2 XS 40	614.99	614.99	0.00	615.14	615.14	0.00
235474.7 XS 46	614.91	614.91	0.00	615.04	615.04	0.00
235157.2 N Park St U/S	614.86	614.86	0.00	615.01	615.01	0.00
235082.5 N Park St D/S	614.83	614.83	0.00	614.98	614.98	0.00
234804.6 XS 45	614.75	614.75	0.00	614.94	614.94	0.00
234551.4 I-96 West U/S	614.73	614.73	0.00	614.90	614.90	0.00
234504.4 I-96 West D/S	614.66	614.66	0.00	614.83	614.83	0.00
234457.4 I-96 East U/S	614.66	614.66	0.00	614.82	614.82	0.00
234410.5 I-96 East D/S	614.52	614.52	0.00	614.68	614.68	0.00
233807.3 XS 39	614.38	614.38	0.00	614.59	614.59	0.00
231462.9 XS 38	614.08	614.08	0.00	614.23	614.23	0.00
228851.2 XS 37	613.77	613.77	0.00	613.90	613.90	0.00
227668.5 XS 36	613.60	613.60	0.00	613.74	613.74	0.00
225261.3 XS 35	613.14	613.14	0.00	613.34	613.34	0.00
224424.1 XS 34	612.99	612.99	0.00	613.18	613.18	0.00
223798.2 Ann St U/S	612.88	612.88	0.00	613.07	613.07	0.00
223733.8 Ann St D/S	612.84	612.84	0.00	613.05	613.05	0.00
223275.7 XS 33	612.77	612.77	0.00	612.95	612.95	0.00
222995.3 XS 32	612.74	612.74	0.00	612.90	612.90	0.00
222730.9 RR3 U/S	612.62	612.62	0.00	612.83	612.83	0.00
222717.4 RR3 D/S	612.57	612.57	0.00	612.80	612.80	0.00
222516.4 XS 31	612.56	612.56	0.00	612.75	612.75	0.00
221221.6 XS 30	612.18	612.17	-0.01	612.49	612.49	0.00
220387.9 XS 29	611.85	611.85	0.00	612.23	612.23	0.00
219837.8 Leonard St U/S	611.72	611.72	0.00	612.04	612.04	0.00
219767.8 Leonard St D/S	611.67	611.67	0.00	611.99	611.99	0.00
219354.2 XS 28	611.60	611.60	0.00	611.87	611.87	0.00
218588.5 XS 27	611.46	611.46	0.00	611.71	611.71	0.00
217611.5 XS 26	611.19	611.19	0.00	611.50	611.50	0.00
216869.4 Sixth St U/S	611.07	611.07	0.00	611.33	611.33	0.00
216832.0 Sixth St D/S	611.05	611.05	0.00	611.32	611.32	0.00
216378.8 XS 25	610.98	610.98	0.00	611.23	611.23	0.00
216034.2 Dam No. 5 U/S	610.89	610.89	0.00	611.14	611.14	0.00
216020.2 Dam No. 5 D/S	605.98	605.94	-0.04	606.38	606.34	-0.04
215862.7 XS 24	605.94	605.89	-0.05	606.32	606.28	-0.04
215642.2 XS 23	605.88	605.84	-0.04	606.25	606.21	-0.04
215385.6 I-196 West U/S	605.75	605.70	-0.05	606.16	606.12	-0.04
215330.5 I-196 West D/S	605.69	605.64	-0.05	606.11	606.06	-0.05
215315.2 I-196 East U/S	605.69	605.65	-0.04	606.08	606.04	-0.04
215253.2 I-196 East D/S	605.63	605.58	-0.05	606.03	605.99	-0.04
214870.9 XS 22	605.51	605.46	-0.05	605.91	605.87	-0.04
214720.8 Dam No. 4 U/S	605.32	605.39	0.07	605.84	605.82	-0.02
214711.5 Dam No. 4 D/S	605.30	605.39	0.09	605.68	605.81	0.13
214608.3 Bridge St U/S	605.27	605.37	0.10	605.65	605.74	0.09
214526.8 Bridge St D/S	605.11	605.22	0.11	605.56	605.66	0.10
214399.5 Dam No. 3 U/S	605.09	605.22	0.13	605.51	605.57	0.06
214393.3 Dam No. 3 D/S	605.03	605.22	0.19	605.39	605.56	0.17
214151.6 XS 21	605.01	605.16	0.15	605.32	605.47	0.15
213966.6	604.98	605.13	0.15	605.28	605.43	0.15
213926.6	604.96	605.02	0.06	605.27	605.40	0.13
213856.9 Dam No. 2 U/S	604.94	604.99	0.05	605.26	605.28	0.02
213851.6 Dam No. 2 D/S	604.93	605.01	0.08	605.19	605.27	0.08
213726.4	604.89	604.95	0.06	605.16	605.23	0.07
213666.4 XS 20	604.89	604.95	0.06	605.15	605.21	0.06
213522.5 ped bridge U/S	604.84	604.90	0.06	605.13	605.19	0.06

10-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
213489.9 ped bridge D/S	604.79	604.86	0.07	605.10	605.16	0.06
213370.1	604.74	604.81	0.07	605.07	605.13	0.06
213300	604.74	604.71	-0.03	605.05	605.10	0.05
213220.0 Dam No. 1 U/S	604.71	604.72	0.01	605.04	604.99	-0.05
213213.0 Dam No. 1 D/S	604.69	604.72	0.03	604.95	604.99	0.04
213163.8 Pearl St U/S	604.67	604.71	0.04	604.94	604.98	0.04
213093.7 Pearl St D/S	604.59	604.63	0.04	604.87	604.91	0.04
213028.2	604.56	604.60	0.04	604.86	604.89	0.03
212980.5 XS 19	604.55	604.57	0.02	604.85	604.88	0.03
212877.2	604.52	604.55	0.03	604.83	604.85	0.02
212766.3	604.51	604.52	0.01	604.81	604.83	0.02
212706.3	604.51	604.51	0.00	604.79	604.81	0.02
212611.5 XS 18	604.51	604.52	0.01	604.77	604.78	0.01
212446.8 ped bridge U/S	604.49	604.50	0.01	604.75	604.76	0.01
212414.5 ped bridge D/S	604.47	604.48	0.01	604.73	604.74	0.01
212334.2 XS 17	604.46	604.47	0.01	604.71	604.72	0.01
212250	604.45	604.45	0.00	604.70	604.70	0.00
212188.7	604.44	604.44	0.00	604.69	604.69	0.00
212103.5 XS 16	604.43	604.43	0.00	604.67	604.67	0.00
211964.7 Fulton St U/S	604.42	604.42	0.00	604.58	604.58	0.00
211868.1 Fulton St D/S	604.38	604.38	0.00	604.53	604.53	0.00
211664.8 XS 15	604.32	604.32	0.00	604.51	604.51	0.00
211561.3 XS 14	604.30	604.30	0.00	604.50	604.50	0.00
211348.6 US Hwy 131 U/S	604.24	604.24	0.00	604.48	604.48	0.00
211144.8 US Hwy 131 D/S	604.14	604.14	0.00	604.43	604.43	0.00
210918.9 XS 13	604.14	604.14	0.00	604.34	604.34	0.00
210676.0 XS 12B	604.14	604.14	0.00	604.32	604.32	0.00
209996.9 XS 12A	604.05	604.05	0.00	604.27	604.27	0.00
209711.4 RR2 U/S	604.05	604.05	0.00	604.16	604.16	0.00
209656.6 RR2 D/S	604.03	604.03	0.00	604.14	604.14	0.00
209422.2 XS 11	603.97	603.97	0.00	604.12	604.12	0.00
209175.5 XS 10	603.82	603.82	0.00	604.09	604.09	0.00
208859.8 Wealthy St U/S	603.66	603.66	0.00	604.04	604.04	0.00
208777.1 Wealthy St D/S	603.62	603.62	0.00	604.00	604.00	0.00
208327.8 XS 9	603.62	603.62	0.00	603.87	603.87	0.00
207340.5 RR1 U/S	603.57	603.57	0.00	603.77	603.77	0.00
207324.2 RR1 D/S	603.54	603.54	0.00	603.74	603.74	0.00
206988	603.48	603.48	0.00	603.71	603.71	0.00
206651.9	603.42	603.42	0.00	603.68	603.68	0.00
206315.8 XS 8	603.39	603.39	0.00	603.64	603.64	0.00
205904	603.32	603.32	0.00	603.59	603.59	0.00
205492.2	603.22	603.22	0.00	603.51	603.51	0.00
205080.5	603.13	603.13	0.00	603.44	603.44	0.00
204668.7 XS 7	603.04	603.04	0.00	603.36	603.36	0.00
204250.5	602.90	602.90	0.00	603.28	603.28	0.00
203832.4 XS 6	602.81	602.81	0.00	603.19	603.19	0.00
203398.8	602.74	602.74	0.00	603.08	603.08	0.00
202965.1	602.67	602.67	0.00	602.99	602.99	0.00
202531.5	602.60	602.60	0.00	602.90	602.90	0.00
202097.9 XS 5	602.54	602.54	0.00	602.82	602.82	0.00
201740	602.50	602.50	0.00	602.75	602.75	0.00
201382.2	602.46	602.46	0.00	602.68	602.68	0.00
201024.4 XS 4	602.44	602.44	0.00	602.62	602.62	0.00
200751	602.40	602.40	0.00	602.59	602.59	0.00
200477.6 I-196 East U/S	602.38	602.38	0.00	602.55	602.55	0.00
200408.8 I-196 East D/S	602.37	602.37	0.00	602.53	602.53	0.00
200340.0 I-196 West U/S	602.36	602.36	0.00	602.52	602.52	0.00
200271.2 I-196 West D/S	602.35	602.35	0.00	602.51	602.51	0.00
200063.8 XS 3	602.16	602.16	0.00	602.46	602.46	0.00

10-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
199857.4	602.11	602.11	0.00	602.42	602.42	0.00
199651.1	602.04	602.04	0.00	602.37	602.37	0.00
199444.7	601.97	601.97	0.00	602.32	602.32	0.00
199238.3	601.87	601.87	0.00	602.27	602.27	0.00
199031.9 XS 2	601.80	601.80	0.00	602.21	602.21	0.00
198803.4	601.76	601.76	0.00	602.14	602.14	0.00
198574.8	601.75	601.75	0.00	602.07	602.07	0.00
198346.3	601.76	601.76	0.00	602.00	602.00	0.00
198117.8 XS 1	601.76	601.76	0.00	601.93	601.93	0.00
196113.4	601.18	601.18	0.00	601.49	601.49	0.00
195990.1	601.27	601.27	0.00	601.41	601.41	0.00
195958.1	601.27	601.27	0.00	601.40	601.40	0.00
195867.6	601.16	601.16	0.00	601.38	601.38	0.00
195493.9	601.11	601.11	0.00	601.32	601.32	0.00
194983.9	601.08	601.08	0.00	601.25	601.25	0.00
192633.9	600.83	600.83	0.00	601.00	601.00	0.00
190233.9	600.26	600.26	0.00	600.62	600.62	0.00
183733.9	599.99	599.99	0.00	600.03	600.03	0.00
180433.9	599.64	599.64	0.00	599.82	599.82	0.00
180333.9	599.47	599.47	0.00	599.70	599.70	0.00
180191.9	599.50	599.50	0.00	599.66	599.66	0.00
180190.9	599.48	599.48	0.00	599.66	599.66	0.00
180134.9	599.47	599.47	0.00	599.65	599.65	0.00
180133.9	599.48	599.48	0.00	599.64	599.64	0.00
177683.9	599.19	599.19	0.00	599.37	599.37	0.00
176303.9	598.85	598.85	0.00	599.13	599.13	0.00
175383.9	598.83	598.83	0.00	598.96	598.96	0.00
174783.9	598.78	598.78	0.00	598.90	598.90	0.00
172643.9	598.68	598.68	0.00	598.75	598.75	0.00
171243.9	598.52	598.52	0.00	598.64	598.64	0.00
169743.9	598.39	598.39	0.00	598.53	598.53	0.00
167243.9	598.10	598.10	0.00	598.21	598.21	0.00
165443.9	597.86	597.86	0.00	598.03	598.03	0.00
163763.9	597.69	597.69	0.00	597.79	597.79	0.00
162163.9	597.55	597.55	0.00	597.65	597.65	0.00
161233.9	597.48	597.48	0.00	597.57	597.57	0.00
159383.9	597.35	597.35	0.00	597.45	597.45	0.00
157683.9	597.23	597.23	0.00	597.32	597.32	0.00
155083.9	597.14	597.14	0.00	597.23	597.23	0.00
153553.9	597.07	597.07	0.00	597.16	597.16	0.00
152203.9	596.85	596.85	0.00	597.00	597.00	0.00

5-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
244283.5 XS 44	614.66	614.66	0.00	614.80	614.80	0.00
241690.0 XS 43	614.41	614.41	0.00	614.53	614.53	0.00
239160.3 XS 42	614.16	614.16	0.00	614.27	614.27	0.00
237272.0 XS 41	613.97	613.97	0.00	614.08	614.08	0.00
236330.2 XS 40	613.86	613.86	0.00	613.99	613.99	0.00
235474.7 XS 46	613.78	613.78	0.00	613.89	613.89	0.00
235157.2 N Park St U/S	613.74	613.74	0.00	613.86	613.86	0.00
235082.5 N Park St D/S	613.72	613.72	0.00	613.84	613.84	0.00
234804.6 XS 45	613.65	613.65	0.00	613.81	613.81	0.00
234551.4 I-96 West U/S	613.63	613.63	0.00	613.77	613.77	0.00
234504.4 I-96 West D/S	613.56	613.56	0.00	613.70	613.70	0.00
234457.4 I-96 East U/S	613.56	613.56	0.00	613.69	613.69	0.00
234410.5 I-96 East D/S	613.42	613.42	0.00	613.56	613.56	0.00
233807.3 XS 39	613.30	613.30	0.00	613.48	613.48	0.00
231462.9 XS 38	612.99	612.99	0.00	613.13	613.13	0.00
228851.2 XS 37	612.68	612.68	0.00	612.80	612.80	0.00
227668.5 XS 36	612.52	612.52	0.00	612.64	612.64	0.00
225261.3 XS 35	612.10	612.10	0.00	612.26	612.26	0.00
224424.1 XS 34	611.96	611.96	0.00	612.12	612.12	0.00
223798.2 Ann St U/S	611.86	611.86	0.00	612.02	612.02	0.00
223733.8 Ann St D/S	611.83	611.83	0.00	612.00	612.00	0.00
223275.7 XS 33	611.77	611.77	0.00	611.91	611.91	0.00
222995.3 XS 32	611.73	611.73	0.00	611.87	611.87	0.00
222730.9 RR3 U/S	611.63	611.63	0.00	611.81	611.81	0.00
222717.4 RR3 D/S	611.59	611.59	0.00	611.78	611.78	0.00
222516.4 XS 31	611.58	611.58	0.00	611.73	611.73	0.00
221221.6 XS 30	611.24	611.24	0.00	611.50	611.50	0.00
220387.9 XS 29	610.95	610.95	0.00	611.26	611.26	0.00
219837.8 Leonard St U/S	610.82	610.82	0.00	611.09	611.09	0.00
219767.8 Leonard St D/S	610.78	610.78	0.00	611.04	611.04	0.00
219354.2 XS 28	610.72	610.72	0.00	610.94	610.94	0.00
218588.5 XS 27	610.59	610.59	0.00	610.80	610.80	0.00
217611.5 XS 26	610.36	610.36	0.00	610.61	610.61	0.00
216869.4 Sixth St U/S	610.26	610.26	0.00	610.46	610.46	0.00
216832.0 Sixth St D/S	610.23	610.23	0.00	610.45	610.45	0.00
216378.8 XS 25	610.17	610.17	0.00	610.37	610.37	0.00
216034.2 Dam No. 5 U/S	610.10	610.10	0.00	610.30	610.30	0.00
216020.2 Dam No. 5 D/S	604.34	604.33	-0.01	604.73	604.71	-0.02
215862.7 XS 24	604.29	604.28	-0.01	604.66	604.64	-0.02
215642.2 XS 23	604.23	604.22	-0.01	604.57	604.56	-0.01
215385.6 I-196 West U/S	604.08	604.06	-0.02	604.47	604.46	-0.01
215330.5 I-196 West D/S	604.01	604.00	-0.01	604.41	604.40	-0.01
215315.2 I-196 East U/S	604.02	604.00	-0.02	604.39	604.37	-0.02
215253.2 I-196 East D/S	603.95	603.93	-0.02	604.33	604.32	-0.01
214870.9 XS 22	603.81	603.80	-0.01	604.19	604.18	-0.01
214720.8 Dam No. 4 U/S	603.61	603.73	0.12	604.10	604.12	0.02
214711.5 Dam No. 4 D/S	603.58	603.73	0.15	603.93	604.11	0.18
214608.3 Bridge St U/S	603.55	603.70	0.15	603.90	604.04	0.14
214526.8 Bridge St D/S	603.40	603.55	0.15	603.81	603.96	0.15
214399.5 Dam No. 3 U/S	603.37	603.55	0.18	603.76	603.87	0.11
214393.3 Dam No. 3 D/S	603.31	603.55	0.24	603.65	603.86	0.21
214151.6 XS 21	603.29	603.49	0.20	603.57	603.76	0.19
213966.6	603.25	603.45	0.20	603.53	603.72	0.19
213926.6	603.23	603.30	0.07	603.52	603.69	0.17
213856.9 Dam No. 2 U/S	603.21	603.26	0.05	603.50	603.55	0.05
213851.6 Dam No. 2 D/S	603.20	603.29	0.09	603.44	603.53	0.09
213726.4	603.16	603.24	0.08	603.41	603.49	0.08
213666.4 XS 20	603.16	603.24	0.08	603.40	603.47	0.07
213522.5 ped bridge U/S	603.11	603.19	0.08	603.37	603.45	0.08

5-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
213489.9 ped bridge D/S	603.07	603.15	0.08	603.35	603.42	0.07
213370.1	603.02	603.10	0.08	603.32	603.40	0.08
213300	603.02	602.99	-0.03	603.30	603.36	0.06
213220.0 Dam No. 1 U/S	602.99	603.00	0.01	603.28	603.25	-0.03
213213.0 Dam No. 1 D/S	602.97	603.00	0.03	603.20	603.24	0.04
213163.8 Pearl St U/S	602.95	602.99	0.04	603.19	603.23	0.04
213093.7 Pearl St D/S	602.89	602.93	0.04	603.14	603.18	0.04
213028.2	602.86	602.90	0.04	603.12	603.16	0.04
212980.5 XS 19	602.85	602.87	0.02	603.12	603.15	0.03
212877.2	602.83	602.85	0.02	603.10	603.12	0.02
212766.3	602.81	602.83	0.02	603.08	603.09	0.01
212706.3	602.81	602.82	0.01	603.06	603.08	0.02
212611.5 XS 18	602.81	602.82	0.01	603.04	603.05	0.01
212446.8 ped bridge U/S	602.79	602.80	0.01	603.02	603.03	0.01
212414.5 ped bridge D/S	602.77	602.78	0.01	603.00	603.01	0.01
212334.2 XS 17	602.76	602.78	0.02	602.98	602.99	0.01
212250	602.75	602.76	0.01	602.97	602.97	0.00
212188.7	602.75	602.75	0.00	602.96	602.96	0.00
212103.5 XS 16	602.74	602.74	0.00	602.95	602.95	0.00
211964.7 Fulton St U/S	602.73	602.73	0.00	602.87	602.87	0.00
211868.1 Fulton St D/S	602.70	602.70	0.00	602.83	602.83	0.00
211664.8 XS 15	602.65	602.65	0.00	602.81	602.81	0.00
211561.3 XS 14	602.64	602.64	0.00	602.80	602.80	0.00
211348.6 US Hwy 131 U/S	602.58	602.58	0.00	602.78	602.78	0.00
211144.8 US Hwy 131 D/S	602.49	602.49	0.00	602.73	602.73	0.00
210918.9 XS 13	602.49	602.49	0.00	602.65	602.65	0.00
210676.0 XS 12B	602.49	602.49	0.00	602.64	602.64	0.00
209996.9 XS 12A	602.41	602.41	0.00	602.59	602.59	0.00
209711.4 RR2 U/S	602.40	602.40	0.00	602.50	602.50	0.00
209656.6 RR2 D/S	602.39	602.39	0.00	602.48	602.48	0.00
209422.2 XS 11	602.34	602.34	0.00	602.46	602.46	0.00
209175.5 XS 10	602.21	602.21	0.00	602.44	602.44	0.00
208859.8 Wealthy St U/S	602.07	602.07	0.00	602.39	602.39	0.00
208777.1 Wealthy St D/S	602.04	602.04	0.00	602.35	602.35	0.00
208327.8 XS 9	602.04	602.04	0.00	602.24	602.24	0.00
207340.5 RR1 U/S	601.98	601.98	0.00	602.15	602.15	0.00
207324.2 RR1 D/S	601.96	601.96	0.00	602.13	602.13	0.00
206988	601.91	601.91	0.00	602.10	602.10	0.00
206651.9	601.85	601.85	0.00	602.07	602.07	0.00
206315.8 XS 8	601.83	601.83	0.00	602.04	602.04	0.00
205904	601.76	601.76	0.00	601.99	601.99	0.00
205492.2	601.68	601.68	0.00	601.92	601.92	0.00
205080.5	601.59	601.59	0.00	601.85	601.85	0.00
204668.7 XS 7	601.51	601.51	0.00	601.79	601.79	0.00
204250.5	601.40	601.40	0.00	601.71	601.71	0.00
203832.4 XS 6	601.32	601.32	0.00	601.63	601.63	0.00
203398.8	601.25	601.25	0.00	601.53	601.53	0.00
202965.1	601.19	601.19	0.00	601.45	601.45	0.00
202531.5	601.12	601.12	0.00	601.37	601.37	0.00
202097.9 XS 5	601.07	601.07	0.00	601.30	601.30	0.00
201740	601.02	601.02	0.00	601.24	601.24	0.00
201382.2	600.99	600.99	0.00	601.18	601.18	0.00
201024.4 XS 4	600.97	600.97	0.00	601.12	601.12	0.00
200751	600.93	600.93	0.00	601.09	601.09	0.00
200477.6 I-196 East U/S	600.91	600.91	0.00	601.05	601.05	0.00
200408.8 I-196 East D/S	600.90	600.90	0.00	601.04	601.04	0.00
200340.0 I-196 West U/S	600.90	600.90	0.00	601.03	601.03	0.00
200271.2 I-196 West D/S	600.89	600.89	0.00	601.02	601.02	0.00
200063.8 XS 3	600.73	600.73	0.00	600.98	600.98	0.00

5-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
199857.4	600.67	600.67	0.00	600.94	600.94	0.00
199651.1	600.61	600.61	0.00	600.89	600.89	0.00
199444.7	600.54	600.54	0.00	600.85	600.85	0.00
199238.3	600.45	600.45	0.00	600.80	600.80	0.00
199031.9 XS 2	600.39	600.39	0.00	600.74	600.74	0.00
198803.4	600.34	600.34	0.00	600.68	600.68	0.00
198574.8	600.32	600.32	0.00	600.62	600.62	0.00
198346.3	600.32	600.32	0.00	600.56	600.56	0.00
198117.8 XS 1	600.32	600.32	0.00	600.49	600.49	0.00
196113.4	599.79	599.79	0.00	600.06	600.06	0.00
195990.1	599.87	599.87	0.00	599.99	599.99	0.00
195958.1	599.86	599.86	0.00	599.98	599.98	0.00
195867.6	599.77	599.77	0.00	599.96	599.96	0.00
195493.9	599.73	599.73	0.00	599.90	599.90	0.00
194983.9	599.69	599.69	0.00	599.85	599.85	0.00
192633.9	599.45	599.45	0.00	599.61	599.61	0.00
190233.9	598.95	598.95	0.00	599.25	599.25	0.00
183733.9	598.66	598.66	0.00	598.70	598.70	0.00
180433.9	598.34	598.34	0.00	598.49	598.49	0.00
180333.9	598.20	598.20	0.00	598.39	598.39	0.00
180191.9	598.22	598.22	0.00	598.36	598.36	0.00
180190.9	598.20	598.20	0.00	598.35	598.35	0.00
180134.9	598.19	598.19	0.00	598.34	598.34	0.00
180133.9	598.20	598.20	0.00	598.33	598.33	0.00
177683.9	597.93	597.93	0.00	598.08	598.08	0.00
176303.9	597.60	597.60	0.00	597.86	597.86	0.00
175383.9	597.57	597.57	0.00	597.69	597.69	0.00
174783.9	597.52	597.52	0.00	597.63	597.63	0.00
172643.9	597.42	597.42	0.00	597.49	597.49	0.00
171243.9	597.26	597.26	0.00	597.37	597.37	0.00
169743.9	597.14	597.14	0.00	597.27	597.27	0.00
167243.9	596.84	596.84	0.00	596.95	596.95	0.00
165443.9	596.60	596.60	0.00	596.77	596.77	0.00
163763.9	596.41	596.41	0.00	596.51	596.51	0.00
162163.9	596.24	596.24	0.00	596.36	596.36	0.00
161233.9	596.18	596.18	0.00	596.27	596.27	0.00
159383.9	596.04	596.04	0.00	596.14	596.14	0.00
157683.9	595.93	595.93	0.00	596.01	596.01	0.00
155083.9	595.85	595.85	0.00	595.93	595.93	0.00
153553.9	595.79	595.79	0.00	595.87	595.87	0.00
152203.9	595.59	595.59	0.00	595.71	595.71	0.00

2-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
244283.5 XS 44	612.48	612.48	0.00	612.59	612.59	0.00
241690.0 XS 43	612.26	612.26	0.00	612.36	612.36	0.00
239160.3 XS 42	612.03	612.03	0.00	612.12	612.12	0.00
237272.0 XS 41	611.86	611.86	0.00	611.94	611.94	0.00
236330.2 XS 40	611.76	611.76	0.00	611.85	611.85	0.00
235474.7 XS 46	611.70	611.70	0.00	611.77	611.77	0.00
235157.2 N Park St U/S	611.67	611.67	0.00	611.75	611.75	0.00
235082.5 N Park St D/S	611.65	611.65	0.00	611.73	611.73	0.00
234804.6 XS 45	611.60	611.60	0.00	611.71	611.71	0.00
234551.4 I-96 West U/S	611.59	611.59	0.00	611.68	611.68	0.00
234504.4 I-96 West D/S	611.51	611.51	0.00	611.61	611.61	0.00
234457.4 I-96 East U/S	611.51	611.51	0.00	611.60	611.60	0.00
234410.5 I-96 East D/S	611.39	611.39	0.00	611.47	611.47	0.00
233807.3 XS 39	611.28	611.28	0.00	611.41	611.41	0.00
231462.9 XS 38	610.98	610.98	0.00	611.11	611.11	0.00
228851.2 XS 37	610.69	610.69	0.00	610.79	610.79	0.00
227668.5 XS 36	610.56	610.56	0.00	610.65	610.65	0.00
225261.3 XS 35	610.22	610.22	0.00	610.33	610.33	0.00
224424.1 XS 34	610.11	610.11	0.00	610.21	610.21	0.00
223798.2 Ann St U/S	610.03	610.03	0.00	610.13	610.13	0.00
223733.8 Ann St D/S	610.00	610.00	0.00	610.11	610.11	0.00
223275.7 XS 33	609.95	609.95	0.00	610.05	610.05	0.00
222995.3 XS 32	609.92	609.92	0.00	610.01	610.01	0.00
222730.9 RR3 U/S	609.84	609.84	0.00	609.96	609.96	0.00
222717.4 RR3 D/S	609.81	609.81	0.00	609.94	609.94	0.00
222516.4 XS 31	609.81	609.81	0.00	609.90	609.90	0.00
221221.6 XS 30	609.54	609.54	0.00	609.72	609.72	0.00
220387.9 XS 29	609.31	609.31	0.00	609.52	609.52	0.00
219837.8 Leonard St U/S	609.20	609.20	0.00	609.38	609.38	0.00
219767.8 Leonard St D/S	609.17	609.17	0.00	609.35	609.35	0.00
219354.2 XS 28	609.12	609.12	0.00	609.26	609.26	0.00
218588.5 XS 27	609.02	609.02	0.00	609.15	609.15	0.00
217611.5 XS 26	608.85	608.85	0.00	609.01	609.01	0.00
216869.4 Sixth St U/S	608.78	608.78	0.00	608.90	608.90	0.00
216832.0 Sixth St D/S	608.76	608.76	0.00	608.89	608.89	0.00
216378.8 XS 25	608.72	608.72	0.00	608.84	608.84	0.00
216034.2 Dam No. 5 U/S	608.67	608.67	0.00	608.79	608.79	0.00
216020.2 Dam No. 5 D/S	601.84	601.86	0.02	602.18	602.20	0.02
215862.7 XS 24	601.79	601.81	0.02	602.09	602.11	0.02
215642.2 XS 23	601.71	601.74	0.03	601.99	602.01	0.02
215385.6 I-196 West U/S	601.53	601.55	0.02	601.87	601.89	0.02
215330.5 I-196 West D/S	601.46	601.48	0.02	601.80	601.83	0.03
215315.2 I-196 East U/S	601.46	601.49	0.03	601.77	601.80	0.03
215253.2 I-196 East D/S	601.39	601.41	0.02	601.72	601.74	0.02
214870.9 XS 22	601.24	601.27	0.03	601.54	601.57	0.03
214720.8 Dam No. 4 U/S	601.01	601.20	0.19	601.44	601.51	0.07
214711.5 Dam No. 4 D/S	601.00	601.19	0.19	601.27	601.50	0.23
214608.3 Bridge St U/S	600.97	601.17	0.20	601.24	601.42	0.18
214526.8 Bridge St D/S	600.83	601.03	0.20	601.15	601.35	0.20
214399.5 Dam No. 3 U/S	600.78	601.02	0.24	601.10	601.26	0.16
214393.3 Dam No. 3 D/S	600.74	601.01	0.27	601.00	601.25	0.25
214151.6 XS 21	600.71	600.95	0.24	600.92	601.15	0.23
213966.6	600.67	600.91	0.24	600.88	601.11	0.23
213926.6	600.64	600.73	0.09	600.87	601.08	0.21
213856.9 Dam No. 2 U/S	600.61	600.65	0.04	600.85	600.91	0.06
213851.6 Dam No. 2 D/S	600.60	600.69	0.09	600.78	600.89	0.11
213726.4	600.56	600.65	0.09	600.75	600.84	0.09
213666.4 XS 20	600.56	600.65	0.09	600.74	600.83	0.09
213522.5 ped bridge U/S	600.52	600.61	0.09	600.71	600.80	0.09

2-Year Flood Event

	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
213489.9 ped bridge D/S	600.49	600.58	0.09	600.69	600.78	0.09
213370.1	600.44	600.54	0.10	600.67	600.76	0.09
213300	600.44	600.43	-0.01	600.65	600.72	0.07
213220.0 Dam No. 1 U/S	600.41	600.43	0.02	600.63	600.61	-0.02
213213.0 Dam No. 1 D/S	600.40	600.43	0.03	600.56	600.60	0.04
213163.8 Pearl St U/S	600.38	600.42	0.04	600.56	600.59	0.03
213093.7 Pearl St D/S	600.34	600.38	0.04	600.52	600.56	0.04
213028.2	600.32	600.35	0.03	600.51	600.55	0.04
212980.5 XS 19	600.31	600.33	0.02	600.50	600.54	0.04
212877.2	600.29	600.32	0.03	600.48	600.51	0.03
212766.3	600.28	600.29	0.01	600.46	600.48	0.02
212706.3	600.28	600.29	0.01	600.45	600.47	0.02
212611.5 XS 18	600.28	600.29	0.01	600.44	600.45	0.01
212446.8 ped bridge U/S	600.26	600.27	0.01	600.41	600.43	0.02
212414.5 ped bridge D/S	600.24	600.25	0.01	600.40	600.41	0.01
212334.2 XS 17	600.23	600.25	0.02	600.39	600.40	0.01
212250	600.22	600.23	0.01	600.37	600.38	0.01
212188.7	600.22	600.22	0.00	600.36	600.36	0.00
212103.5 XS 16	600.21	600.21	0.00	600.35	600.35	0.00
211964.7 Fulton St U/S	600.21	600.21	0.00	600.30	600.30	0.00
211868.1 Fulton St D/S	599.63	599.63	0.00	599.72	599.72	0.00
211664.8 XS 15	599.60	599.60	0.00	599.71	599.71	0.00
211561.3 XS 14	599.59	599.59	0.00	599.70	599.70	0.00
211348.6 US Hwy 131 U/S	599.54	599.54	0.00	599.69	599.69	0.00
211144.8 US Hwy 131 D/S	599.44	599.44	0.00	599.61	599.61	0.00
210918.9 XS 13	599.44	599.44	0.00	599.55	599.55	0.00
210676.0 XS 12B	599.43	599.43	0.00	599.54	599.54	0.00
209996.9 XS 12A	599.37	599.37	0.00	599.49	599.49	0.00
209711.4 RR2 U/S	599.36	599.36	0.00	599.42	599.42	0.00
209656.6 RR2 D/S	599.35	599.35	0.00	599.41	599.41	0.00
209422.2 XS 11	599.31	599.31	0.00	599.40	599.40	0.00
209175.5 XS 10	599.22	599.22	0.00	599.38	599.38	0.00
208859.8 Wealthy St U/S	599.12	599.12	0.00	599.34	599.34	0.00
208777.1 Wealthy St D/S	599.10	599.10	0.00	599.31	599.31	0.00
208327.8 XS 9	599.09	599.09	0.00	599.22	599.22	0.00
207340.5 RR1 U/S	599.04	599.04	0.00	599.15	599.15	0.00
207324.2 RR1 D/S	599.03	599.03	0.00	599.14	599.14	0.00
206988	598.99	598.99	0.00	599.11	599.11	0.00
206651.9	598.94	598.94	0.00	599.09	599.09	0.00
206315.8 XS 8	598.92	598.92	0.00	599.06	599.06	0.00
205904	598.87	598.87	0.00	599.02	599.02	0.00
205492.2	598.80	598.80	0.00	598.97	598.97	0.00
205080.5	598.74	598.74	0.00	598.91	598.91	0.00
204668.7 XS 7	598.67	598.67	0.00	598.86	598.86	0.00
204250.5	598.60	598.60	0.00	598.80	598.80	0.00
203832.4 XS 6	598.53	598.53	0.00	598.74	598.74	0.00
203398.8	598.48	598.48	0.00	598.67	598.67	0.00
202965.1	598.42	598.42	0.00	598.60	598.60	0.00
202531.5	598.37	598.37	0.00	598.54	598.54	0.00
202097.9 XS 5	598.32	598.32	0.00	598.48	598.48	0.00
201740	598.28	598.28	0.00	598.43	598.43	0.00
201382.2	598.25	598.25	0.00	598.39	598.39	0.00
201024.4 XS 4	598.22	598.22	0.00	598.34	598.34	0.00
200751	598.20	598.20	0.00	598.31	598.31	0.00
200477.6 I-196 East U/S	598.18	598.18	0.00	598.28	598.28	0.00
200408.8 I-196 East D/S	598.10	598.10	0.00	598.20	598.20	0.00
200340.0 I-196 West U/S	598.09	598.09	0.00	598.19	598.19	0.00
200271.2 I-196 West D/S	598.08	598.08	0.00	598.18	598.18	0.00
200063.8 XS 3	597.97	597.97	0.00	598.15	598.15	0.00

2-Year Flood Event

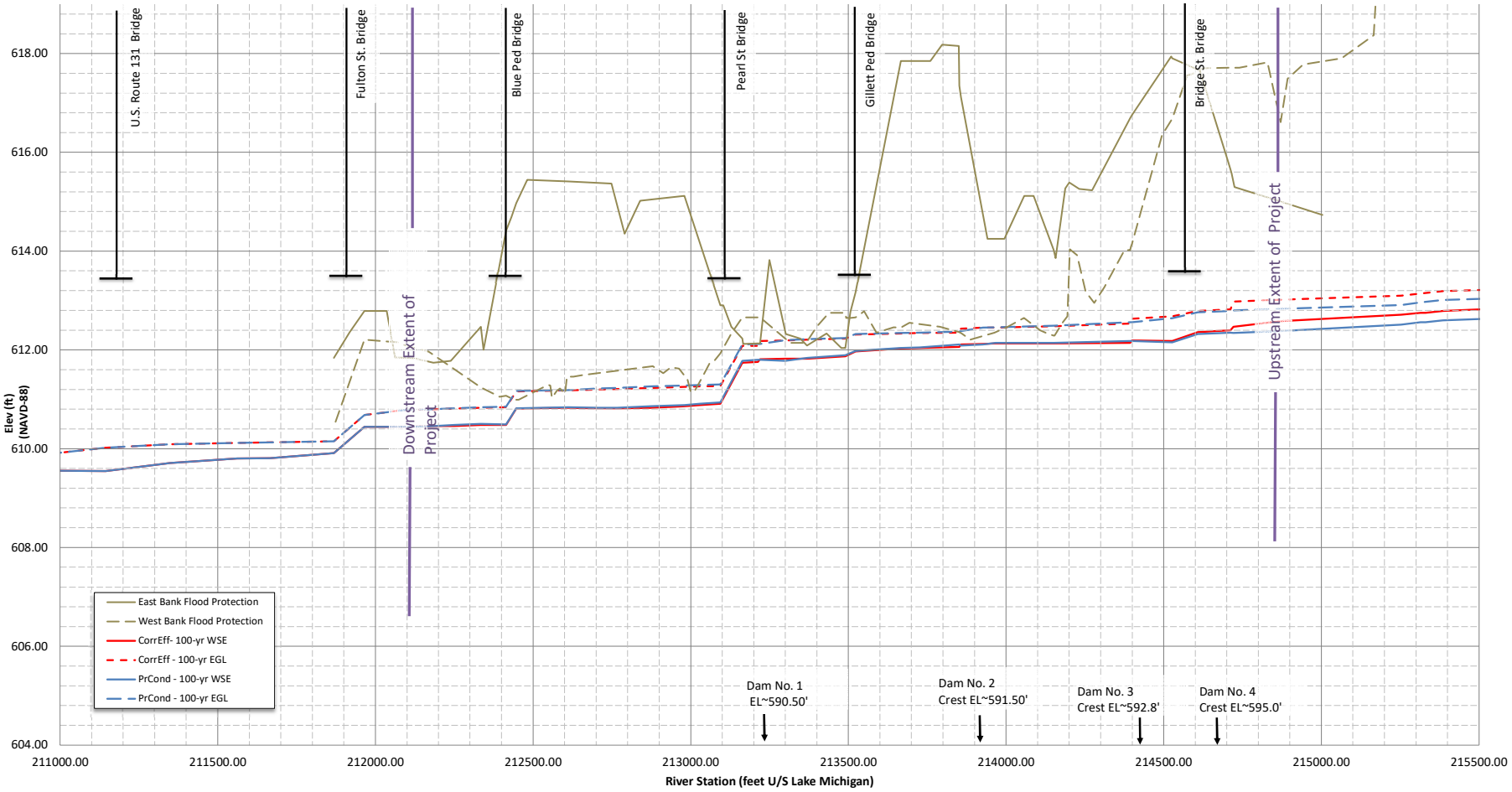
	Water-surface elevation			Energy-grade elevation		
River Station	Corrected Effective	Proposed Conditions	Δ (PC - CE)	Corrected Effective	Proposed Conditions	Δ (PC - CE)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft-NAVD-88*	*ft*
199857.4	597.93	597.93	0.00	598.11	598.11	0.00
199651.1	597.87	597.87	0.00	598.08	598.08	0.00
199444.7	597.82	597.82	0.00	598.04	598.04	0.00
199238.3	597.76	597.76	0.00	598.00	598.00	0.00
199031.9 XS 2	597.70	597.70	0.00	597.95	597.95	0.00
198803.4	597.66	597.66	0.00	597.90	597.90	0.00
198574.8	597.62	597.62	0.00	597.86	597.86	0.00
198346.3	597.60	597.60	0.00	597.81	597.81	0.00
198117.8 XS 1	597.60	597.60	0.00	597.75	597.75	0.00
196113.4	597.15	597.15	0.00	597.35	597.35	0.00
195990.1	597.20	597.20	0.00	597.30	597.30	0.00
195958.1	597.19	597.19	0.00	597.29	597.29	0.00
195867.6	597.14	597.14	0.00	597.28	597.28	0.00
195493.9	597.10	597.10	0.00	597.23	597.23	0.00
194983.9	597.06	597.06	0.00	597.18	597.18	0.00
192633.9	596.85	596.85	0.00	596.97	596.97	0.00
190233.9	596.43	596.43	0.00	596.66	596.66	0.00
183733.9	596.09	596.09	0.00	596.13	596.13	0.00
180433.9	595.83	595.83	0.00	595.93	595.93	0.00
180333.9	595.72	595.72	0.00	595.85	595.85	0.00
180191.9	595.74	595.74	0.00	595.83	595.83	0.00
180190.9	595.72	595.72	0.00	595.82	595.82	0.00
180134.9	595.72	595.72	0.00	595.82	595.82	0.00
180133.9	595.72	595.72	0.00	595.81	595.81	0.00
177683.9	595.47	595.47	0.00	595.59	595.59	0.00
176303.9	595.16	595.16	0.00	595.38	595.38	0.00
175383.9	595.12	595.12	0.00	595.22	595.22	0.00
174783.9	595.07	595.07	0.00	595.17	595.17	0.00
172643.9	594.95	594.95	0.00	595.02	595.02	0.00
171243.9	594.80	594.80	0.00	594.91	594.91	0.00
169743.9	594.70	594.70	0.00	594.81	594.81	0.00
167243.9	594.39	594.39	0.00	594.50	594.50	0.00
165443.9	594.16	594.16	0.00	594.31	594.31	0.00
163763.9	593.95	593.95	0.00	594.06	594.06	0.00
162163.9	593.72	593.72	0.00	593.86	593.86	0.00
161233.9	593.66	593.66	0.00	593.75	593.75	0.00
159383.9	593.51	593.51	0.00	593.61	593.61	0.00
157683.9	593.42	593.42	0.00	593.48	593.48	0.00
155083.9	593.36	593.36	0.00	593.42	593.42	0.00
153553.9	593.30	593.30	0.00	593.37	593.37	0.00
152203.9	593.12	593.12	0.00	593.22	593.22	0.00

ATTACHMENT 12:
HYDRAULIC MODEL – WSE AND EGL PROFILES

Attachment 12

100-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 211+000 to 214+500

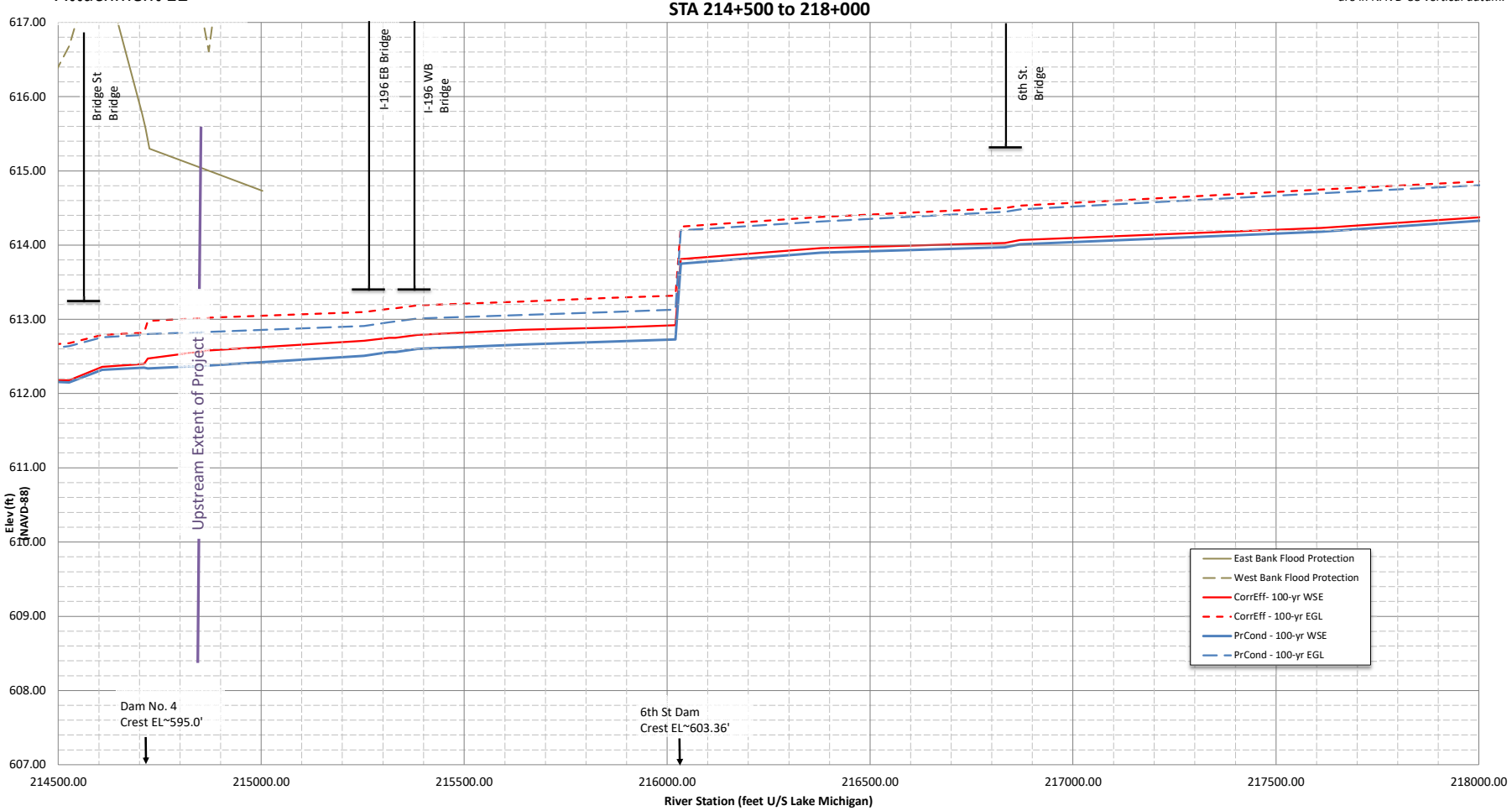
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

100-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 214+500 to 218+000

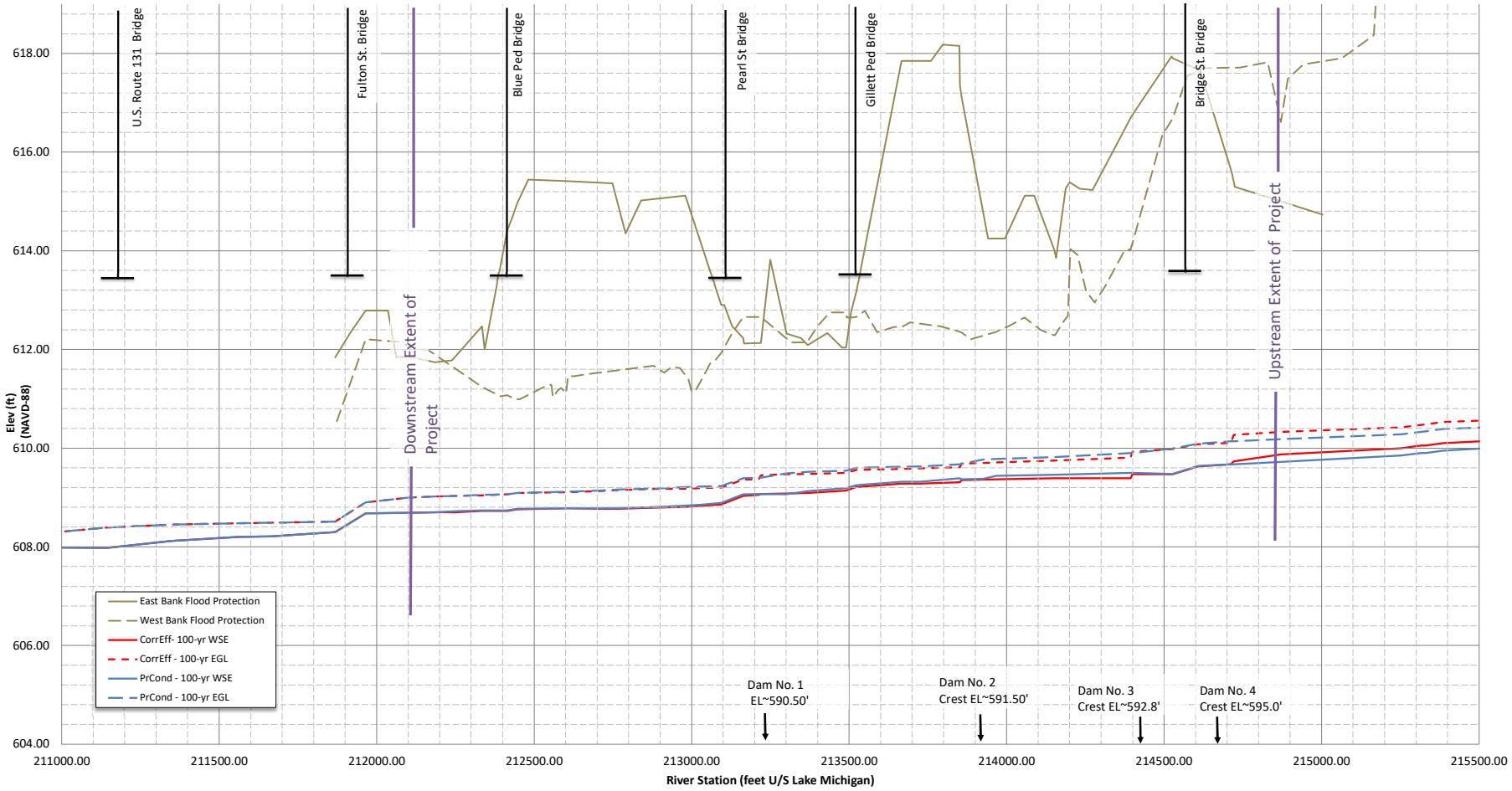
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

50-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 211+000 to 214+500

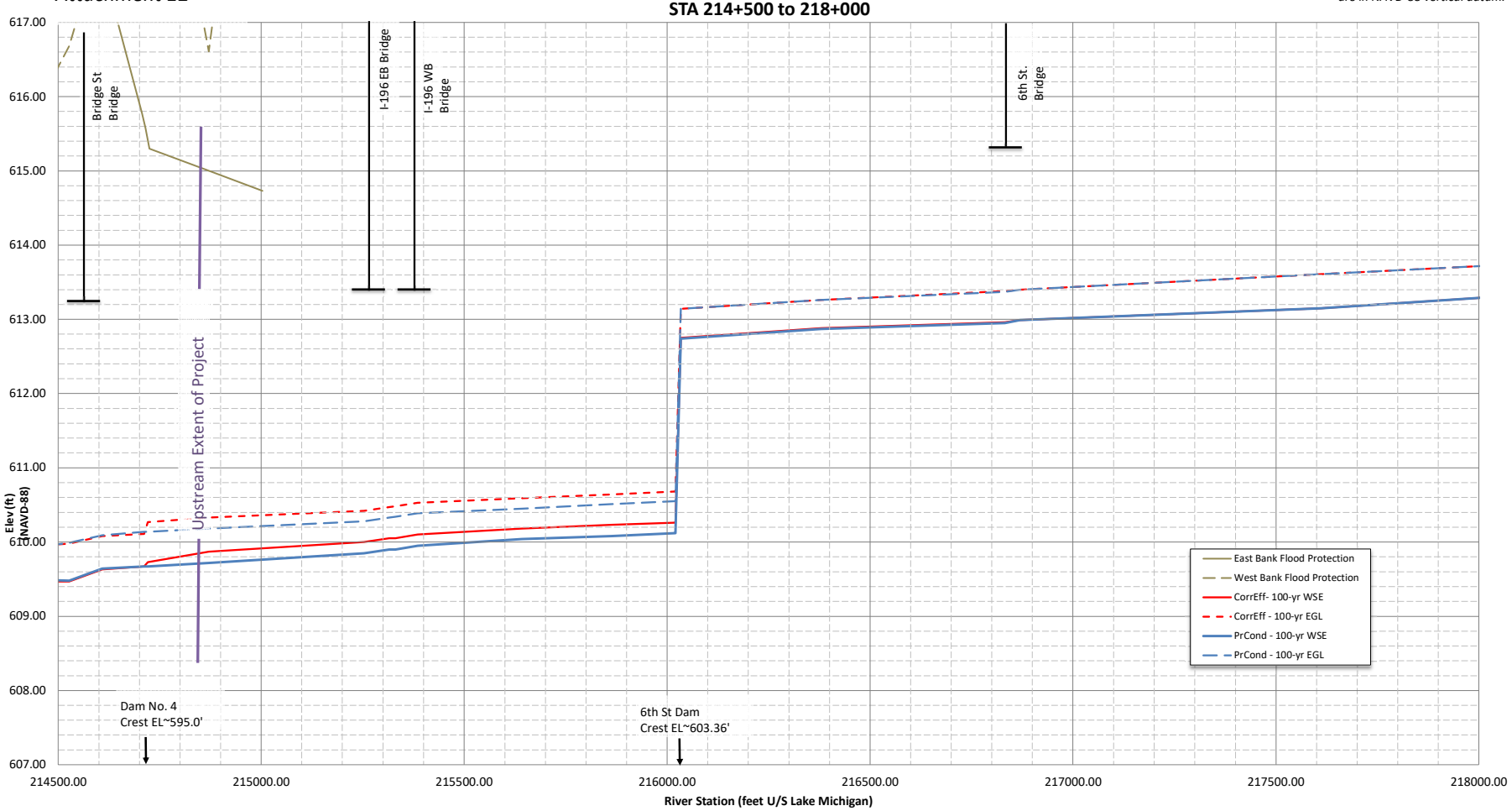
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

50-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 214+500 to 218+000

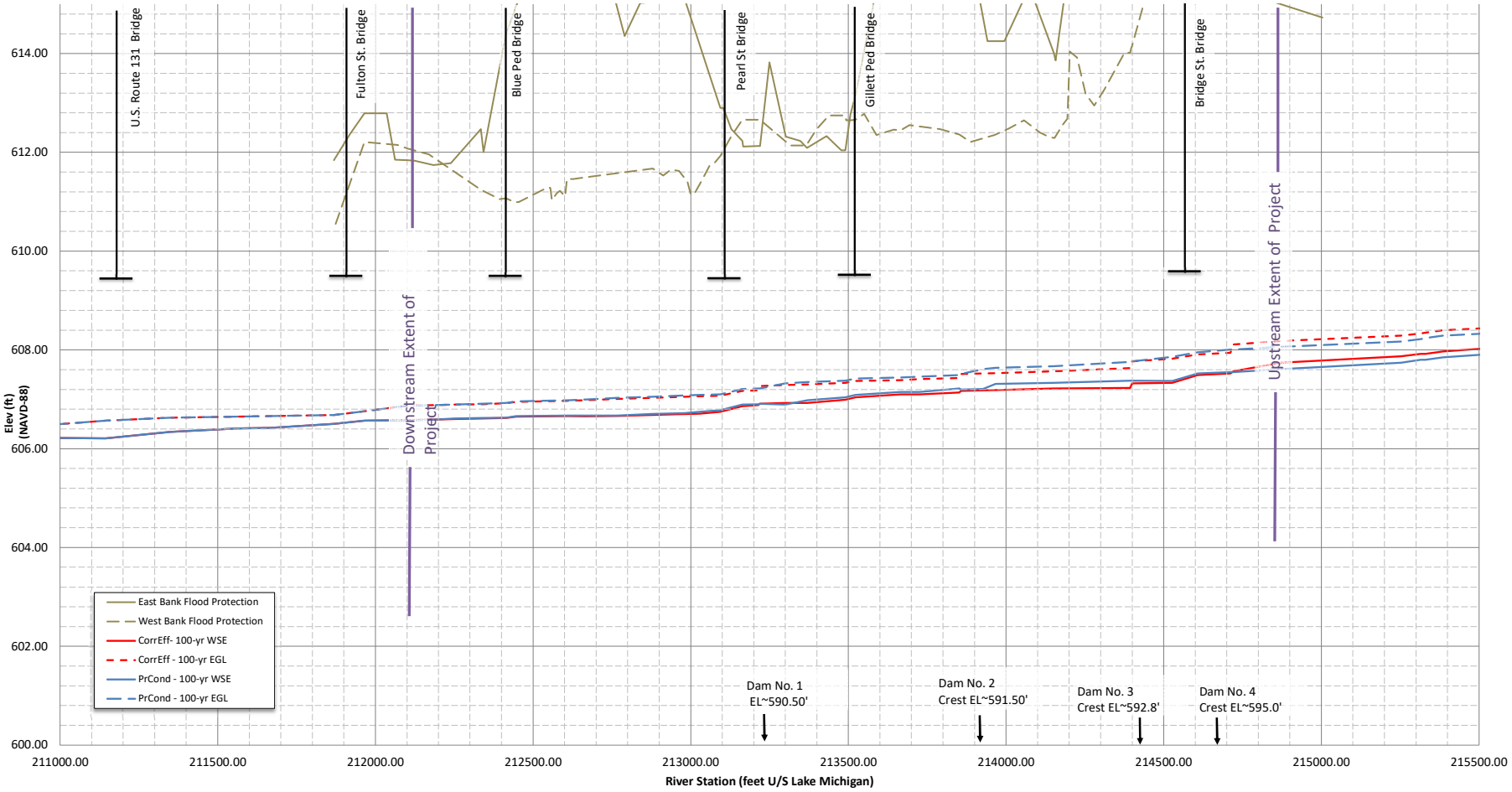
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

25-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 211+000 to 214+500

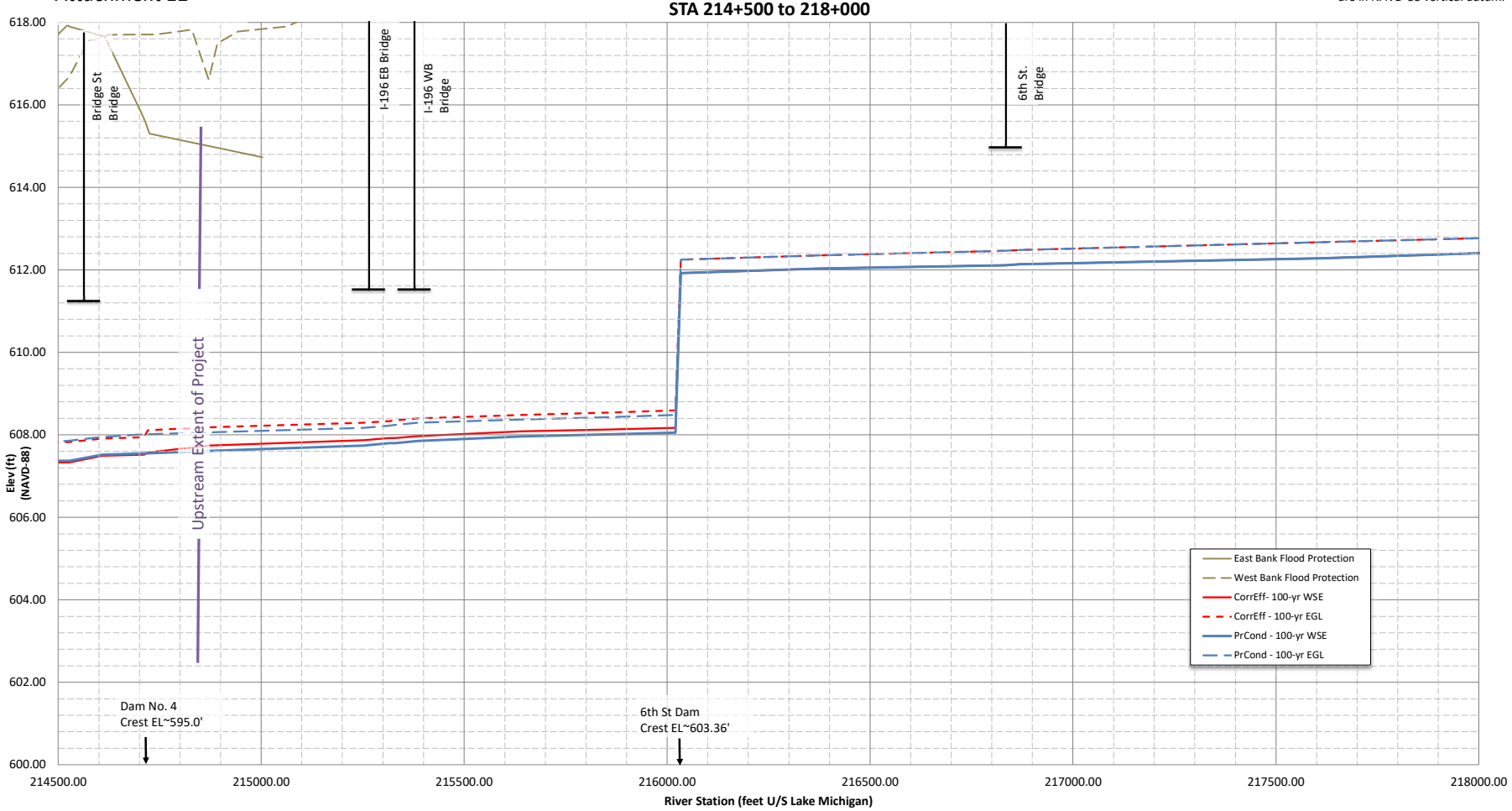
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

25-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 214+500 to 218+000

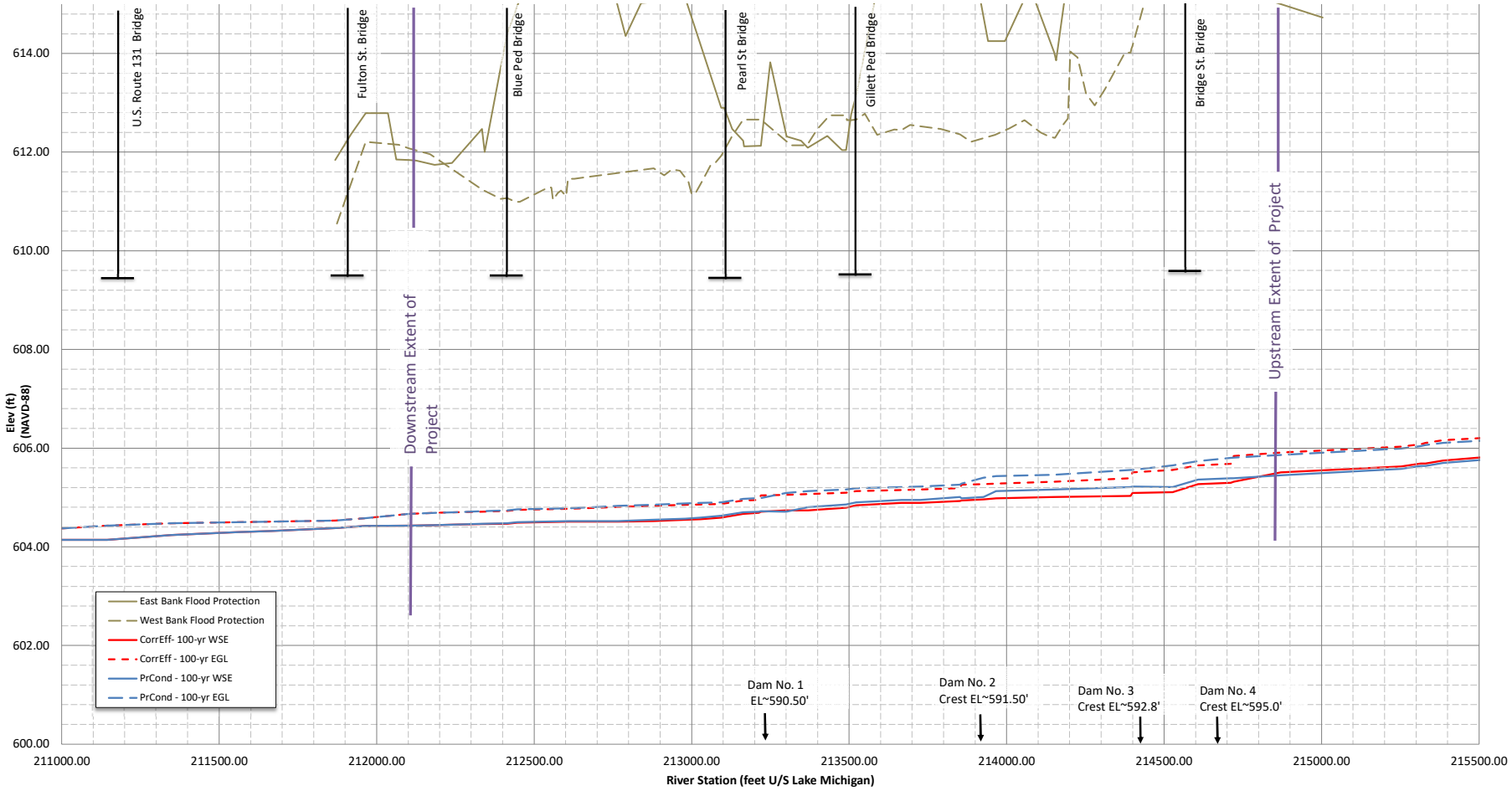
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

10-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 211+000 to 214+500

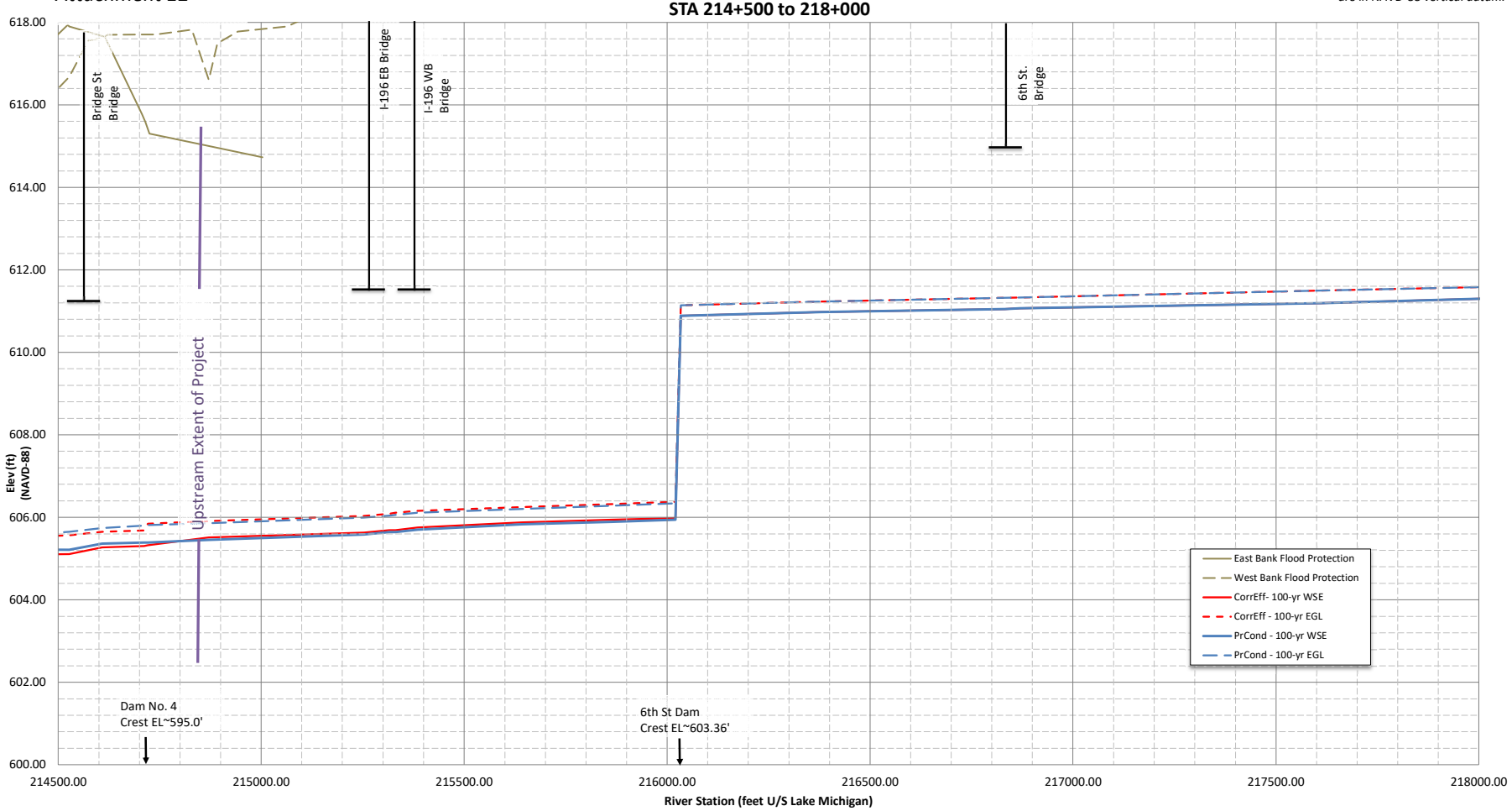
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

10-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 214+500 to 218+000

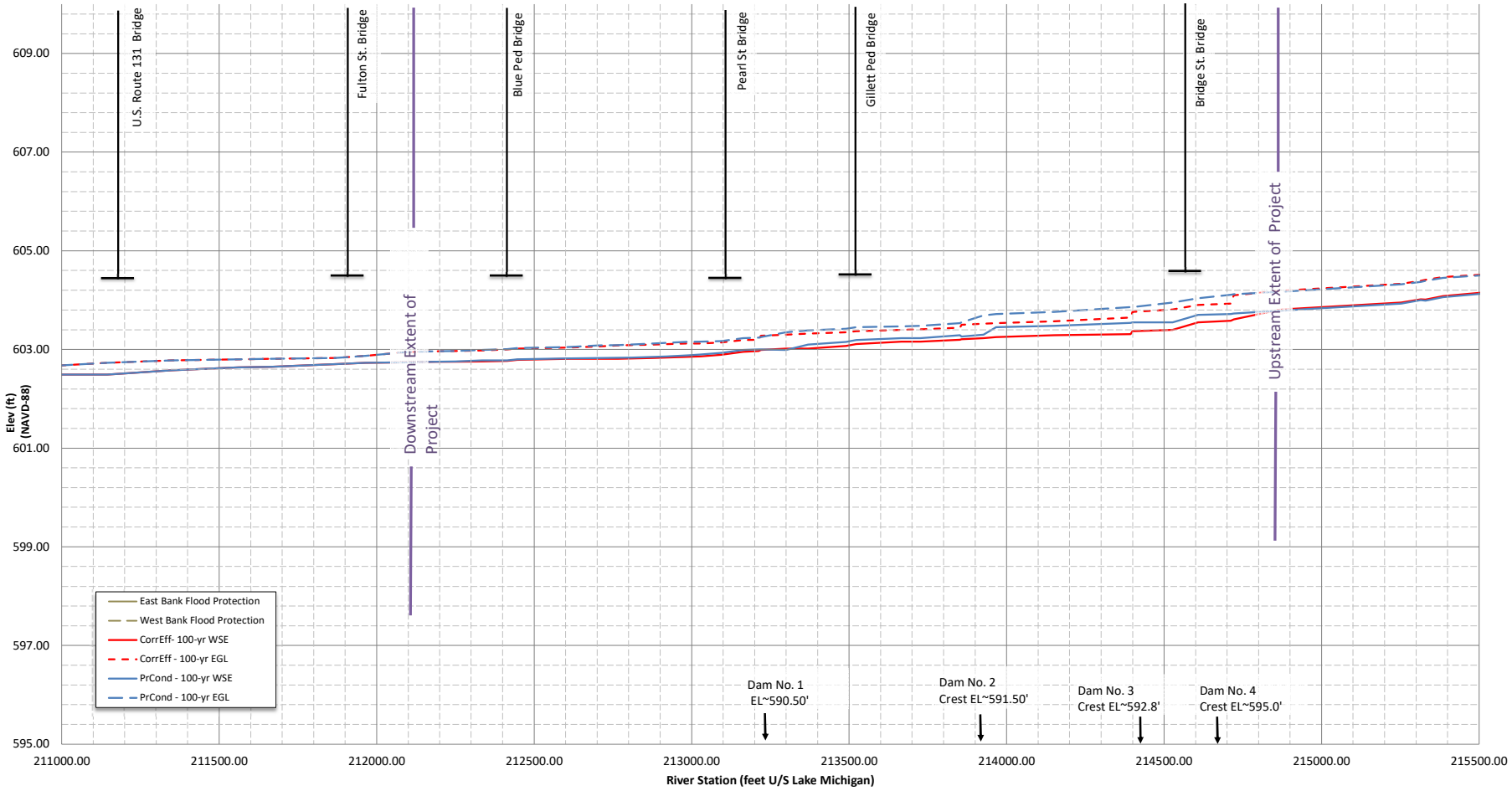
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

5-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 211+000 to 214+500

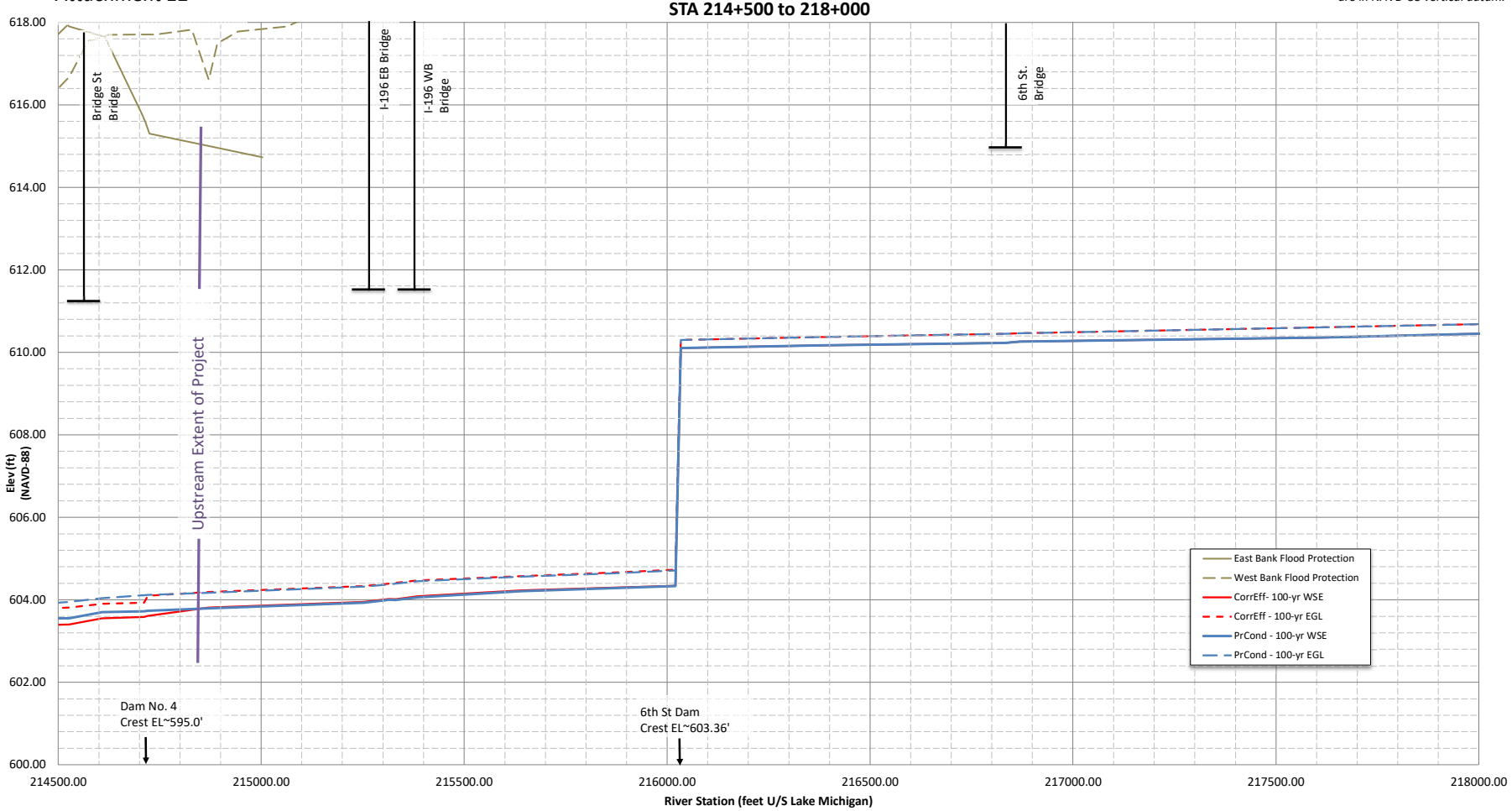
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

5-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 214+500 to 218+000

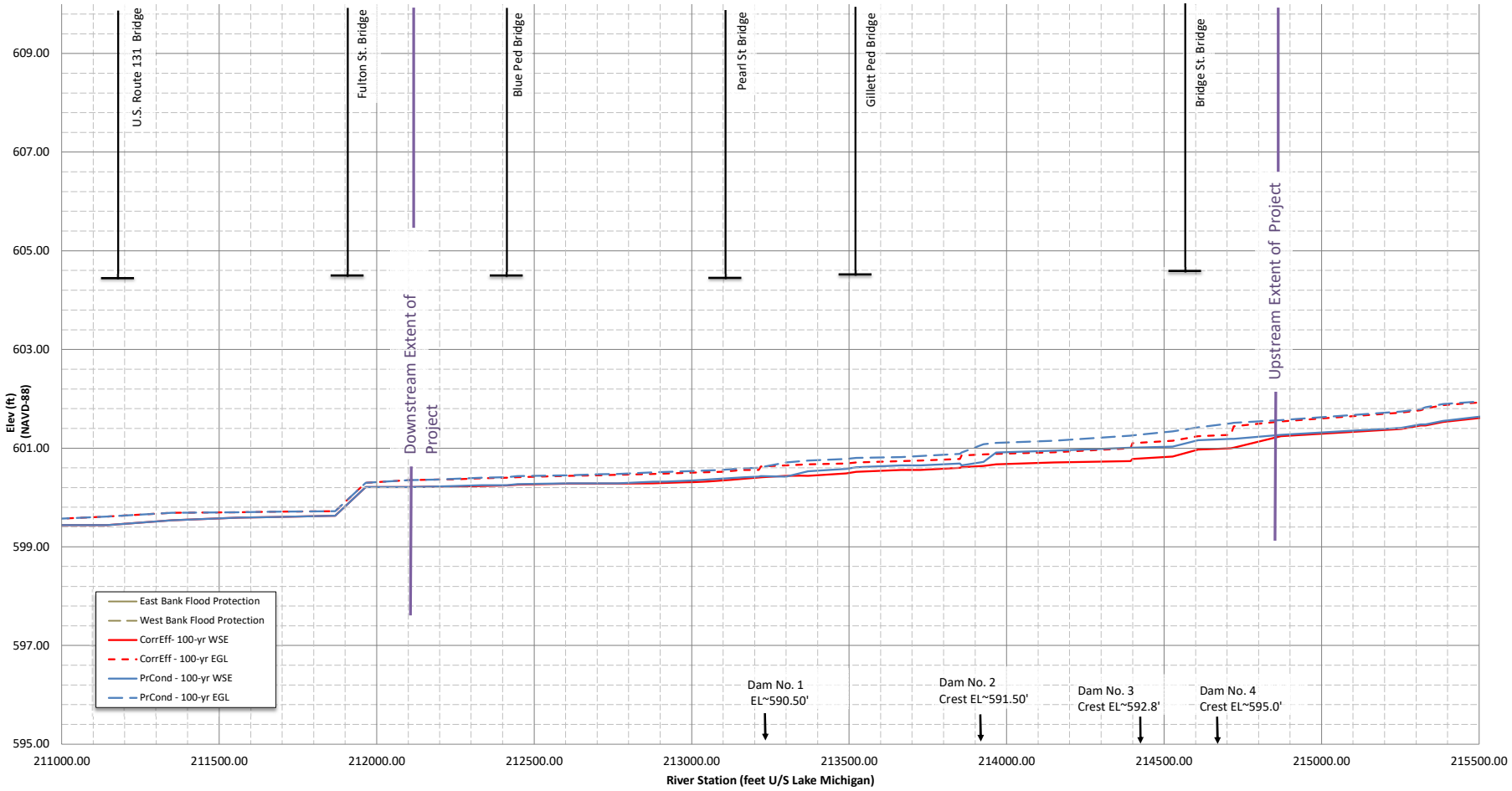
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

2-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 211+000 to 214+500

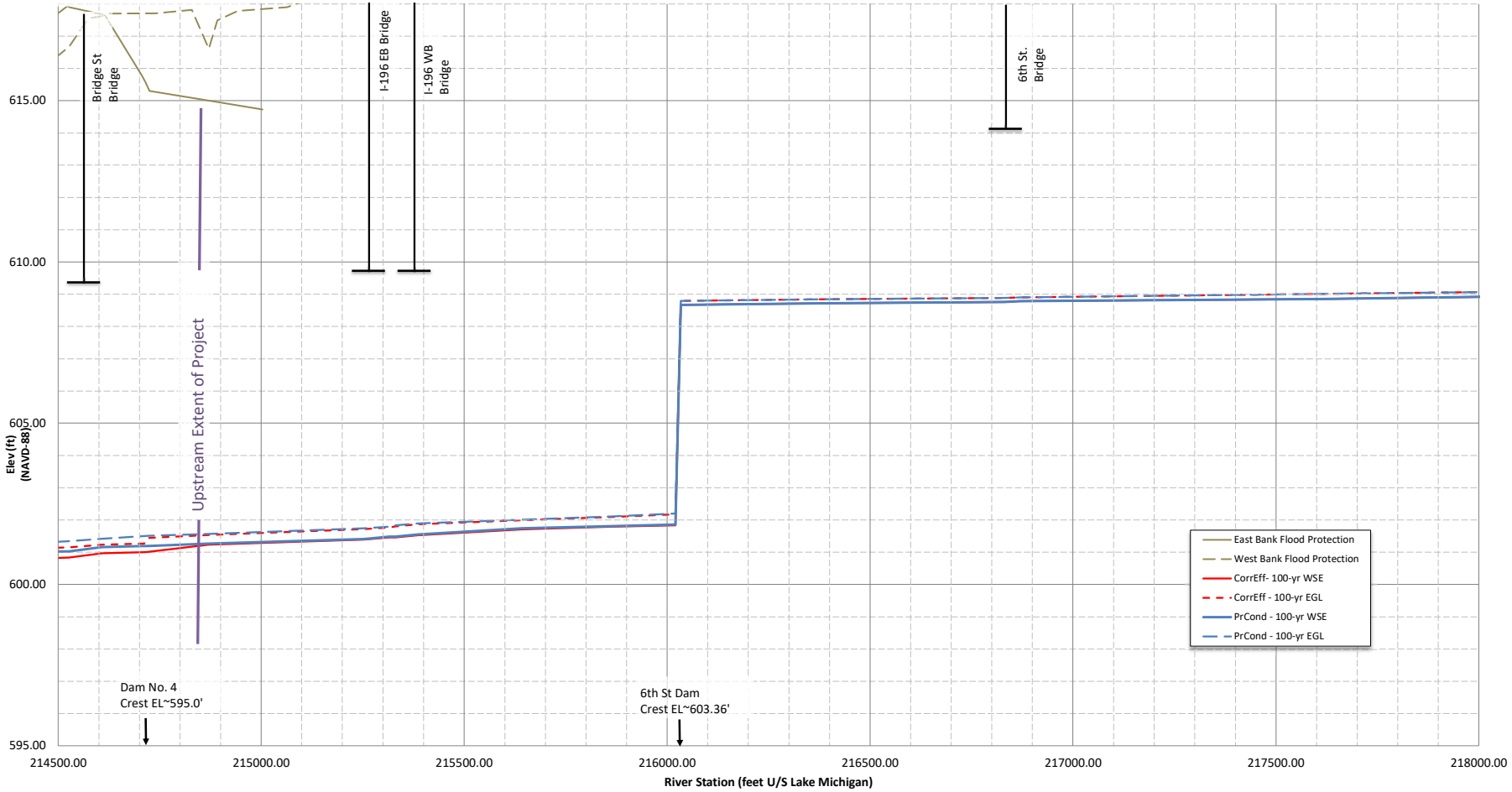
All elevation shown in this chart are in NAVD-88 vertical datum.



Attachment 12

2-yr Flood Modeling Results - Hydraulic and Energy Grade Line
STA 214+500 to 218+000

All elevation shown in this chart are in NAVD-88 vertical datum.



ATTACHMENT 13:
AFFECTED PROPERTY NOTICE TABLES

Energy-Grade Line Elevation Change (in feet). Proposed - Corrected Effective. Positive denotes a increase, negative values denote decrease.

Parcel Number	Owner	Address	River Station (nearest XS)	50,000 cfs (100-yr)	44,000 cfs (50-yr)	38,000 cfs (25-yr)	31,000 cfs (10-yr)	26,000 cfs (5-yr)	18,000 cfs (2 yr)
41-13-24-404-019	CITY OF GRAND RAPIDS	624 FRONT AVE NW	2158+62.7	-0.18	-0.13	-0.10	-0.04	-0.02	0.02
41-13-24-405-001	CITY OF GRAND RAPIDS	629 FRONT AVE NW	2158+62.7	-0.18	-0.13	-0.10	-0.04	-0.02	0.02
41-13-24-404-006	CITY OF GRAND RAPIDS	600 FRONT AVE NW	2148+70.9	-0.18	-0.14	-0.12	-0.04	-0.01	0.03
41-13-24-452-018	CITY OF GRAND RAPIDS	271 BRIDGE ST NW	2148+70.9	-0.18	-0.14	-0.12	-0.04	-0.01	0.03
41-13-25-201-010	NARA UNITED STATES OF AMERICA	303 PEARL ST NW	2143+99.5	-0.06	-0.02	0.00	0.06	0.11	0.16
41-13-25-205-010	CITY OF GRAND RAPIDS	220 FRONT AVE NW	2133+00.0	0.01	0.03	0.03	0.05	0.06	0.07
41-13-25-254-005	CITY OF GRAND RAPIDS	272 PEARL ST NW	2127+66.3	0.02	0.01	0.02	0.02	0.01	0.02
41-13-25-254-004	GRAND VALLEY STATE UNIVERSITY	60 FRONT AVE NW	2124+46.8	0.01	0.00	0.01	0.01	0.01	0.02
41-13-25-503-008	DDA	58 FRONT AVE NW	2123+34.2	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-503-008	DDA	58 FRONT AVE NW	2124+46.8	0.01	0.00	0.01	0.01	0.01	0.02
41-13-25-503-009	DDA	56 FRONT AVE NW	2123+34.2	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-503-009	DDA	56 FRONT AVE NW	2124+46.8	0.01	0.00	0.01	0.01	0.01	0.02
41-13-25-253-004	GRAND VALLEY STATE UNIVERSITY	305 FULTON ST W	2121+03.5	0.00	0.00	0.00	0.00	0.00	0.00
41-13-24-431-019	CITY OF GRAND RAPIDS	647 MONROE AVE NW	2163+78.8	-0.06	0.00	0.00	0.00	0.00	0.00
41-13-24-431-012	BOARD OF TRUSTEES OF MSU	533 MONROE AVE NW	2156+42.2	-0.18	-0.13	-0.11	-0.04	-0.01	0.02
41-13-24-431-013	COUNTY OF KENT	525 MONROE AVE NW	2156+42.2	-0.18	-0.13	-0.11	-0.04	-0.01	0.02
41-13-24-431-014	COUNTY OF KENT	519 MONROE AVE NW	2153+85.6	-0.18	-0.14	-0.11	-0.04	-0.01	0.02
41-13-24-431-015	COUNTY OF KENT	511 MONROE AVE NW	2153+85.6	-0.18	-0.14	-0.11	-0.04	-0.01	0.02
-----	MDOT	MONROE AVE NW	2152+53.2	-0.18	-0.13	-0.11	-0.04	-0.01	0.02
41-13-24-480-001	U S POSTAL SERVICE	225 MICHIGAN ST NW	2148+70.9	-0.18	-0.14	-0.12	-0.04	-0.01	0.03
41-13-25-207-023	GR-KENT CO CONVENTION/ARENA AUTHOR	333 MONROE AVE NW	2141+51.6	0.02	0.07	0.11	0.15	0.19	0.23
41-13-25-256-001	AMWAY HOTEL CORPORATION	220 LYON ST NW	2133+00.0	0.01	0.03	0.03	0.05	0.06	0.07
41-13-25-256-001	AMWAY HOTEL CORPORATION	220 LYON ST NW	2132+20.0	-0.05	-0.04	-0.04	-0.05	-0.03	-0.02
41-13-25-276-022	AMWAY HOTEL CORPORATION	225 PEARL ST NW	2132+13.0	0.04	0.03	0.04	0.04	0.04	0.04
41-13-25-276-022	AMWAY HOTEL CORPORATION	225 PEARL ST NW	2132+20.0	-0.05	-0.04	-0.04	-0.05	-0.03	-0.02
41-13-25-262-001	FORSLUND CONDOS	250/252 PEARL ST NW	2130+93.7	0.03	0.03	0.04	0.04	0.04	0.04
41-13-25-257-012	DDA	251 LOUIS CAMPAU	2128+77.2	0.03	0.01	0.02	0.02	0.02	0.03
41-13-25-258-012	OLDTOWN RIVERFRONT BLDG	85 CAMPAU AVE NW	2126+11.5	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-259-016	ANDERSON EYE PROPERTIES LLC	57 CAMPAU AVE NW	2124+46.8	0.01	0.00	0.01	0.01	0.01	0.02
41-13-25-260-015	CITY OF GRAND RAPIDS	49 CAMPAU AVE NW	2124+14.5	0.01	0.00	0.01	0.01	0.01	0.01
41-13-25-263-010	EENHOORN PLAZA TOWERS LLC	231 FULTON ST W	2123+34.2	0.01	0.01	0.01	0.01	0.01	0.01

Hydraulic Grade Line Elevation Change (in feet). Proposed - Corrected Effective. Positive denotes a increase, negative values denote decrease.

Parcel Number	Owner	Address	River Station (nearest XS)	55,000 cfs (100-yr)	48,000 cfs (50-yr)	42,000 cfs (25-yr)	33,000 cfs (10-yr)	27,000 cfs (5-yr)	18,000 cfs (2 yr)
41-13-24-404-019	CITY OF GRAND RAPIDS	624 FRONT AVE NW	2158+62.7	-0.19	-0.14	-0.11	-0.05	-0.01	0.02
41-13-24-405-001	CITY OF GRAND RAPIDS	629 FRONT AVE NW	2158+62.7	-0.19	-0.14	-0.11	-0.05	-0.01	0.02
41-13-24-404-006	CITY OF GRAND RAPIDS	600 FRONT AVE NW	2148+70.9	-0.19	-0.15	-0.13	-0.05	-0.01	0.03
41-13-24-452-018	CITY OF GRAND RAPIDS	271 BRIDGE ST NW	2148+70.9	-0.19	-0.15	-0.13	-0.05	-0.01	0.03
41-13-25-201-010	NARA UNITED STATES OF AMERICA	303 PEARL ST NW	2143+99.5	-0.01	0.04	0.06	0.13	0.18	0.24
41-13-25-205-010	CITY OF GRAND RAPIDS	220 FRONT AVE NW	2133+00.0	-0.03	-0.02	-0.03	-0.03	-0.03	-0.01
41-13-25-254-005	CITY OF GRAND RAPIDS	272 PEARL ST NW	2127+66.3	0.01	0.01	0.01	0.01	0.02	0.01
41-13-25-254-004	GRAND VALLEY STATE UNIVERSITY	60 FRONT AVE NW	2124+46.8	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-503-008	DDA	58 FRONT AVE NW	2123+34.2	0.02	0.01	0.01	0.01	0.02	0.02
41-13-25-503-008	DDA	58 FRONT AVE NW	2124+46.8	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-503-009	DDA	56 FRONT AVE NW	2123+34.2	0.02	0.01	0.01	0.01	0.02	0.02
41-13-25-503-009	DDA	56 FRONT AVE NW	2124+46.8	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-253-004	GRAND VALLEY STATE UNIVERSITY	305 FULTON ST W	2121+03.5	0.00	0.00	0.00	0.00	0.00	0.00
41-13-24-431-019	CITY OF GRAND RAPIDS	647 MONROE AVE NW	2163+78.8	-0.06	-0.01	0.00	0.00	0.00	0.00
41-13-24-431-012	BOARD OF TRUSTEES OF MSU	533 MONROE AVE NW	2156+42.2	-0.19	-0.14	-0.11	-0.04	-0.01	0.03
41-13-24-431-013	COUNTY OF KENT	525 MONROE AVE NW	2156+42.2	-0.19	-0.14	-0.11	-0.04	-0.01	0.03
41-13-24-431-014	COUNTY OF KENT	519 MONROE AVE NW	2153+85.6	-0.19	-0.15	-0.11	-0.05	-0.02	0.02
41-13-24-431-015	COUNTY OF KENT	511 MONROE AVE NW	2153+85.6	-0.19	-0.15	-0.11	-0.05	-0.02	0.02
-----	MDOT	MONROE AVE NW	2152+53.2	-0.19	-0.14	-0.12	-0.05	-0.02	0.02
41-13-24-480-001	U S POSTAL SERVICE	225 MICHIGAN ST NW	2148+70.9	-0.19	-0.15	-0.13	-0.05	-0.01	0.03
41-13-25-207-023	GR-KENT CO CONVENTION/ARENA AUTHOR	333 MONROE AVE NW	2141+51.6	0.02	0.08	0.12	0.15	0.20	0.24
41-13-25-256-001	AMWAY HOTEL CORPORATION	220 LYON ST NW	2133+00.0	-0.03	-0.02	-0.03	-0.03	-0.03	-0.01
41-13-25-256-001	AMWAY HOTEL CORPORATION	220 LYON ST NW	2132+20.0	0.00	0.01	0.00	0.01	0.01	0.02
41-13-25-276-022	AMWAY HOTEL CORPORATION	225 PEARL ST NW	2132+13.0	0.05	0.03	0.03	0.03	0.03	0.03
41-13-25-276-022	AMWAY HOTEL CORPORATION	225 PEARL ST NW	2132+20.0	0.00	0.01	0.00	0.01	0.01	0.02
41-13-25-262-001	FORSLUND CONDOS	250/252 PEARL ST NW	2130+93.7	0.03	0.03	0.04	0.04	0.04	0.04
41-13-25-257-012	DDA	251 LOUIS CAMPAU	2128+77.2	0.03	0.02	0.02	0.03	0.02	0.03
41-13-25-258-012	OLDTOWN RIVERFRONT BLDG	85 CAMPAU AVE NW	2126+11.5	0.01	0.00	0.01	0.01	0.01	0.01
41-13-25-259-016	ANDERSON EYE PROPERTIES LLC	57 CAMPAU AVE NW	2124+46.8	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-260-015	CITY OF GRAND RAPIDS	49 CAMPAU AVE NW	2124+14.5	0.01	0.01	0.01	0.01	0.01	0.01
41-13-25-263-010	EENHOORN PLAZA TOWERS LLC	231 FULTON ST W	2123+34.2	0.02	0.01	0.01	0.01	0.02	0.02

ATTACHMENT 14:
PHOTO LOG

Work Site Photographs

Grand River Revitalization Project

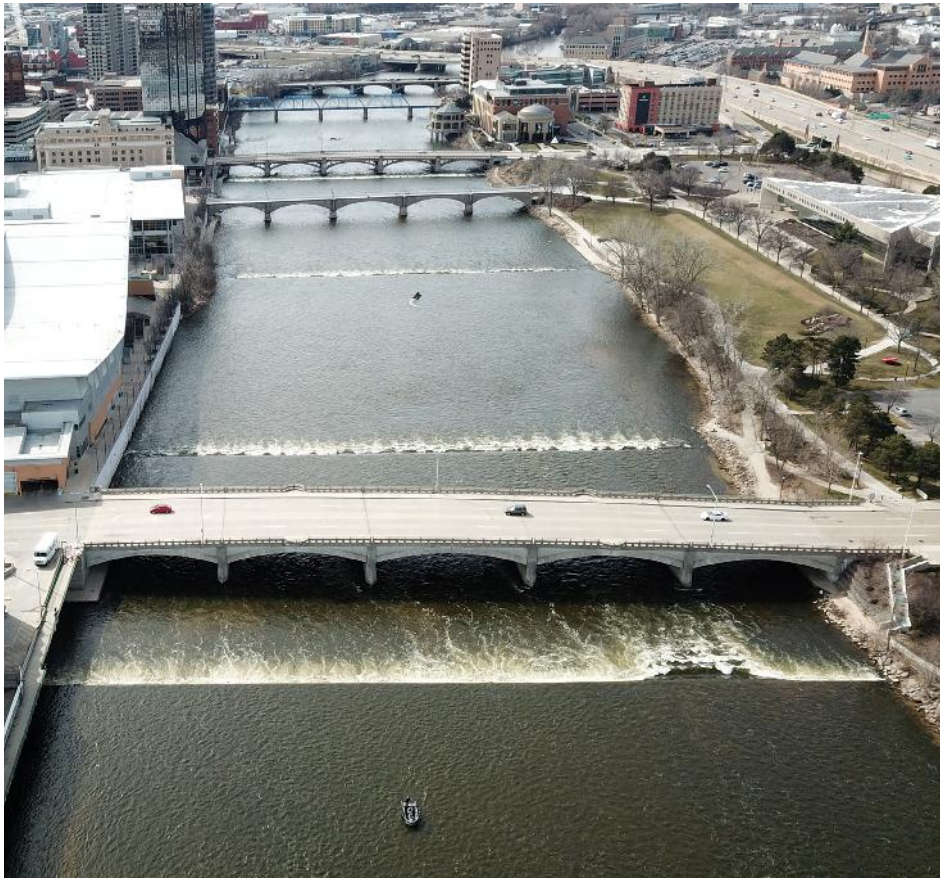
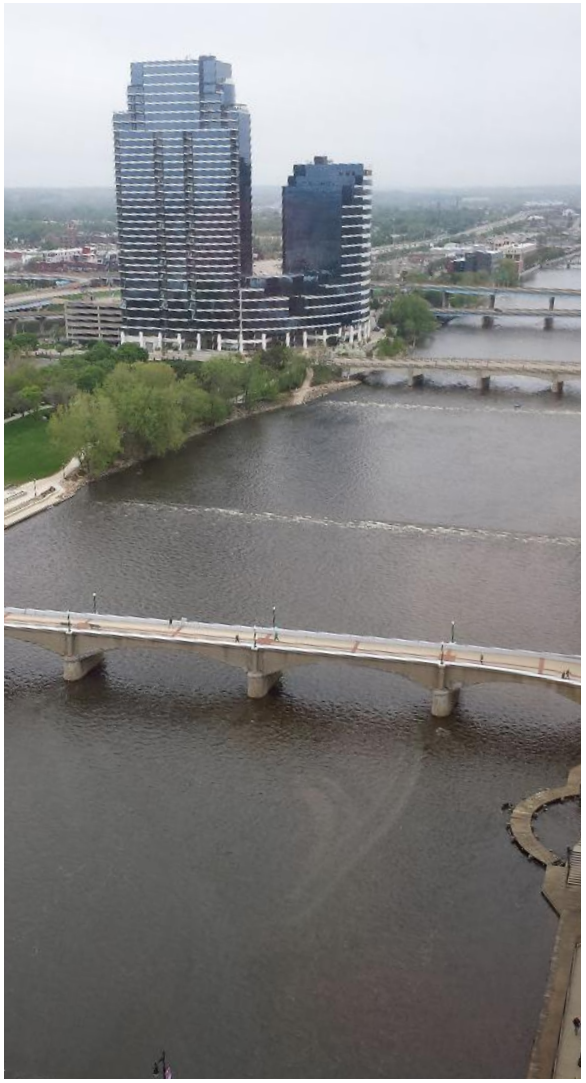


Photo point #1



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts the Grand River location of restored rapid reach below the I-196
Photo Direction	N
Applicant Name	City of Grand Rapids
Date Stamp	30-Oct-14
File Name	20130511_085018.jpg

Photo point #2



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts rip rap above concrete wall in Ah-Nab-Awen Park. Wade fishing steps and in channel grade controls are proposed are proposed here
Photo Direction	S
Applicant Name	City of Grand Rapids
Date Stamp	27-Oct-11
File Name	IMPG0328.jpg

Photo point #3



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts rip rap bank at Ah-Nab-Awen Park. Temporary work bridge from this bank to temporary coffer dam for construction
Photo Direction	N
Applicant Name	City of Grand Rapids
Date Stamp	27-Oct-11
File Name	IMGP0330.jpg

Photo point #4



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts existing boat ramp in Fish Ladder Park to be protected in place. Proposed in-channel work includes grading and boulder and cobble fill.
Photo Direction	E
Applicant Name	City of Grand Rapids
Date Stamp	23-Jun-15
File Name	IMGP1031.jpg

Photo point #5



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts low head dam #3 to be removed. Other proposed in-channel work includes grading and boulder/ cobble fill.
Photo Direction	NE
Applicant Name	City of Grand Rapids
Date Stamp	16-Jan-15
File Name	IMG_3188.jpg

Photo point #6



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts Pearl St Bridge, location of riprap scour protection. Other in-channel work includes channel grading, install of concrete wave blocks u/s of Pearl St Bridge, and boulder grade control downstream of bridge
Photo Direction	S
Applicant Name	City of Grand Rapids
Date Stamp	28-Oct-11
File Name	IMGP1051.jpg

Photo point #7



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts low head dam #2 to be removed. Riprap proposed on bridge pier on Bridge St bridge depicted in photograph. Other in-channel work includes grading and boulder/cobble fill. Temporary work bridge proposed from pictured bank
Photo Direction	NW
Applicant Name	City of Grand Rapids
Date Stamp	26-Oct-13
File Name	IMGP1961.jpg

Photo point #8





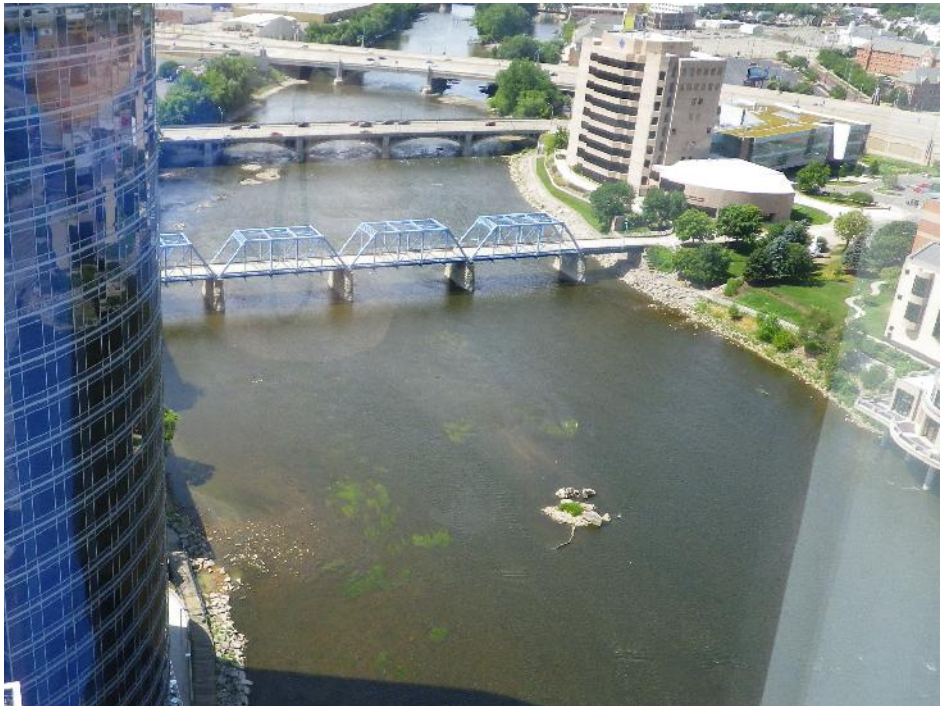
Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts grand River between Pearl St a nd Gillett Pedestrian Bridge. Proposed in-channel work includes grading, boulder, cobble, and pre-cast conrete structure fill. A temporary coffer dam proposed in the middle of the channel for con-struction.
Photo Direction	W
Applicant Name	City of Grand Rapids
Date Stamp	10-Oct-13
File Name	IMGP1051.jpg and IMGP0834.jpg

Photo point #9



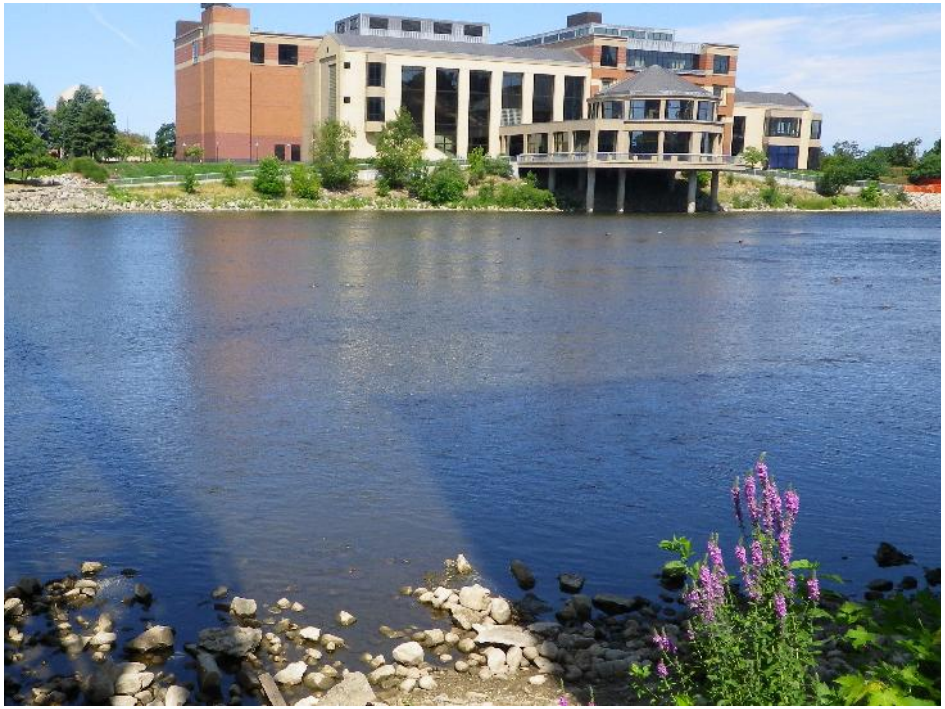
Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts low head dam #1 to be removed. Other in-channel work includes grading and boulder and cobble fill. A temporary work bridge is proposed from Ah-Nab-Awen park pictured here.
Photo Direction	S
Applicant Name	City of Grand Rapids
Date Stamp	28-Oct-11
File Name	

Photo point #10



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts Grand River. Temporary work bridge proposed from east bank pictured here. In-channel permanent work includes grading and boulder.cobble fill.
Photo Direction	SW
Applicant Name	City of Grand Rapids
Date Stamp	08-Jul-12
File Name	IMGP0904.jpg

Photo point #11



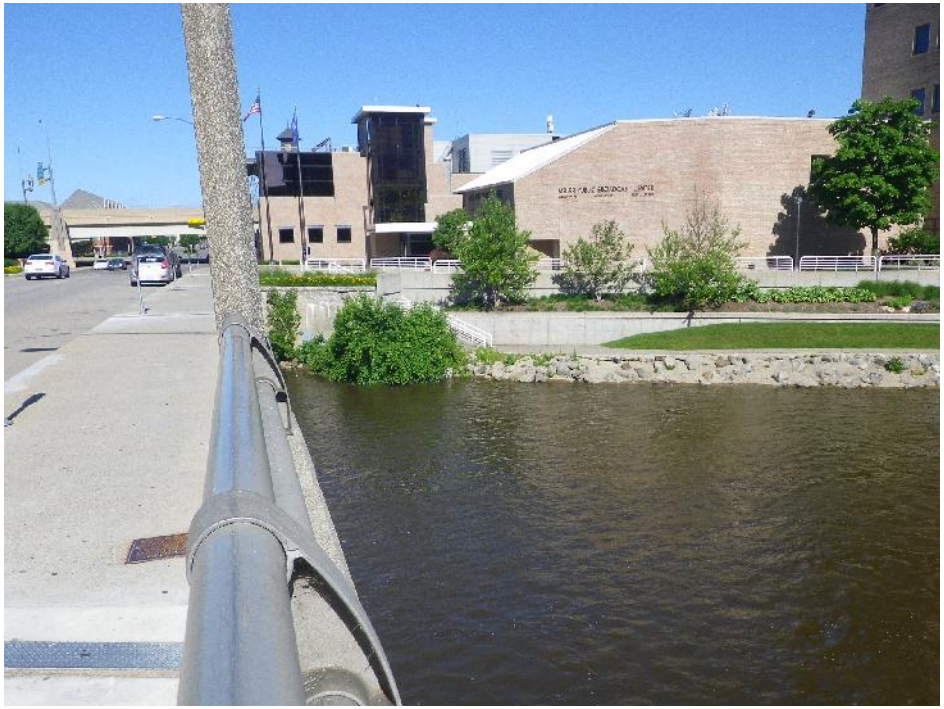
Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts Grand River. Temporary work bridge proposed from east bank pictured on left side of photograph here. In-channel permanent work includes grading and boulder. cobble fill.
Photo Direction	W
Applicant Name	City of Grand Rapids
Date Stamp	23-Jun-15
File Name	IMGP0977.jpg

Photo point #12



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts Grand River from Fulton St. Bridge, the downstream extent of the project. Permanent in-channel work includes boulder/ cobble fill. Temporary coffer dams to be placed in the center of the channel for construction
Photo Direction	N
Applicant Name	City of Grand Rapids
Date Stamp	08-Jun-12
File Name	IMGP0883.jpg

Photo point #13



Attributes	
Subject	Grand River Revitalization
Comment	Photo depicts west bank at downstream extent of the project. River access steps proposed on riprap bank depicted here
Photo Direction	W
Applicant Name	City of Grand Rapids
Date Stamp	23-Jun-15
File Name	IMGP0977.jpg

APPENDIX E

Other Supporting Information

Temporary Conditions Hydraulics Report May 2024

Temporary Conditions Hydraulics Report
GRAND RIVER REVITALIZATION LOWER REACH PROJECT
GRAND RAPIDS, MICHIGAN

Temporary Conditions Hydraulics Report

Prepared for:
City of Grand Rapids

Prepared by:
RiverRestoration
P.O. Box 248
Carbondale, CO 81623

May 2024







This document entitled – Temporary Hydraulic Conditions for the RCPP Reach, Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org, LLC for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.

Approved by
Scott Prins, P.E

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Attachment 2 – HEC-RAS 100-yr Output Tables

Section 1 - Introduction

This report, prepared for the City of Grand Rapids, details the harmful interference evaluation of the proposed temporary construction activities within the Lower Reach Project. Harmful interference is defined by Michigan Department of Environmental, Great Lakes and Energy (EGLE) as "causing an increase stage or change in the direction of flow that causes, or is likely to cause: damage to property, a threat to life, pollution, impairment, or destruction of water or other natural resources" (EGLE, 2019).

The models developed herein are for relative comparison of temporary river conditions only. The models developed herein are not intended for the evaluation of National Flood Insurance Program (NFIP) flood hazards under 44 Code of Federal Regulations Part 65.

This hydraulic analysis was conducted to examine potential temporary flood stage impacts resulting from the construction of the Grand River Revitalization Lower Reach Project (Project). The Project spans from the low-head dam upstream of the Bridge Street Bridge to the upstream face of Fulton Street Bridge. A detailed evaluation of flood stage impacts associated with the proposed in-channel improvements of the Project, including background information of the Project can be found in Report I1 - Hydraulics Report.

To construct the Project, temporary causeways, work isolation measures, and other best management practices (BMPs) will encroach into the floodplain of the Grand River through the Project reach. As detailed in this analysis, the proposed temporary conditions required to construct the Project will cause temporary rises in water surface elevations (WSE) for a range of flow rates. These temporary increases in the water surface profile are expected to remain contained within the existing City of Grand Rapids flood protection system up to the 100-year flood event.

Section 2 - Method of Analysis

Corrected effective and temporary construction conditions water surface profiles were computed using HEC-RAS 4.1, provided by the U.S. Army Corps of Engineers. All elevations are given in North American Vertical Datum of 1998 (NAVD88).

The flow rates for Grand River through the Project reach were obtained from EGLE and are provided in Table 1. Correspondence regarding the determination of project flow rates can be found in Attachment 2 of Report I1. This report is meant to be a supplement of the main Hydraulics Report with a focus on temporary construction conditions. All hydraulic modeling assumptions made in the overall hydraulic analysis effort are carried through to this report.

Table 1. *Project Flow Rates*

Recurrence Interval	Flow (cfs)
100-yr	50,000
50-yr	44,000
25-yr	38,000
10-yr	31,000
5-yr	26,000
2-yr	18,000
Bankfull	13,000

2.1 Corrected Effective Model

As described in Report I1, Section 2.2.2, the Corrected Effective Model was developed from the Effective Model and includes 11 additional cross sections to represent the location of the proposed channel improvements. The HEC-RAS output for this model is under plan "Corrected Effective."

2.2 Temporary Conditions Models

The project is proposed to be constructed by access provided from a staging area in Ah-Nab-Awen Park and in-channel causeways accessing each work area from the park. At Dam 2, the west half of the proposed improvements would be constructed within isolation conditions after installing a cofferdam around the work area and diverting flow to the east side of the channel. Construction activities will be limited by flow depths in the river are anticipated to be performed during flow rates less than approximately 4,000 cfs. Above this flow, depths would likely exceed those for safe and efficient construction in the flowing water and would begin to overtop the cofferdam at the Dam 2 location. Additionally, because construction would only occur during the lower flow periods, the temporary structures (causeways and cofferdam) are proposed to remain in the river during periods of higher flows when construction is unable to occur. Removing temporary structures prior to 4,000 cfs being exceeded would not provide for feasible construction of the project.

The proposed hydraulic feature at the Dam 2 location replaces the grade control function of Dam 3 and part of Dam 4. In order to maintain stable grade control within the reach until the completion of the proposed new hydraulic feature, the removal of Dams 3 and 4 is proposed to be done after the completion of the feature at Dam 2. This also allows for the coffered work at Dam 2 to occur during historically low flows during summer (July and August) when construction would be most efficient and potential impacts to flooding or bridge scour during isolation would be minimized.

Refer to the construction sequencing discussion in Report D1 and the temporary care of water sheets (T Sheets) in permit drawings for reference.

Three temporary conditions models have been evaluated for potential flood impacts:

- Temporary Conditions Model 1 assumes that causeways to Dams 1 and 2, as well as causeways to all work downstream of Pearl Street have been installed and all dams remain in place.
- Temporary Conditions Model 2 assumes that the cofferdam at the Dam 2 location has been installed in addition to all causeways as described in model 1. All dams remain in place
- Temporary Conditions Model 3 assumes that the cofferdam has been removed and all proposed improvements have been completed, but all causeways still need to be removed from the channel.

These temporary conditions models make conservative assumptions as to what all would potentially be in the river at one time. This is to provide the contractor flexibility to perform the work as efficiently as possible, while still adhering to the sequencing detailed in Report D1.

The HEC-RAS plans corresponding to the three temporary conditions models are discussed in the following subsections and cross section maps are provided in Attachment 1 to this report. A full description of the recommended construction sequencing and care of water activities can be found in Report D1 – Construction Sequencing and Methods.

Section 3 - Modeling Results and Discussion

The baseline comparison of the 100-year WSE between Effective Model and the Corrected Effective Model is presented in Figure 1 of TOC No. 5 Hydraulics Report. In order to evaluate the potential rises to the flood profile during construction, water surface elevations for the temporary conditions were compared to water surface elevations for corrected effective conditions for the range of flow rates listed in Section 2. Conservative assumptions have been made for each temporary conditions model; all assume that all causeways are in the river at the same time, and temporary conditions models 2 and 3 assume all proposed improvements are in the river along with temporary causeways before they are removed. Table 2 (following page) presents the 100-year WSE comparisons. Complete tabular results of water surface elevations for the 100-yr flood event are provided in Attachment 2.

The modeling results show that for the 100-year event, the temporary conditions are predicted to cause maximum increases in water levels downstream of 6th Street Dam of 0.07 feet for temporary conditions model 1, 0.10 feet for temporary conditions model 2, and 0.11 feet for temporary conditions model 3.

Temporary conditions models 1 and 2 calculate small increases in modeled 100-yr water surfaces upstream of 6th Street Dam. These conditions have been conservatively modeled in regard to potential temporary fill in the river at one time, and would be very unlikely to exist in the river over winter and into spring when historically large flow events occur. Temporary conditions model 1 represents construction during the ~3-week duration of coffered isolation at Dam 2. This condition would be during the historically driest part of the year (July and August) and would not be left in the river over winter. Temporary conditions model 2 represents the stage of construction, immediately following the completion of the Dam 2 feature, but immediately before the removal of dams 3 and 4, which would be a very short period

of time (~1 - 2 weeks). This condition would only be left over winter if Dams 3 and 4 are unable to be safely removed prior to flow conditions being too deep or swift in the fall.

The anticipated construction schedule is to have all improvements (including dam removals) completed in one season. All potential increases in flood levels associated with construction would be a temporary condition due to the presence of work isolation measures and construction activities and would remain within the City's flood protection system.

Table 2 – *Temporary Conditions WSE vs Corrected Effective WSE*

River STA	*Notes*	Corrected Effective (CEM)	Temp. Conditions Model 1 (TC1)	Temp. Conditions Model 2 (TC2)	Temp. Conditions Model 3 (TC3)
216869.4	*Sixth St U/S*	614.07	614.09	614.10	614.03
216832.0	*Sixth St D/S*	614.03	614.05	614.06	613.99
216378.8	*XS 25*	613.96	613.98	613.99	613.92
216034.2	*Dam No. 5 U/S*	613.81	613.84	613.84	613.77
216020.2	*Dam No. 5 D/S*	612.92	612.98	612.99	612.80
215862.7	*XS 24*	612.89	612.95	612.96	612.77
215642.2	*XS 23*	612.86	612.92	612.93	612.74
215385.6	*I-196 West U/S*	612.79	612.85	612.86	612.67
215330.5	*I-196 West D/S*	612.75	612.81	612.82	612.63
215315.2	*I-196 East U/S*	612.75	612.81	612.82	612.63
215253.2	*I-196 East D/S*	612.71	612.77	612.78	612.59
214870.9	*XS 22*	612.58	612.64	612.65	612.46
214720.8	*Dam No. 4 U/S*	612.47	612.54	612.55	612.42
214711.5	*Dam No. 4 D/S*	612.40	612.46	612.47	612.43
214608.3	*Bridge St U/S*	612.36	612.42	612.43	612.37
214526.8	*Bridge St D/S*	612.18	612.25	612.26	612.19
214399.5	*Dam No. 3 U/S*	612.19	612.26	612.27	612.24
214393.3	*Dam No. 3 D/S*	612.14	612.20	612.21	612.25
214151.6	*XS 21*	612.13	612.20	612.21	612.21
213966.6	*added*	612.13	612.13	612.18	612.18
213926.6	*added*	612.12	612.05	612.18	612.18
213856.9	*Dam No. 2 U/S*	612.11	612.06	612.17	612.17
213851.6	*Dam No. 2 D/S*	612.06	611.97	612.16	612.16
213726.4	*added*	612.04	612.03	612.11	612.11
213666.4	*XS 20*	612.03	612.03	612.11	612.11
213522.5	*ped bridge U/S*	611.97	611.95	612.04	612.04
213489.9	*ped bridge D/S*	611.87	611.86	611.95	611.95
213370.1	*added*	611.82	611.81	611.90	611.90

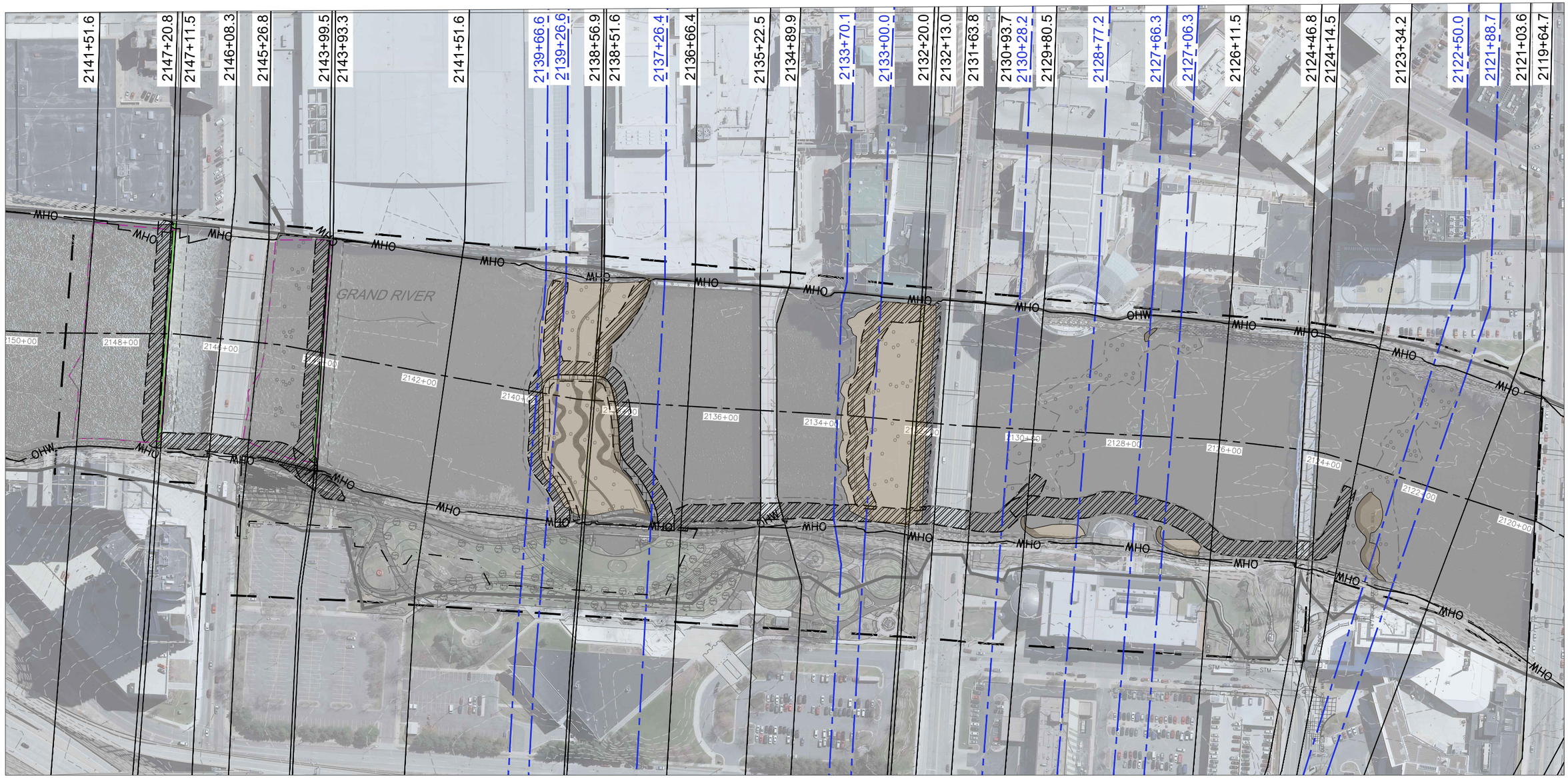
River STA	*Notes*	Corrected Effective (CEM)	Temp. Conditions Model 1 (TC1)	Temp. Conditions Model 2 (TC2)	Temp. Conditions Model 3 (TC3)
213300.0	*added*	611.82	611.74	611.85	611.85
213220.0	*Dam No. 1 U/S*	611.81	611.78	611.87	611.87
213213.0	*Dam No. 1 D/S*	611.76	611.75	611.81	611.81
213163.8	*Pearl St U/S*	611.74	611.79	611.82	611.82
213093.7	*Pearl St D/S*	610.91	610.92	610.96	610.96
213028.2	*added*	610.88	610.89	610.93	610.93
212980.5	*XS 19*	610.86	610.85	610.88	610.88
212877.2	*added*	610.83	610.83	610.86	610.86
212766.3	*added*	610.82	610.81	610.82	610.82
212706.3	*added*	610.82	610.81	610.82	610.82
212611.5	*XS 18*	610.83	610.83	610.84	610.84
212446.8	*ped bridge U/S*	610.81	610.81	610.82	610.82
212414.5	*ped bridge D/S*	610.48	610.47	610.49	610.49
212334.2	*XS 17*	610.48	610.47	610.50	610.50
212250.0	*added*	610.46	610.46	610.48	610.48
212188.7	*added*	610.46	610.46	610.46	610.46
212103.5	*XS 16*	610.44	610.44	610.44	610.44
211964.7	*Fulton St U/S*	610.44	610.44	610.44	610.44
211868.1	*Fulton St D/S*	609.91	609.91	609.91	609.91

3.1. Conclusion

Modeling results indicate that with conservative assumptions, the temporary conditions may result small modeled increases of 0.01'-0.11' in 100-year water levels within the project area downstream of 6th Street Dam during construction and could have a very low probability of small modeled increases of up to 0.03' upstream of 6th Street Dam under the temporary conditions when Dams 3 and 4 are in place with temporary fill in the project reach. Modeled increases would remain with the City's flood protection system. Under the anticipated construction schedule, there would be no modeled increase in 100-yr levels upstream of 6th Street Dam during winter and spring months when large flooding has historically occurred most frequently. Any increases modeled for this evaluation of temporary construction activities associated with the project are less significant than those modeled and permitted for the recent in-river work on the I-196 Bridge piers.

It is the opinion of the engineer, Scott Prins (RiverRestoration.org, LLC), that based on the temporary hydraulic modeling results and analysis presented here, the temporary condition of the Project will cause no harmful interference to upstream properties.

ATTACHMENT 1:
HEC-RAS CROSS SECTION MAP



LEGEND

- CONSTRUCTION ACCESS CAUSEWAY
- WORK ISOLATION COFFERDAM
- AREA OF PROPOSED IMPROVEMENTS (SEE R SHEETS)
- STAGING AREA
- LIMITS OF TOTAL DIRECT IMPACTS
- OHW — ORDINARY HIGH WATER MARK
- 100-YR FLOOD PROTECTION
- APPROX. DAM REMOVAL GRADING LIMITS
- EMERGENT HABITAT BOULDER (PLAN). SEE DETAIL SHEET D01
- BOULDER STRUCTURE
- CONSTRUCTED RIFFLE (IMPORTED COARSE ALLUVIUM)
- STABILIZING STRUCTURE (IMPORTED RIPRAP D50 12")

HEC-RAS CROSS SECTIONS:

- FEMA PRELIMINARY EFFECTIVE SECTION
- CORRECTED EFFECTIVE SECTION - ADDED FOR PROJECT

NORTH

0 100' 200'

SCALE: 1" = 100'

THE UNDERGROUND LOCATIONS SHOWN FOR BEDROCK, NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

REVISIONS

NO.	DATE	DESCRIPTION

SURVEYED & DESIGNED BY:

City of Grand Rapids
Public Services
Engineering Department

IMPROVEMENTS ALONG THE

GRAND RIVER

FROM FULTON ST. TO I-196

(GRAND RIVER REVITALIZATION PROJECT)
DRAFT 60% PLAN SET
NOT FOR CONSTRUCTION

Drawn by _____
Check: Field _____
Check: Office _____

GPF No. 5315

Sheet No. ___ of 35

ATTACHMENT 2 – HEC-RAS OUTPUT TABLES

100-Year Flood Event

River Station	Corrected Effective	Temp Conditions Model 1		Temp Conditions Model 2		Temp Conditions Model 3	
		Temporary Conditions	Δ (TC - EC)	Temporary Conditions	Δ (TC - EC)	Temporary Conditions	Δ (TC - EC)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft*
244283.5 XS 44	619.61	619.62	0.01	619.62	0.01	619.60	-0.01
241690.0 XS 43	619.35	619.36	0.01	619.36	0.01	619.34	-0.01
239160.3 XS 42	619.09	619.10	0.01	619.10	0.01	619.08	-0.01
237272.0 XS 41	618.89	618.90	0.01	618.90	0.01	618.88	-0.01
236330.2 XS 40	618.74	618.75	0.01	618.75	0.01	618.73	-0.01
235474.7 XS 46	618.63	618.64	0.01	618.65	0.02	618.62	-0.01
235157.2 N Park St U/S	618.55	618.56	0.01	618.56	0.01	618.53	-0.02
235082.5 N Park St D/S	618.48	618.49	0.01	618.49	0.01	618.46	-0.02
234804.6 XS 45	618.37	618.38	0.01	618.38	0.01	618.35	-0.02
234551.4 I-96 West U/S	618.34	618.35	0.01	618.36	0.02	618.33	-0.01
234504.4 I-96 West D/S	618.27	618.28	0.01	618.28	0.01	618.26	-0.01
234457.4 I-96 East U/S	618.27	618.28	0.01	618.28	0.01	618.25	-0.02
234410.5 I-96 East D/S	618.12	618.13	0.01	618.13	0.01	618.10	-0.02
233807.3 XS 39	617.99	618.00	0.01	618.00	0.01	617.97	-0.02
231462.9 XS 38	617.75	617.77	0.02	617.77	0.02	617.74	-0.01
228851.2 XS 37	617.46	617.48	0.02	617.48	0.02	617.45	-0.01
227668.5 XS 36	617.28	617.29	0.01	617.29	0.01	617.26	-0.02
225261.3 XS 35	616.71	616.73	0.02	616.73	0.02	616.69	-0.02
224424.1 XS 34	616.50	616.52	0.02	616.52	0.02	616.48	-0.02
223798.2 Ann St U/S	616.36	616.38	0.02	616.38	0.02	616.34	-0.02
223733.8 Ann St D/S	616.31	616.33	0.02	616.33	0.02	616.29	-0.02
223275.7 XS 33	616.24	616.25	0.01	616.26	0.02	616.22	-0.02
222995.3 XS 32	616.20	616.22	0.02	616.22	0.02	616.18	-0.02
222730.9 RR3 U/S	616.04	616.06	0.02	616.07	0.03	616.02	-0.02
222717.4 RR3 D/S	615.97	615.99	0.02	615.99	0.02	615.95	-0.02
222516.4 XS 31	615.96	615.98	0.02	615.98	0.02	615.94	-0.02
221221.6 XS 30	615.45	615.47	0.02	615.48	0.03	615.43	-0.02
220387.9 XS 29	615.05	615.07	0.02	615.08	0.03	615.02	-0.03
219837.8 Leonard St U/S	614.91	614.93	0.02	614.93	0.02	614.88	-0.03
219767.8 Leonard St D/S	614.85	614.88	0.03	614.88	0.03	614.83	-0.02
219354.2 XS 28	614.77	614.79	0.02	614.80	0.03	614.74	-0.03
218588.5 XS 27	614.59	614.62	0.03	614.62	0.03	614.57	-0.02
217611.5 XS 26	614.23	614.26	0.03	614.26	0.03	614.20	-0.03
216869.4 Sixth St U/S	614.07	614.09	0.02	614.10	0.03	614.03	-0.04
216832.0 Sixth St D/S	614.03	614.05	0.02	614.06	0.03	613.99	-0.04
216378.8 XS 25	613.96	613.98	0.02	613.99	0.03	613.92	-0.04
216034.2 Dam No. 5 U/S	613.81	613.84	0.03	613.84	0.03	613.77	-0.04
216020.2 Dam No. 5 D/S	612.92	612.98	0.06	612.99	0.07	612.80	-0.12
215862.7 XS 24	612.89	612.95	0.06	612.96	0.07	612.77	-0.12
215642.2 XS 23	612.86	612.92	0.06	612.93	0.07	612.74	-0.12
215385.6 I-196 West U/S	612.79	612.85	0.06	612.86	0.07	612.67	-0.12
215330.5 I-196 West D/S	612.75	612.81	0.06	612.82	0.07	612.63	-0.12
215315.2 I-196 East U/S	612.75	612.81	0.06	612.82	0.07	612.63	-0.12
215253.2 I-196 East D/S	612.71	612.77	0.06	612.78	0.07	612.59	-0.12
214870.9 XS 22	612.58	612.64	0.06	612.65	0.07	612.46	-0.12
214720.8 Dam No. 4 U/S	612.47	612.54	0.07	612.55	0.08	612.42	-0.05
214711.5 Dam No. 4 D/S	612.40	612.46	0.06	612.47	0.07	612.43	0.03
214608.3 Bridge St U/S	612.36	612.42	0.06	612.43	0.07	612.37	0.01
214526.8 Bridge St D/S	612.18	612.25	0.07	612.26	0.08	612.19	0.01
214399.5 Dam No. 3 U/S	612.19	612.26	0.07	612.27	0.08	612.24	0.05
214393.3 Dam No. 3 D/S	612.14	612.20	0.06	612.21	0.07	612.25	0.11
214151.6 XS 21	612.13	612.20	0.07	612.21	0.08	612.21	0.08
213966.6	612.13	612.13	0.00	612.18	0.05	612.18	0.05
213926.6	612.12	612.05	-0.07	612.18	0.06	612.18	0.06
213856.9 Dam No. 2 U/S	612.11	612.06	-0.05	612.17	0.06	612.17	0.06
213851.6 Dam No. 2 D/S	612.06	611.97	-0.09	612.16	0.10	612.16	0.10
213726.4	612.04	612.03	-0.01	612.11	0.07	612.11	0.07
213666.4 XS 20	612.03	612.03	0.00	612.11	0.08	612.11	0.08
213522.5 ped bridge U/S	611.97	611.95	-0.02	612.04	0.07	612.04	0.07
213489.9 ped bridge D/S	611.87	611.86	-0.01	611.95	0.08	611.95	0.08
213370.1	611.82	611.81	-0.01	611.90	0.08	611.90	0.08
213300	611.82	611.74	-0.08	611.85	0.03	611.85	0.03
213220.0 Dam No. 1 U/S	611.81	611.78	-0.03	611.87	0.06	611.87	0.06
213213.0 Dam No. 1 D/S	611.76	611.75	-0.01	611.81	0.05	611.81	0.05
213163.8 Pearl St U/S	611.74	611.79	0.05	611.82	0.08	611.82	0.08
213093.7 Pearl St D/S	610.91	610.92	0.01	610.96	0.05	610.96	0.05
213028.2	610.88	610.89	0.01	610.93	0.05	610.93	0.05
212980.5 XS 19	610.86	610.85	-0.01	610.88	0.02	610.88	0.02
212877.2	610.83	610.83	0.00	610.86	0.03	610.86	0.03
212766.3	610.82	610.81	-0.01	610.82	0.00	610.82	0.00
212706.3	610.82	610.81	-0.01	610.82	0.00	610.82	0.00
212611.5 XS 18	610.83	610.83	0.00	610.84	0.01	610.84	0.01
212446.8 ped bridge U/S	610.81	610.81	0.00	610.82	0.01	610.82	0.01
212414.5 ped bridge D/S	610.48	610.47	-0.01	610.49	0.01	610.49	0.01
212334.2 XS 17	610.48	610.47	-0.01	610.50	0.02	610.50	0.02
212250	610.46	610.46	0.00	610.48	0.02	610.48	0.02
212188.7	610.46	610.46	0.00	610.46	0.00	610.46	0.00
212103.5 XS 16	610.44	610.44	0.00	610.44	0.00	610.44	0.00
211964.7 Fulton St U/S	610.44	610.44	0.00	610.44	0.00	610.44	0.00

100-Year Flood Event

River Station	Corrected Effective	Temp Conditions Model 1		Temp Conditions Model 2		Temp Conditions Model 3	
		Temporary Conditions	Δ (TC - EC)	Temporary Conditions	Δ (TC - EC)	Temporary Conditions	Δ (TC - EC)
ft	*ft-NAVD-88*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft*	*ft-NAVD-88*	*ft*
211868.1 Fulton St D/S	609.91	609.91	0.00	609.91	0.00	609.91	0.00
211664.8 XS 15	609.81	609.81	0.00	609.81	0.00	609.81	0.00
211561.3 XS 14	609.80	609.80	0.00	609.80	0.00	609.80	0.00
211348.6 US Hwy 131 U/S	609.71	609.71	0.00	609.71	0.00	609.71	0.00
211144.8 US Hwy 131 D/S	609.55	609.55	0.00	609.55	0.00	609.55	0.00
210918.9 XS 13	609.56	609.56	0.00	609.56	0.00	609.56	0.00
210676.0 XS 12B	609.57	609.57	0.00	609.57	0.00	609.57	0.00
209996.9 XS 12A	609.44	609.44	0.00	609.44	0.00	609.44	0.00
209711.4 RR2 U/S	609.44	609.44	0.00	609.44	0.00	609.44	0.00
209656.6 RR2 D/S	609.21	609.21	0.00	609.21	0.00	609.21	0.00
209422.2 XS 11	609.12	609.12	0.00	609.12	0.00	609.12	0.00
209175.5 XS 10	608.89	608.89	0.00	608.89	0.00	608.89	0.00
208859.8 Wealthy St U/S	608.64	608.64	0.00	608.64	0.00	608.64	0.00
208777.1 Wealthy St D/S	608.59	608.59	0.00	608.59	0.00	608.59	0.00
208327.8 XS 9	608.60	608.60	0.00	608.60	0.00	608.60	0.00
207340.5 RR1 U/S	608.54	608.54	0.00	608.54	0.00	608.54	0.00
207324.2 RR1 D/S	608.51	608.51	0.00	608.51	0.00	608.51	0.00
206988	608.41	608.41	0.00	608.41	0.00	608.41	0.00
206651.9	608.34	608.34	0.00	608.34	0.00	608.34	0.00
206315.8 XS 8	608.33	608.33	0.00	608.33	0.00	608.33	0.00
205904	608.26	608.26	0.00	608.26	0.00	608.26	0.00
205492.2	608.10	608.10	0.00	608.10	0.00	608.10	0.00
205080.5	607.96	607.96	0.00	607.96	0.00	607.96	0.00
204668.7 XS 7	607.83	607.83	0.00	607.83	0.00	607.83	0.00
204250.5	607.62	607.62	0.00	607.62	0.00	607.62	0.00
203832.4 XS 6	607.48	607.48	0.00	607.48	0.00	607.48	0.00
203398.8	607.41	607.41	0.00	607.41	0.00	607.41	0.00
202965.1	607.32	607.32	0.00	607.32	0.00	607.32	0.00
202531.5	607.23	607.23	0.00	607.23	0.00	607.23	0.00
202097.9 XS 5	607.15	607.15	0.00	607.15	0.00	607.15	0.00
201740	607.15	607.15	0.00	607.15	0.00	607.15	0.00
201382.2	607.12	607.12	0.00	607.12	0.00	607.12	0.00
201024.4 XS 4	607.09	607.09	0.00	607.09	0.00	607.09	0.00
200751	607.02	607.02	0.00	607.02	0.00	607.02	0.00
200477.6 I-196 East U/S	607.01	607.01	0.00	607.01	0.00	607.01	0.00
200408.8 I-196 East D/S	606.99	606.99	0.00	606.99	0.00	606.99	0.00
200340.0 I-196 West U/S	606.99	606.99	0.00	606.99	0.00	606.99	0.00
200271.2 I-196 West D/S	606.98	606.98	0.00	606.98	0.00	606.98	0.00
200063.8 XS 3	606.69	606.69	0.00	606.69	0.00	606.69	0.00
199857.4	606.64	606.64	0.00	606.64	0.00	606.64	0.00
199651.1	606.58	606.58	0.00	606.58	0.00	606.58	0.00
199444.7	606.47	606.47	0.00	606.47	0.00	606.47	0.00
199238.3	606.36	606.36	0.00	606.36	0.00	606.36	0.00
199031.9 XS 2	606.30	606.30	0.00	606.30	0.00	606.30	0.00
198803.4	606.29	606.29	0.00	606.29	0.00	606.29	0.00
198574.8	606.31	606.31	0.00	606.31	0.00	606.31	0.00
198346.3	606.34	606.34	0.00	606.34	0.00	606.34	0.00
198117.8 XS 1	606.34	606.34	0.00	606.34	0.00	606.34	0.00
196113.4	605.62	605.62	0.00	605.62	0.00	605.62	0.00
195990.1	605.76	605.76	0.00	605.76	0.00	605.76	0.00
195958.1	605.68	605.68	0.00	605.68	0.00	605.68	0.00
195867.6	605.50	605.50	0.00	605.50	0.00	605.50	0.00
195493.9	605.45	605.45	0.00	605.45	0.00	605.45	0.00
194983.9	605.43	605.43	0.00	605.43	0.00	605.43	0.00
192633.9	605.17	605.17	0.00	605.17	0.00	605.17	0.00
190233.9	604.51	604.51	0.00	604.51	0.00	604.51	0.00
183733.9	604.29	604.29	0.00	604.29	0.00	604.29	0.00
180433.9	603.82	603.82	0.00	603.82	0.00	603.82	0.00
180333.9	603.58	603.58	0.00	603.58	0.00	603.58	0.00
180191.9	603.62	603.62	0.00	603.62	0.00	603.62	0.00
180190.9	603.58	603.58	0.00	603.58	0.00	603.58	0.00
180134.9	603.56	603.56	0.00	603.56	0.00	603.56	0.00
180133.9	603.58	603.58	0.00	603.58	0.00	603.58	0.00
177683.9	603.26	603.26	0.00	603.26	0.00	603.26	0.00
176303.9	602.87	602.87	0.00	602.87	0.00	602.87	0.00
175383.9	602.88	602.88	0.00	602.88	0.00	602.88	0.00
174783.9	602.84	602.84	0.00	602.84	0.00	602.84	0.00
172643.9	602.75	602.75	0.00	602.75	0.00	602.75	0.00
171243.9	602.57	602.57	0.00	602.57	0.00	602.57	0.00
169743.9	602.39	602.39	0.00	602.39	0.00	602.39	0.00
167243.9	602.13	602.13	0.00	602.13	0.00	602.13	0.00
165443.9	601.88	601.88	0.00	601.88	0.00	601.88	0.00
163763.9	601.74	601.74	0.00	601.74	0.00	601.74	0.00
162163.9	601.65	601.65	0.00	601.65	0.00	601.65	0.00
161233.9	601.58	601.58	0.00	601.58	0.00	601.58	0.00
159383.9	601.47	601.47	0.00	601.47	0.00	601.47	0.00
157683.9	601.30	601.30	0.00	601.30	0.00	601.30	0.00
155083.9	601.14	601.14	0.00	601.14	0.00	601.14	0.00
153553.9	601.07	601.07	0.00	601.07	0.00	601.07	0.00

APPENDIX E

Other Supporting Information

Hydraulic Influence at the 6th Street Dam; June **2024**

Hydraulic Influence at the 6th Street Dam
GRAND RIVER REVITALIZATION PROJECT
GRAND RAPIDS, MICHIGAN

Evaluation of Sea Lamprey (*Petromyzon marinus*) Hydraulic Conditions at the 6th Street Dam for the Grand Rapids Revitalization Lower Reach Project

Prepared for:
City of Grand Rapids

Prepared by:
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June 2024

Grand Rapids WhiteWater

RIVER RESTORATION.ORG

CITY OF GRAND RAPIDS

This document entitled Post Project Hydraulic Influence at the 6th Street Dam, Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org LLC (RiverRestoration) for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.

Approved by
Scott Prins, P.E.

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1.0 INTRODUCTION

The concrete 6th Street Dam in the Grand River at Grand Rapids, MI has been assumed to be an effective barrier to upstream migration of the invasive sea lamprey (*Petromyzon marinus*) (Great Lakes Fishery Commission (GLFC), 2018). Proposed modifications to the Grand River associated with the Grand River Revitalization Lower Reach Project include the demolition of four low-head dams and construction of naturalized instream restoration features between Bridge Street and Fulton Street. Hydraulic conditions at the 6th Street Dam under post-project conditions have been modeled to show that the hydraulics of 6th Street Dam will not be impacted to result in reduced effectiveness in blocking sea lamprey as compared to corrected effective conditions. Temporary conditions during construction have also been modeled to evaluate impacts to tailwater conditions at 6th Street Dam. These evaluations and corresponding hydraulic modeling results are reported in this memorandum.

Hydraulic comparisons are made to channel conditions prior to recent instream work conducted by Michigan Department of Transportation (MDOT). This is referred to as the Existing Conditions Configuration herein.

2.0 MODELING RESULTS EVALUATION OF EXISTING AND PROPOSED CONDITIONS

Flow rates below bankfull flow of 13,000 cfs, were evaluated in SRH-2D and comparisons were made between existing and proposed conditions. Flood flows, greater than bankfull flow, were evaluated and compared using the effective HEC-RAS FEMA flood model.

Tailwater elevations were taken from both models directly downstream of 6th Street Dam, at River Station 2160+20.2; Table 1 compares the calculated rating curves. The crest of 6th Street Dam is submerged by tailwater at the 5-year flood (26,000 cfs). Proposed Conditions tailwater elevations were modeled to remain at or at or below Existing Conditions, within modeling error, for all flow rates evaluated. An 18" vertical separation between tailwater and crest was maintained for similar flow rates as existing conditions.

Table 1: Comparison of modeled tailwater elevations at 6th Street Dam

Flowrate (cfs)	Existing Conditions (ft)	Proposed Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	595.62	-0.30	SRH-2D
2,500	596.64	596.33	-0.31	
3,900	597.26	596.93	-0.33	
5,000	597.67	597.35	-0.32	
7,500	598.50	598.19	-0.31	
10,000 (1-year)	599.20	598.96	-0.24	
13,000 (Bankfull)	599.90	599.88	-0.02	HEC-RAS
18,000 (2-year)	601.84	601.86	0.02	
26,000 (5-year)	604.34 (1)	604.33 (1)	-0.01	
31,000 (10-year)	605.98 (1)	605.94 (1)	-0.04	
38,000 (25-year)	608.17 (1)	608.06 (1)	-0.11	
44,000 (50-year)	610.26 (1)	610.12 (1)	-0.14	
50,000 (100-year)	612.92 (1)	612.73 (1)	-0.19	

(1) Less than 18" vertical separation between tailwater and crest of dam

3.0 MODELING RESULTS EVALUATION OF EXISTING AND TEMPORARY CONSTRUCTION CONDITIONS

The project is proposed to be constructed by access provided from a staging area in Ah-Nab-Awen Park and in-channel causeways accessing each work area from the park. At Dam 2, the west half of the proposed improvements would be constructed within isolation conditions after installing a cofferdam around the work area and diverting flow to the east side of the channel. Construction activities will be limited by flow depths in the river are anticipated to be performed during flow rates less than approximately 4,000 cfs. Above this flow, depths would likely exceed those for safe and efficient construction in the flowing water and would begin to overtop the cofferdam at the Dam 2 location. Additionally, because construction would only occur during the lower flow periods, the temporary structures (causeways and cofferdam) are proposed to remain in the river during periods of higher flows when construction is unable to occur. Removing temporary structures prior to 4,000 cfs being exceeded would not provide for feasible construction of the project.

The proposed hydraulic feature at the Dam 2 location replaces the grade control function of Dam 3 and part of Dam 4. In order to maintain stable grade control within the reach until the completion of the proposed new hydraulic feature, the removal of Dams 3 and 4 is proposed to be done after the completion of the feature at Dam 2.

Refer to the construction sequencing discussion in Report D1 and the temporary care of water sheets (T Sheets) in permit drawings for reference.

Three temporary conditions models have been evaluated for potential impacts to tailwater at 6th Street Dam:

- Temporary Conditions Model 1 assumes that causeways to Dams 1 and 2, as well as causeways to all work downstream of Pearl Street have bene installed and all dams remain in place.
- Temporary Conditions Model 2 assumes that the cofferdam at the Dam 2 location has been installed in addition to all causeways as described in model 1. All dams remain in place
- Temporary Conditions Model 3 assumes that the cofferdam has been removed and all proposed improvements have been completed, but all causeways still need to be removed from the channel.

These temporary conditions models make conservative assumptions as to what all would potentially be in the river at one time. This is to provide the contractor flexibility to perform the work as efficiently as possible, while still adhering to the sequencing detailed in Report D1.

Modeling results for tailwater at 6th Street Dam are compared and discussed for each temporary condition below. Low flows, which include flow rates below bankfull flow of 13,000 cfs, were evaluated in SRH-2D and comparisons were made between existing and temporary conditions. High flows, which includes flow rates greater than bankfull flow, were evaluated and compared using the effective HEC-RAS FEMA flood model. Tailwater elevations were taken from both models directly downstream of 6th Street Dam, at River Station 2160+20.2.

3.1 Temporary Conditions Model 1

Table 1 compares the calculated rating curves for Existing Conditions and Temporary Conditions; the crest of 6th Street Dam is submerged by tailwater at the 5-year flood (26,000 cfs). Modeling results indicate potential for increased tailwater elevations of up to 0.37 feet and an 18" vertical separation from tailwater to dam crest being maintained for flow rates below 18,000 cfs.

Table 2: Comparison of modeled tailwater elevations at 6th Street Dam for Temporary Conditions Model 1

Flowrate (cfs)	Existing Conditions (ft)	Temporary Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	596.25	0.33	SRH-2D
2,500	596.64	596.96	0.32	
3,900	597.26	597.58	0.32	
5,000	597.67	598.00	0.33	
7,500	598.50	598.83	0.33	
10,000 (1-year)	599.20	599.57	0.37	
13,000 (Bankfull)	599.90	600.14	0.24	HEC-RAS
18,000 (2-year)	601.84	602.05 (1)	0.21	
26,000 (5-year)	604.34 (1)	604.52 (1)	0.18	
31,000 (10-year)	605.98 (1)	606.14 (1)	0.16	
38,000 (25-year)	608.17 (1)	608.29 (1)	0.12	
44,000 (50-year)	610.26 (1)	610.36 (1)	0.1	
50,000 (100-year)	612.92 (1)	612.98 (1)	0.06	

(2) Less than 18" vertical separation between tailwater and crest of dam

3.2 Temporary Conditions Model 2

Table 3 compares the calculated rating curves for Existing Conditions and Temporary Conditions. Modeling results indicate potential for increased tailwater elevations of up to 0.33 feet and an 18" vertical separation from tailwater to dam crest being maintained for flow rates below 18,000 cfs.

Table 3: Comparison of modeled tailwater elevations at 6th Street Dam for Temporary Conditions Model 2

Flowrate (cfs)	Existing Conditions (ft)	Temporary Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	596.23	0.31	SRH-2D
2,500	596.64	596.94	0.3	
3,900	597.26	597.55	0.29	
5,000	597.67	597.97	0.3	
7,500	598.50	598.80	0.3	
10,000 (1-year)	599.20	599.53	0.33	
13,000 (Bankfull)	599.90	600.07	0.17	HEC-RAS
18,000 (2-year)	601.84	602.05 (1)	0.21	
26,000 (5-year)	604.34 (1)	604.54 (1)	0.2	
31,000 (10-year)	605.98 (1)	606.15 (1)	0.17	
38,000 (25-year)	608.17 (1)	608.30 (1)	0.13	
44,000 (50-year)	610.26 (1)	610.37 (1)	0.11	
50,000 (100-year)	612.92 (1)	612.99 (1)	0.07	

(3) Less than 18" vertical separation between tailwater and crest of dam

3.3 *Temporary Conditions Model 3*

Table 4 compares the calculated rating curves for Existing Conditions and Temporary Conditions. Modeling results indicate potential for increased tailwater elevations of up to 0.08 feet and an 18" vertical separation from tailwater to dam crest being maintained for flow rates below 18,000 cfs.

Table 4: Comparison of modeled tailwater elevations at 6th Street Dam for Temporary Conditions Model 3

Flowrate (cfs)	Existing Conditions (ft)	Temporary Conditions (ft)	Modeled Change in Tailwater (ft)	Modeling Results
1,200	595.92	595.59	-0.33	SRH-2D
2,500	596.64	596.3	-0.34	
3,900	597.26	596.91	-0.35	
5,000	597.67	597.33	-0.34	
7,500	598.50	598.18	-0.32	
10,000 (1-year)	599.20	598.99	-0.21	
13,000 (Bankfull)	599.90	599.95	0.041	HEC-RAS
18,000 (2-year)	601.84	601.93 (1)	0.09	
26,000 (5-year)	604.34 (1)	604.39 (1)	0.05	
31,000 (10-year)	605.98 (1)	605.99 (1)	0.01	
38,000 (25-year)	608.17 (1)	608.09 (1)	-0.08	
44,000 (50-year)	610.26 (1)	610.16 (1)	-0.1	
50,000 (100-year)	612.92 (1)	612.80 (1)	-0.12	

(4) Less than 18" vertical separation between tailwater and crest of dam

4.0 WATER TEMPERATURE

Water temperature plays a major role in predicting when sea lampreys may be migrating upriver. The following information is included to corelate flow rates and water temperature to various times of year. The project will not have an impact on these correlations. Sea lampreys typically spawn in the Grand River in the late winter through spring months (February through June) (USFWS, *personal communication*). Table 5 provides the calculated mean-monthly flow rates and corresponding average temperatures. For the flow data. forty-years of discharge data were obtained from USGS Gage 04119000 and a mean-monthly flow rate was calculated from the mean-daily rate. For water temperatures, 10°C has been identified as a target, with migration beginning as temperatures sustain above 10°C. The annual hydrograph is summarized along with water temperature in Figure 1.

Table 5: Mean monthly flow rates for active spawning months

Month -	Mean daily flow ft^3/s	Mean monthly water temp. ^oC
February	4,878	2
March	7,725	4
April	7,387	10
May	5,696	15
June	4,024	21

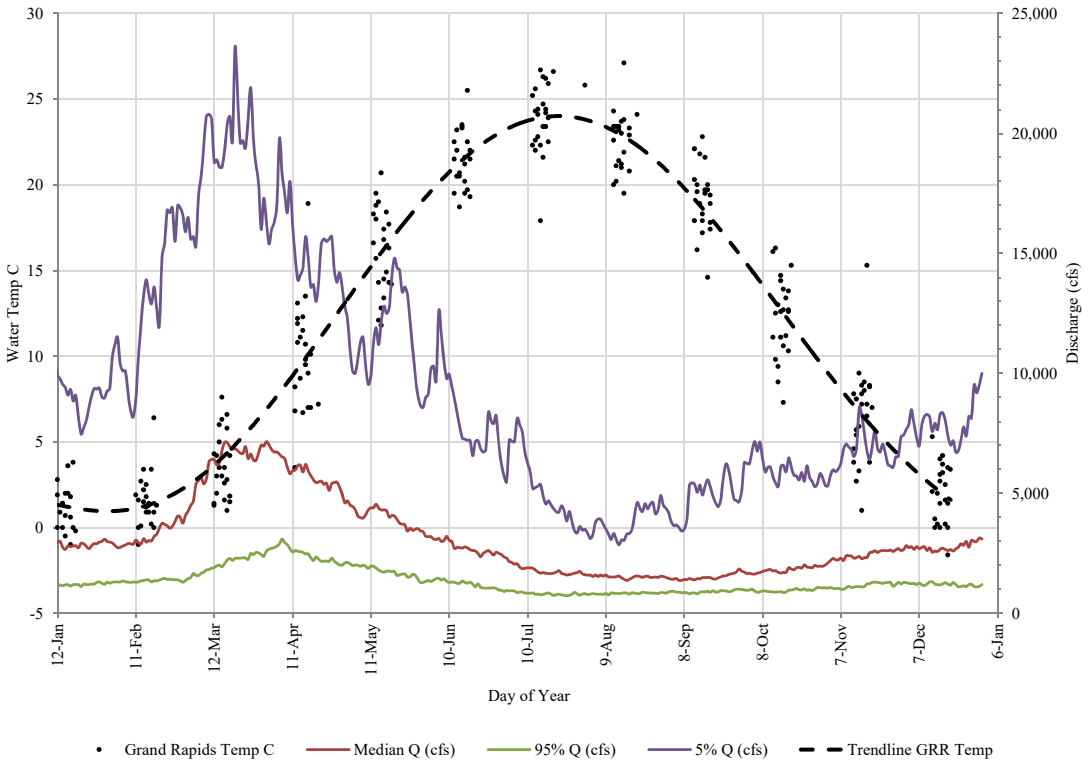

Figure 1: Annual hydrograph with water temperature

5.0 CONCLUSION

The systemic processes of the river and hydraulic characteristics of the 6th Street Dam that contribute to blockage of sea lampreys is not explicitly understood and blockage is likely a combination of various components, including water temperature, vertical free over-fall from crest to tailwater, as well as velocity of flow over and through the dam.

The hydraulic function of 6th Street Dam as a barrier to sea lampreys is not anticipated to be negatively affected by the Lower Reach project. The systemic processes of the river and hydraulic characteristics of the dam that contribute to blockage of sea lampreys is not explicitly understood and blockage is likely a combination of various components, including water temperature, vertical free over-fall from tailwater to crest, as well as velocity of flow over and through the dam.

The project would have no effect on water temperatures or on the dam structure itself.

Modeling results indicate that tailwater elevations would remain at or below existing conditions, within modeling error. Based on this evaluation, the function of 6th Street Dam as a barrier to sea lampreys is anticipated to remain as effective as the existing condition.

The removal of Dams 3 and 4 would be sequenced after the completion of the proposed feature at Dam 2 as means to maintain stable grade control within the reach through construction. The addition of obstruction associated with the temporary causeways and cofferdam resulted in small, modeled increases in tailwater at 6th Street Dam. For this reason, installation of temporary structures would begin immediately following sea lamprey migration season (July 1st) if flow conditions allow. If flows are low enough before sea lamprey migration season ends, isolation measures would be installed if approved after coordination with the USFWS Sea Lamprey Control Program.

Construction is anticipated to be potentially completed in one season but will be dependent on flow conditions throughout the season. If conditions do not allow for full completion of work in one season, some temporary causeway material may be left in the channel over winter (along with all constructed proposed improvements). Potential increases in modeled tailwater elevations that may result if this is the case have been minimized by prioritizing the removal of Dams 3 and 4 immediately following the completion of the feature at Dam 2. Potential modeled impacts to tailwater over winter are represented by temporary conditions models 2 and 3; condition 2 assumes Dams 3 and 4 remain in place and condition 3 assumes they've been removed, which would be the more likely scenario given the anticipated construction schedule.

6.0 REFERENCES

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APPENDIX E

Other Supporting Information

Sediment Transport Report; June 2024

Sediment Transport Report
GRAND RIVER REVITALIZATION PROJECT
GRAND RAPIDS, MICHIGAN

Sediment Transport Report

Prepared for:
City of Grand Rapids

Prepared by:
RiverRestoration
P.O. Box 248
Carbondale, CO 81623

June 2024

Grand Rapids WhiteWater

RIVER RESTORATION.ORG

CITY OF GRAND RAPIDS

This document entitled Sediment Transport Report: Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org, LLC for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.

Approved by
Scott Prins, P.E.

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Section 1 – Introduction

Sediment transport was evaluated for existing and proposed conditions of the Grand River Revitalization Lower Reach Project. Sediment analyses are important to predict long-term stability and function while seeking project benefits and evaluating maintenance requirements. The Grand River at Grand Rapids, MI is a unique geomorphic channel, with a locally steep-gradient and a glacially deposited remnant encompassed within an otherwise low-gradient, sand-bed channel. As the flowrate in the river increases above baseline summer flows, the backwater from the downstream reach affects progressively more upstream area of the steep-gradient channel, reducing sediment transport potential. As such, the sediment dynamics are complex and are a function of both the discharge of the river as well as the location within the project reach. This report describes the sediment analyses performed including survey sampling procedures as well as capacity and competency calculations and presents implications for long-term stability. Proposed instream alterations are not anticipated to have significant effects on the sediment dynamics extending beyond the project reach.

The project reach is composed of a stable substrate with transporting sediment loads, supplied from upstream, passing over the substrate. Transient deposition of upstream sediment load may occur within the reach.

1.1 Sediment Sampling

Sediment sampling has been performed both quantitatively and qualitatively beginning in 2011. Sampling was performed upstream and downstream of the project reach, as well as within the project reach. Analysis of the samples indicates that the channel bed upstream of Ann Street and downstream of US-131 are primarily composed of uniform sand. A broken bedrock outcrop with glacio-fluvial alluvium deposits exists between Ann St. and I-196. Glacio-fluvial alluvium deposits make up the substrate within the project reach between I-196 and Fulton Street. Sampling results indicate that sand supplied from the upstream reach is transported through the project reach to downstream areas. Data also allude to the transport of coarser materials from the upstream end of the project reach which deposit out of the total mobile load at the slope break near Fulton Street.

In 2013, sediment grab samples were collected by RiverRestoration at three locations upstream and downstream of the project site as displayed in Figure 1 to compare with sampling within the project reach in order to evaluate transport of the upstream supply through the reach. Grab samples were obtained near Riverside Park, at Fulton Street Bridge, and downstream of the project reach past the US-131 Bridge. The collected samples were analyzed using sieve distributions by MTC in 2015. Figure 2 illustrates particle size distributions determined by MTC (MTC, 2015) with primarily fine to medium sand indicated upstream and downstream of the project reach (represented in Figure 2 by circles and squares, d_{50} = 0.39 mm) and coarse sand to fine gravel near the downstream extent of the project site (represented by triangles, d_{50} = 3.71 mm). Distributions of the bed sample sizes are provided in Table 1.

Table 1. Grand River Bed Sample Size Distributions (mm)

Location	*D85*	*D60*	*D50*	*D30*	*D15*	*D10*	*Cc*	*Cu*
Riverside Park	0.53	0.42	0.39	0.33	0.29	0.27	0.96	1.57
Fulton St	8.91	4.82	3.71	1.43	0.27	0.23	1.86	21.14
Downstream HW 131	0.59	0.44	0.39	0.32	0.26	0.23	0.98	1.89

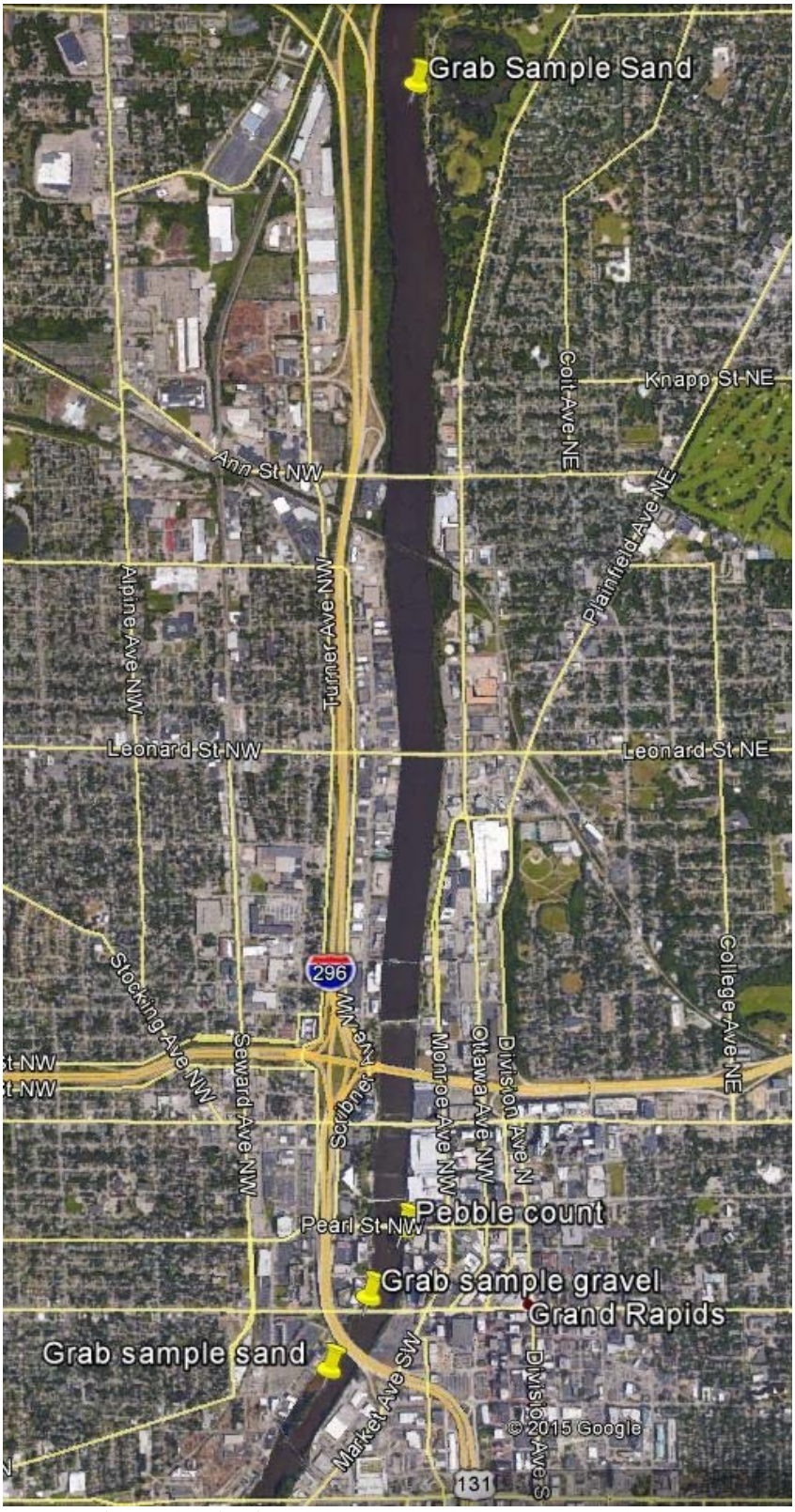

Figure 1. Sediment sampling locations

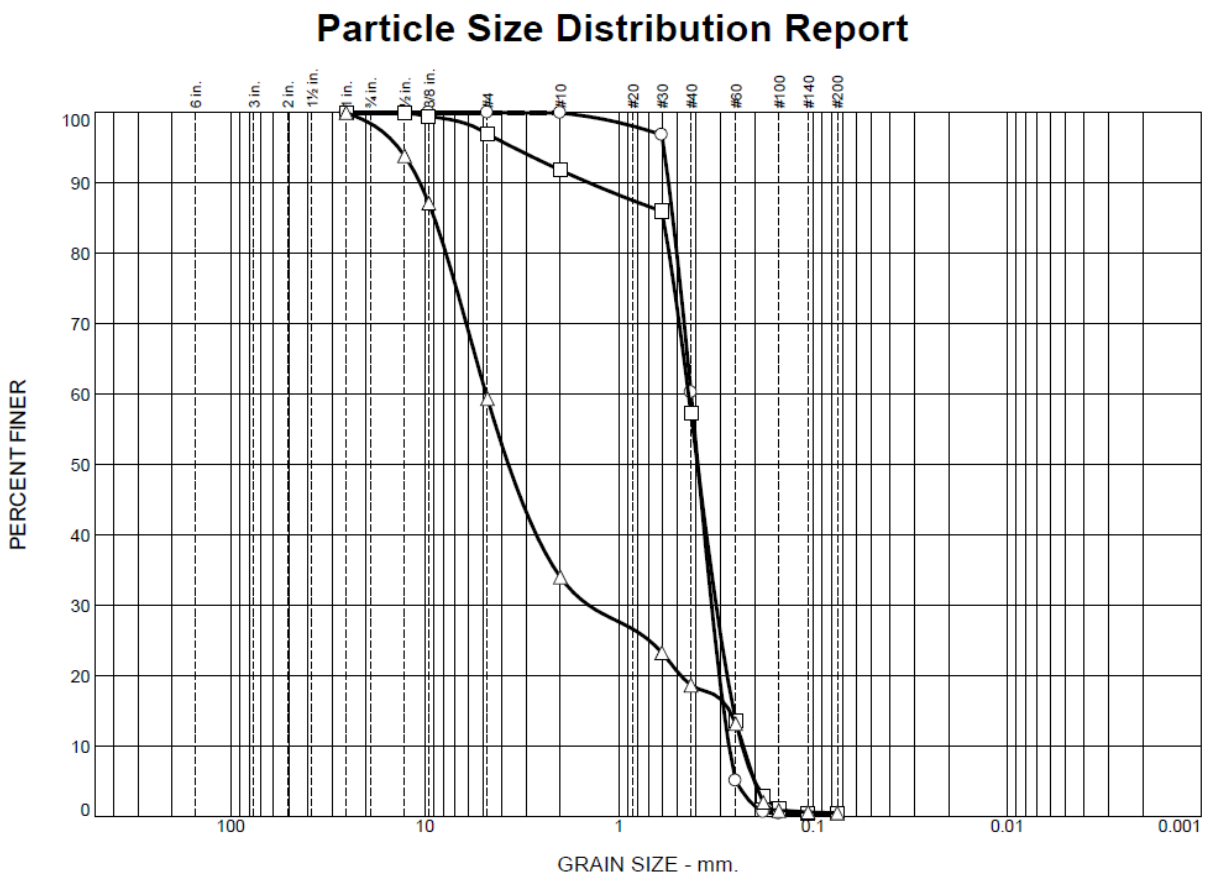

Figure 2. Sediment sampling locations; circle – Riverside Park, square – downstream of project reach, triangle – Fulton St. (MTC, 2015).

1.1.1 Sampling Within the Project Reach

Sampling efforts to date include:

- RiverRestoration performed bathymetric survey in Fall of 2011 combined with probing to develop qualitative substrate characterization;
- Wolman pebble counts of bed substrate were collected August 4, 2015 downstream of Pearl St and June 17, 2016 upstream of Gillette Bridge in sites selected as qualitatively mobile gravel deposits;
- Mussel surveys were performed by EcoAnalysts Inc. (ESI) in November 2014; during the mussel survey, bed substrates were also qualitatively described and mapped (ESI, 2014); and
- A comprehensive substrate sampling of the riverbed was performed by MTC in March 2017. The MTC 2017 sampling included two sample locations between each set of bridges from 6th Street Dam to Fulton Street for a total of 12 substrate samples. Probe sampling was conducted to determine the amount of substrate larger than 6 inches (coarse cobble). Ponar grab sampling was then performed at each location to determine the gradation of the substrate finer than 6 inches (MTC, 2017). The locations and percentages of coarse material (greater than 6 inches) for each sampling location are presented in Table 2. The locations of the samples are presented in Figure 3. On average, 60% of the sampled riverbed was determined to be coarser than 6 inches. Throughout the project reach, the percent distribution of sand ranged from 0% to 5% of the recovered substrate. The downstream sampling location, immediately upstream of Fulton

Street, produced larger percentages of sand; this is indicative of the change in the energy grade of the river at this location.

- Additional substrate sampling was performed in July 2020 at 11 locations using a combination of Geoprobe and Pitch Sampler equipment to collect 1.75-inch diameter macrocores followed by both grain size analysis and chemical analysis of collected samples. The sampling locations for the 2020 survey are presented in Figure 3. During both the 2020 sampling and the 2017, shallow refusal with respect to the planned sampling depths and poor sampler recovery were encountered due to the frequent presence of coarse gravel, cobble and boulder. The 2020 sampling results indicated the presence of coarse-grained material with less than 5% of the material passing the 200 sieve. Each sample was tested for heavy metals, volatile organic compounds, semi-volatile organic compounds, pesticides, polychlorinated biphenyls, dioxins and furan, per and polyfluoroalkyl substances, biochemical oxygen demand, and total solids. Refer to the sampling report for more information (MTC. 2020)

Table 2: MTC, 2017 Sampling Data

Sample Location	Location (MI State Plane South)		Water Depth (ft)	River Bottom Consistency Based on Probing (%)		d50 of collected sample (inches)	Estimated d50 of sample area (inches)
	Northing	Easting		< 6-inches	> 6-inches		
1	536129	12773066	4.5	25	75	0.0	6 or larger
2	536295	12772921	4.0	10	90	2.5	6 or larger
3	536623	12772963	4.2	10	90	*Data Not Available*	6 or larger
4	536936	12773212	2.5	15	85	2.0	6 or larger
5	537353	12773028	3.7	50	50	2.3	6
6	537428	12773240	3.0	60	40	1.7	3.4
7	537827	12773063	2.7	75	25	1.7	2.7
8	538296	12773381	3.9	40	60	2.5	6 or larger
9	538890	12773427	5.8	85	15	1.6	2.3
10	539147	12772180	3.5	50	50	3.0	6
11	539485	12773506	6.8	*Suspected bedrock*		0.0	*NA*
12	539801	12773238	3.7	15	85	3.2	6 or larger

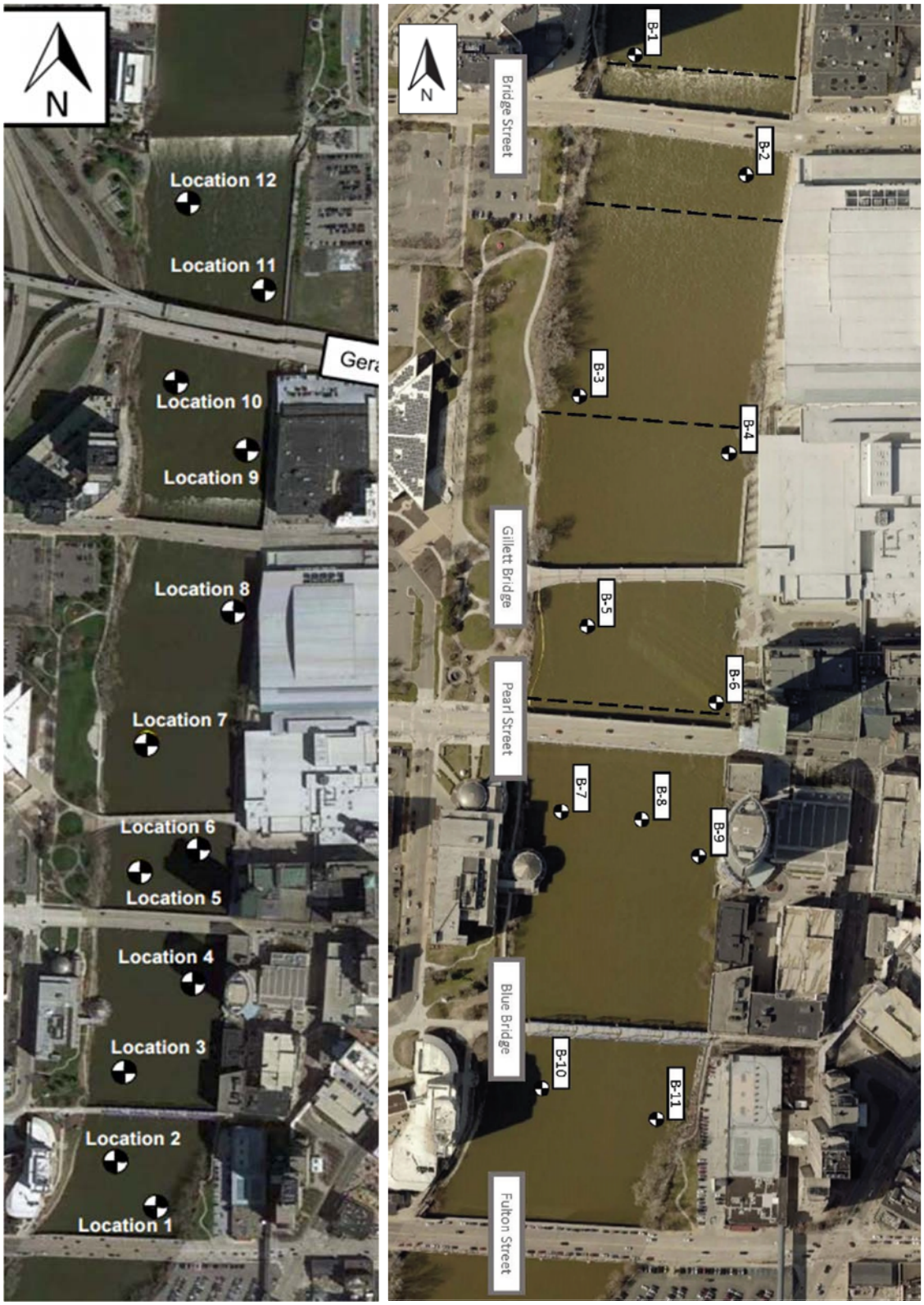

Figure 3: MTC Sampling locations: 2017 Sampling on the left and 2020 Sampling on the right.

Section 2 – Inflowing Suspended Sediment Load Data

The inflowing suspended sediment load was determined based on gage data in order to evaluate the potential for long-term aggradation or degradation. Five USGS stream gages on the Grand River were referenced for comparing sampled sediment loads. Data from these gage records were analyzed along with the sediment modeling findings from Baird (2007). The locations of the USGS gages are presented in Figure 4. A summary of the USGS gages referenced is provided in Table 3.

Table 3. Grand River Gaged Sediment Data

USGS Gage	Proximity to Grand Rapids	Period of Record	Suspended Sediment Concentration, mg/L			Suspended Sediment Discharge, tons/day		
			Max.	Min.	Avg.	Max.	Min.	Avg.
04113000 Lansing	90 miles U/S	4/20/1975 - 5/29/1975	312	24	136	9,440	9,440	9,440
04114000 Portland	65 miles U/S	4/20/1975 - 4/23/1975	347	96	208	11,400	11,400	11,400
04116000 Ionia	40 miles U/S	4/20/1975 - 4/23/1976	227	84	168.6	9,580	3,220	6,772
04119300 Eastmanville	22 miles D/S	2/14/1979 - 10/7/1994	294	1	33.7	8,930	5	669.6
04119400 Eastmanville	25 miles D/S	4/29/2011 - 10/15/2014	895	4	37.9	44,900	29	1,570

2.1 Calibrated SWAT Model (Baird 2007)

Baird (2007) compiled available data on transporting sediment loads and concentrations in the Grand River watershed and used the results to calibrate a comprehensive Soil and Water Assessment Tool (SWAT) model. SWAT uses a wide range of input parameters to predict long-term responses to changes in land use, climate, and vegetation in the form of sediment yields and water quality. The input parameters represent climate, hydrology, ponds and wetlands, groundwater, main channel draining, soils, land cover, and land use. The sediment load of the Lower Grand River (Downstream of Lansing) was predicted by the SWAT model and compared to sampled data at all USGS gage stations shown in Figure 3, with the exception of #04119400, which was not available at the time of the report. All the input parameters listed above are specific to the Grand River watershed. The hydrology, which seasonally fluctuates, has the largest effect on the sediment load. By comparing sediment load to discharge at various points along the river, predictions can be made about suspended sediment load based on a given discharge. The comparison of the SWAT model and gage data are presented in Figure 5. Sediment load in mg/L is presented on the *y*-axis and related to the discharge in cubic meters per second (cms) of the river on the *x*-axis. Both axes are on logarithmic scales.

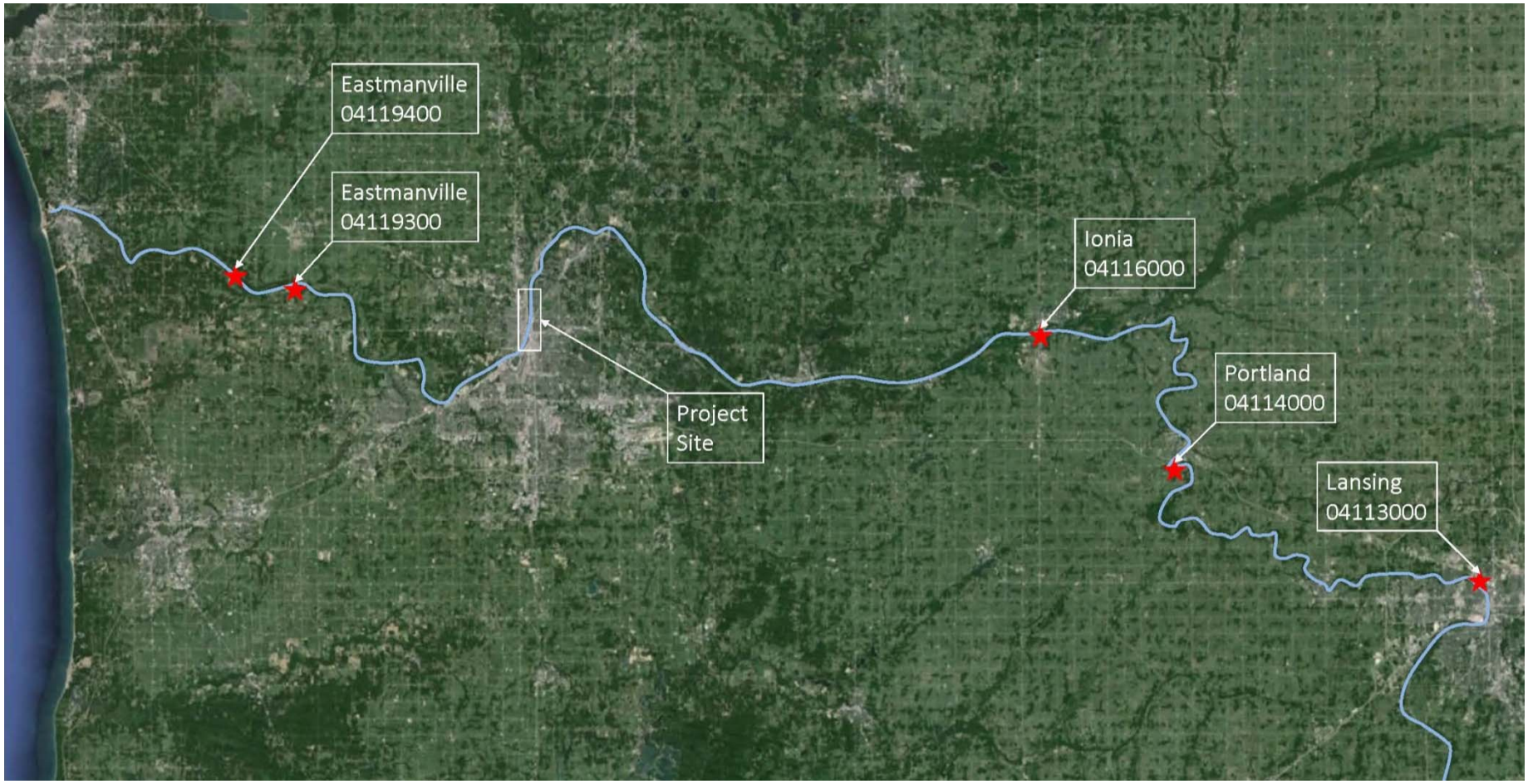

Figure 4. USGS Gage Locations

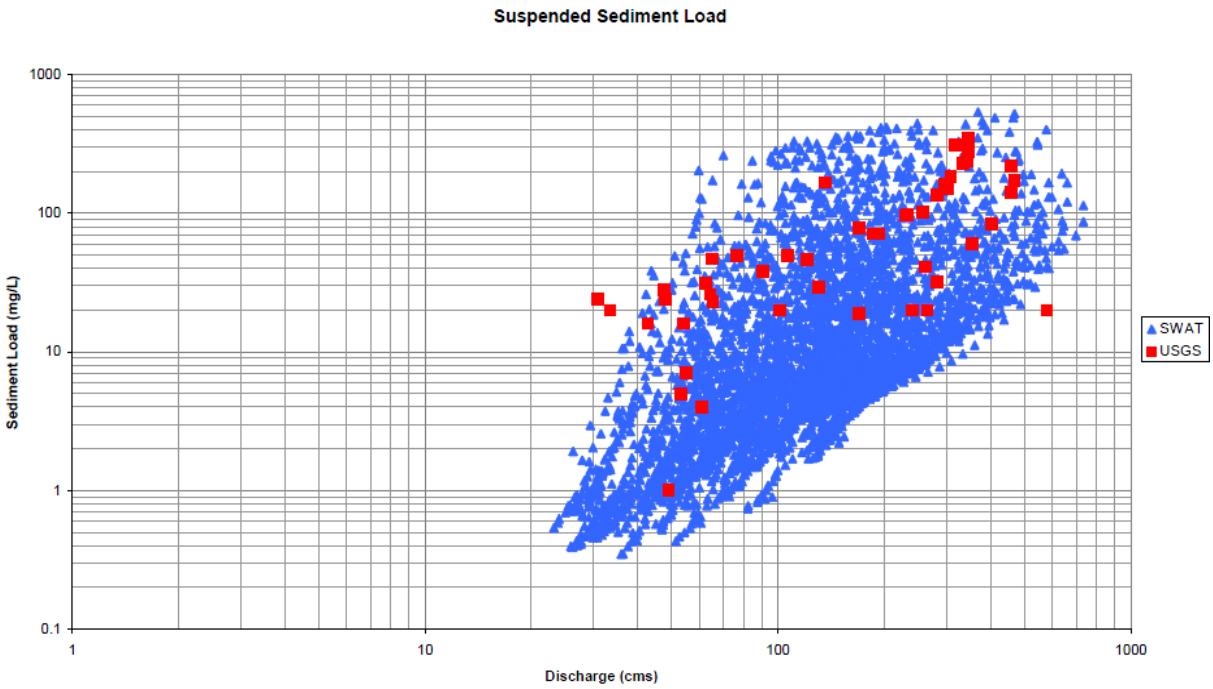

Figure 5. Sediment Load Comparison between USGS Data and SWAT Simulation (from Baird, 2007)

The suspended sediment load data from Baird (2007) was obtained from the four USGS gages presented in Figure 4, excluding #04119400. Figure 6 presents this same data with the addition of new data from gage #04119400 which contains data from 2011 to 2014. It should be noted that the units for discharge in Figure 6 are cubic feet per second (cfs) and not cms.

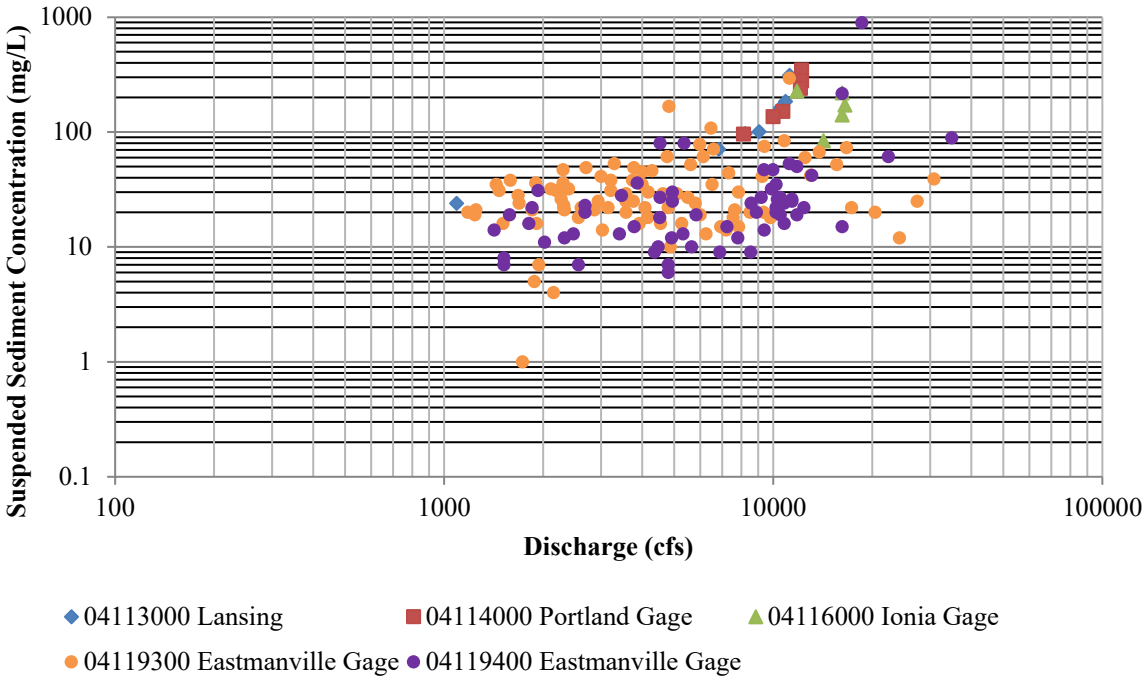

Figure 6. Suspended Sediment Concentration from USGS Gages near Grand Rapids, MI

2.2 *Verification of stable channel dimensions of inflowing reach using Copeland's Method*

Data presented in the above figures provided a range of inflowing sediment concentrations that were evaluated in HEC-RAS using the Copeland method to examine and verify stable channel dimensions for the existing inflowing reach. The Copeland method in HEC-RAS is empirically derived and uses sediment discharge relationships developed by Brownlie (1981) to compare channel width and depth to bed slope in order to predict aggradation or degradation of the channel based on an assumed inflowing sediment load.

The channel characteristics of the upstream reach were evaluated first. This evaluation was based on the dimensions of the river adjacent to Riverside Park near river station 2295+00. Channel dimensions and hydraulic parameters for the upstream reach include a median channel width of 600 feet, 1:1 side slopes on the banks, manning's roughness of 0.03, a particle gradation based on bed sampling of a d_{84} of course sand (0.53 mm), a d_{50} of medium sand (0.39 mm), and a d_{16} of fine sand (0.29 mm), an effective discharge of 10,000 ft^3/s, and an inflowing sediment concentration ranging from 10 mg/L to 300 mg/L which was based on the gaged sediment concentrations. The range of inflowing sediment concentrations produced a range of stable bed slopes at a channel width of 600 feet. Figure 7 presents the predicted stable bed slopes for a channel width of 600 feet over the range of inflowing sediment concentrations. Degradation of the assumed particle size distribution is predicted for conditions above the line and aggradation for conditions below the line.

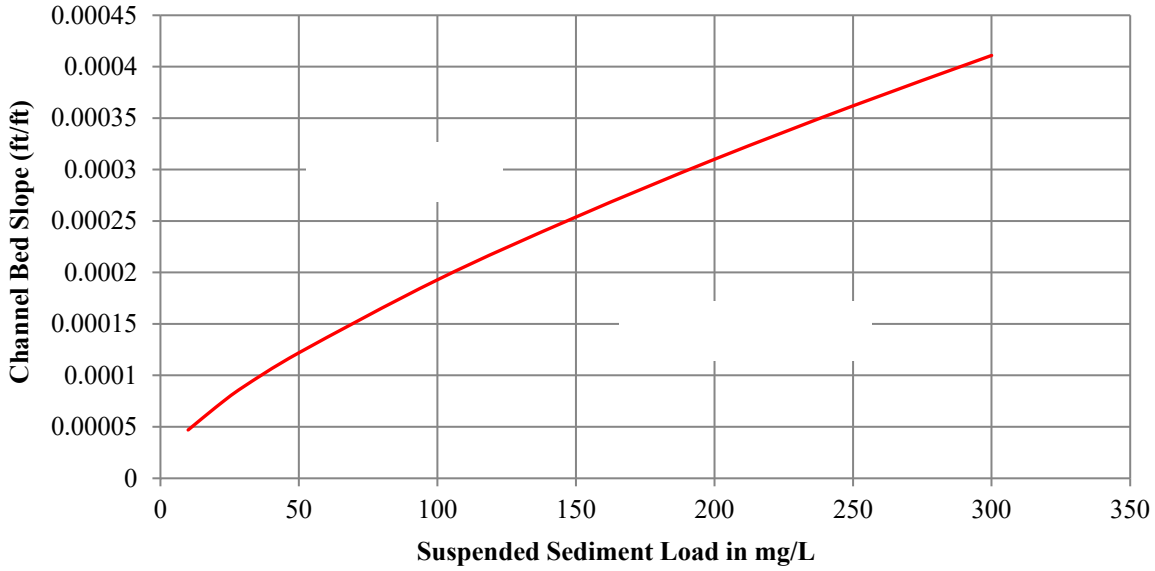

Figure 7: Copeland Stability Curve for 600 ft Wide Channel and Inflowing Sediment Load of 10 mg/L and 300 mg/L

According to gage data, the majority of the inflowing sediment load data were between 10 and 100 mg/L. The stable bed slopes predicted for this sediment concentration range are consistent with slopes calculated from bathymetric survey data. The upstream reach of the Grand River adjacent to Riverside Park is considered a stable reach (i.e. not actively aggrading or degrading) based on calculations, which corresponds to field observations and recent historic reports of the reach. Incoming sediment loads to Riverside Park pass downstream to the project reach; the

anticipated inflowing suspended sediment load to the project reach is 10 to 100 mg/L with the possible larger event of 300 mg/L.

The hydraulic gradient of the Grand River within the project reach is currently distributed by the existing low-head dams with relatively flat water between them. The proposed project seeks to distribute this gradient with more naturally functioning bedforms, including constructed riffles. The imported substrate has been sized to remain stable and also function as hydraulic controls to protect the un-impacted native substrate from being degraded over time. By spreading out the hydraulic gradient over more of the reach, the project would increase the relative energy grade slope between Bridge Street and Fulton Street. The supplied bed load must pass through a much lower-gradient reach upstream. Therefore, there is no concern of aggradation from the inflowing suspended sediment load within the project reach. Instead., inflowing suspended sediment loads are anticipated to seasonally pass through the proposed conditions project reach. The project does not propose importing fine sediment and is not anticipated to have an impact on the suspended sediment load being transported to the lower reach. The potential for local transient deposition of the mobile bed load around in-channel features is discussed in section 5 of this report.

Section 3 – Substrate Mobility Analysis

Sizing of the imported substrate is critical for project success; too small of substrate may mobilize beyond the project reach or destabilize structures through scour, while too large of material may create poor habitat conditions or safety hazards to river users. Balancing these two criteria is the goal of sizing imported substrate.

Therefore, a substrate mobility analysis was performed in order to determine the particle size gradation to use in the proposed stable substrate materials imported to the channel which would avoid persistent degradation of bed material. This analysis compared calculated maximum bed shear stresses to critical shear stresses, or the shear stress at which substrate sizes begin to mobilize.

3.1. Critical Shear Stress and Incipient Motion

Boundary shear-stress magnitudes have been linked to incipient motion of individual particles through empirical and theoretical examination (Julien, 2002). There is a critical shear-stress magnitude (τ_C) which corresponds with the mobilization of a given size class of substrate. Table 4 summarizes mobilization values from Julien (2002). Factors not considered in the values of Table 4 include hydraulic impingement angle, bed slope, substrate matrix, gradation variability, material density, and water temperature.

Shear-stress values from the numerical models can be directly compared to the critical mobility values to approximate the substrate size classification that may remain stable under maximum loading at each location in the Grand River. An incipient motion analysis was performed based on the critical shear stress to determine what individual size particle would be mobile for given flowrates. Bed shear stresses over the proposed grading were iteratively evaluated using hydraulic modeling to determine the critical grain size, or threshold mobile grain size. A factor of safety of 2.0 was then applied to the threshold mobile grain size to determine the proposed gradation of the imported material.

Table 4:Critical Shear Stress by Particle-size Classification for determining approximate condition for sediment mobility - taken from USGS Scientific Investigations Report 2008-5093 (adapted from Julien, 2002)

Particle Classification Name	Ranges of Particle Diameters mm	Shields Parameter (dimensionless)	Critical Bed Shear Stress (τ_C) N/m^2	Critical Bed Shear Stress (τ_C) lb/ft^2
Coarse cobble	128 – 256	0.054 – 0.054	112 – 223	2.34 - 4.66
Fine cobble	64 – 128	0.052 – 0.054	53.8 – 112	1.12 - 2.34
Very coarse gravel	32 – 64	0.05 – 0.052	25.9 – 53.8	0.54 - 1.12
Coarse gravel	16 – 32	0.047 – 0.05	12.2 – 25.9	0.25 - 0.54
Medium gravel	8 – 16	0.044 – 0.047	5.7 – 12.2	0.12 - 0.25
Fine gravel	4 – 8	0.042 – 0.044	2.7 – 5.7	0.056 - 0.12
Very fine gravel	2 – 4	0.039 – 0.042	1.3 – 2.7	0.027 - 0.056
Very coarse sand	1 – 2	0.029 – 0.039	0.47 – 1.3	0.0098 - 0.027
Coarse sand	0.5 – 1	0.033 – 0.029	0.27 – 0.47	0.0056 - 0.0098
Medium sand	0.25 – 0.5	0.048 – 0.033	0.194 – 0.27	0.0041 - 0.0056
Fine sand	0.125 – 0.25	0.072 – 0.048	0.145 – 0.194	0.0030 - 0.0041
Very fine sand	0.0625 – 0.125	0.109 – 0.072	0.110 – 0.145	0.0023 - 0.0030
Coarse silt	0.0310 – 0.0625	0.165 – 0.109	0.0826 – 0.110	0.0017 - 0.0023
Medium silt	0.0156 – 0.0310	0.25 – 0.165	0.0630 – 0.0826	0.0013 - 0.0017
Fine silt	0.0078 – 0.0156	0.3 – 0.25	0.0378 – 0.0630	0.00079 - 0.0013

Hydraulic modeling was performed with SRH-2D, a publicly available computer program from the US Bureau of Reclamation which has been extensively validated for the open-channel flow applications similar to the Grand River (Lai, 2010). The model uses an implicit numerical scheme to calculate the depth-averaged (i.e. two-dimensional) Navier-Stokes equations and generates flow depths, velocities, turbulence parameters, and boundary shear stresses. The unstructured mesh used in the numerical model was sufficiently refined (approximately 1-ft^2 cells) to capture hydraulic gradients produced by the modeled surface.

The determining hydraulic parameter for substrate stability is boundary shear stress. SRH-2D calculates boundary shear stress vectors as follows:

$$(\tau_{bx}, \tau_{by}) = \frac{\rho g n^2 \sqrt{U^2 + V^2}(U, V)}{h^{1/3}}$$

where:
τ_{bx} = bed shear stress in the *x*-direction;
τ_{bx} = bed shear stress in the *y*-direction;
ρ = water density;
g = gravitational acceleration;
n = Manning roughness coefficient;
U = mean-flow velocity in the *x*-direction;
V = mean-flow velocity in the *y*-direction; and
h = flow depth.

Bed shear stresses calculated by SRH-2D are dependent on Manning roughness values, which have been specified based on substrate size. Therefore, sizing the imported substrate to have a minimum factor of safety of 2.0 was an iterative process of calculating maximum bed shear, changing the gradation of substate and increasing Manning n values, and re-calculating bed shear stresses.

3.2. Imported Substrate Gradations

By applying a factor of safety to imported d_{50} grain sizes, the substrate used in the proposed grading has been designed to avoid degradation while promoting a more natural river function. At larger flood flows, backwater from downstream of the project reach reduces bed shear stresses and corresponding mobile particle sizes. For this reason, calculated bed shear stresses for flowrates ranging from 890 ft^3/s to 31,000 ft^3/s were evaluated in SRH-2D. Shear stress values calculated in HEC-RAS during larger flood events were also referenced in this evaluation. The maximum bed shear values over the full range of flows were used to evaluate against existing conditions as well as in reference to Table 4 to determine the gradations and locations of proposed stable substrate fill material. Maximum bed shear maps are presented in Figure 9.

The final substrate configuration of the channel will be a combination of both imported materials and existing native alluvium. Over native alluvium, the existing substrate was found to remain stable with a minimum factor of safety of 2.0 under post-project hydraulics. Where proposed conditions create shear stress exceeding the existing material stability, stable material will be imported to the channel. Figure 8 illustrates the proposed finished grade substrate configuration after construction. Imported substrates for the proposed grading include:

1) Fine alluvium for proposed shear stresses exceeding 1.1 lb/ft^2, specified with d_{50} of 3 inches;
2) Coarse alluvium and riprap for shear stresses exceeding 5.6 lb/ft^2, specified with d_{50} of 12 inches; and
3) Boulder at the structure crests and where shear stresses exceed 18.7 lb/ft^2.

Riprap will be used as sub-grade control structures within riffle features; plain and heavy riprap per MDOT will be combined to provide a d_{50} of 12 inches. The recommended gradations for the imported alluvium size classes are presented in Table 5.

Table 5. Recommended imported coarse and fine alluvium gradations

Weight	Indicator	Coarse	Fine
100%	Passing	30”	8”
60%-85%	Passing	20”	6”
35%-65%	Passing	12”	3”
25%-55%	Passing	8”	1.5”
15%-35%	Passing	4”	3/4”
0%-5%	Passing	1.5”	1/2”
	D_{85}	18”	6”
	D_{50}	12”	3”
	D_{30}	4”	3/4”

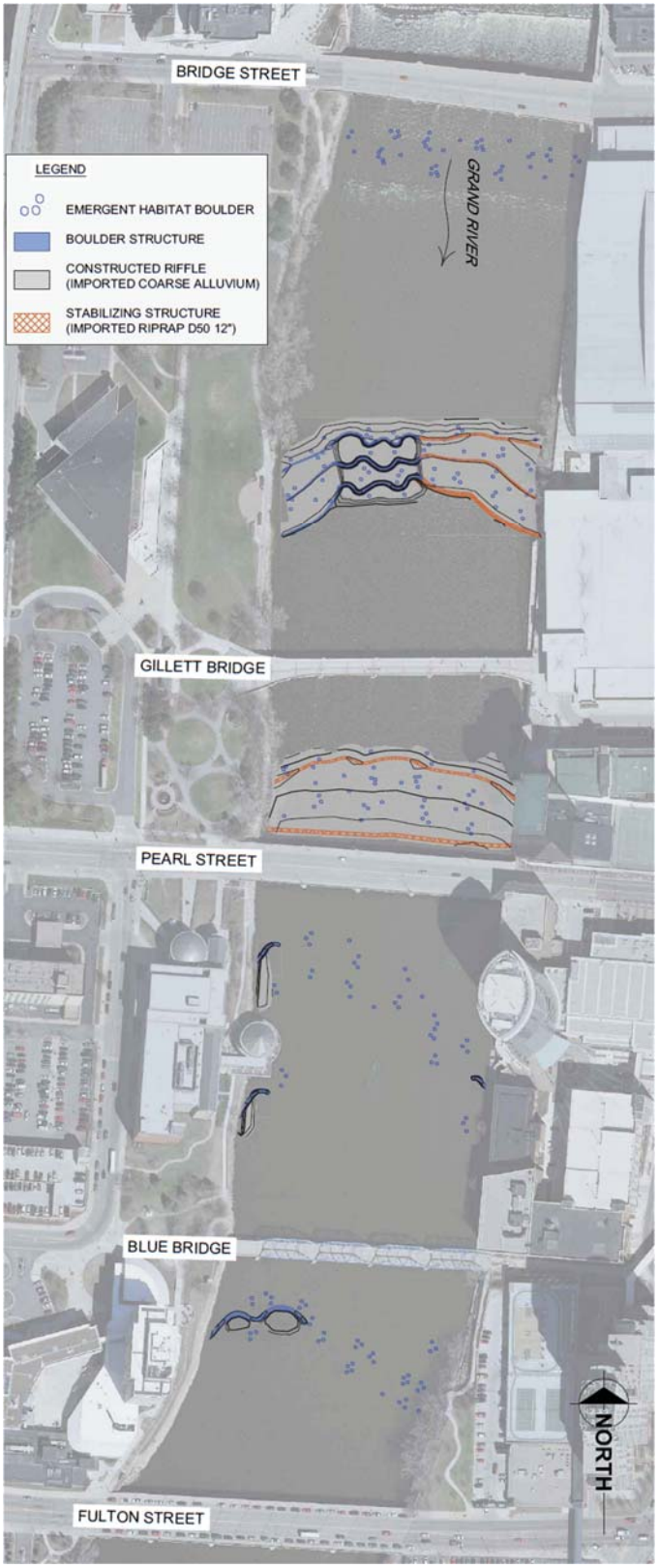

Figure 8: Proposed Substrate Fill Map

3.4. Manning Roughness

The empirically derived parameter, *n*, is the primary user-defined value in the numerical model which affects localized boundary shear stress. Values of *n*, typically termed "roughness" are dependent on the boundary friction of the channel, the resolution of the model, and the depth of flow relative to the substrate size of the bed. The roughness of any one reach of river is unique to the characteristics of the site and determining an *n* value that calibrates modeled channel roughness at the flow rates being modeled is an important part of hydraulic design. Calibration can be achieved by surveying water levels for a range of flow rates throughout the reach for comparison to modeled or calculated water levels. This process was performed on the project reach and a Manning value of 0.03 was determined to calibrate to surveyed water surface profiles under existing conditions during typical flow rates, including the average annual flow rate of 3,900 cfs.

The proposed substrate includes material that is coarser than what currently exists in the channel; therefore, a set of proposed *n* values were used based on proposed substrate size. The *n* values for proposed substrate were based on an investigation report by the USGS in which a series of calibrated *n* values were calibrated for a range of different modeled channels with various grades, substrate size, and flow rates. The data referenced in this investigation report were used to develop equations based on grain size and flow depth to approximate *n* values for various conditions. These findings were used to choose *n* values for modeling proposed substrate within the project reach. The results of this investigation report are presented in Table 6, taken from Blodgett (1980).

Table 6. Manning's roughness coefficient, *n*, for selected values of mean depth and median bed material size (Blodgett, 1980).

Mean depth, d_a (ft)	Median diameter of bed material, D_{50}, in feet													
	Fine sand	Medium sand	Coarse sand	Fine gravel			Medium gravel	Coarse gravel	Small cobble	Medium cobble	Large cobble	Boulders		
	0.0005	0.001	0.005	0.010	0.015	0.020	0.10	0.20	0.30	0.40	0.50	1.0	1.25	1.50
1	0.019	0.019	0.019	0.021	0.022	0.024	0.035	0.044	0.053	0.061	0.068	0.117	0.151	0.198
2	.021	.021	.021	.021	.022	.023	.032	.039	.045	.050	.054	.077	.089	.101
3	.022	.022	.022	.022	.022	.023	.032	.038	.042	.046	.050	.066	.074	.082
4	.023	.023	.023	.023	.023	.023	.031	.036	.041	.044	.047	.061	.068	.074
5	.024	.024	.024	.024	.024	.024	.031	.036	.040	.043	.046	.058	.064	.069
6	.025	.025	.025	.025	.025	.025	.031	.035	.039	.042	.045	.056	.061	.066
7	.026	.026	.026	.026	.026	.026	.030	.035	.038	.041	.044	.054	.059	.063
8	.026	.026	.026	.026	.026	.026	.030	.035	.038	.041	.053	.053	.057	.061
9	.027	.027	.027	.027	.027	.027	.030	.035	.038	.041	.043	.052	.056	.060
10	.027	.027	.027	.027	.027	.027	.030	.035	.038	.040	.042	.051	.055	.059
12	.028	.028	.028	.028	.028	.028	.030	.034	.037	.040	.042	.050	.054	.057
14	.029	.029	.029	.029	.029	.029	.030	.034	.037	.039	.042	.049	.053	.056
15	.029	.029	.029	.029	.029	.029	.030	.034	.037	.039	.041	.049	.052	.055
20	.031	.031	.031	.031	.031	.031	.031	.034	.037	.039	.041	.048	.050	.053
25	.032	.032	.032	.032	.032	.032	.032	.034	.036	.039	.040	.047	.050	.052
30	.033	.033	.033	.033	.033	.033	.033	.034	.036	.038	.040	.046	.049	.051
35	.033	.033	.033	.033	.033	.033	.033	.034	.036	.038	.040	.046	.048	.050
40	.034	.034	.034	.034	.034	.034	.034	.034	.036	.038	.040	.046	.048	.050

Relationships used in preparing table:

Equation 12 $$n = \frac{0.0926\, d_a^{0.167}}{0.794+1.85 \log d_a/D_{50}} \quad \text{for } 1.5 < d_a/D_{50} < 185$$

Equation 17 $$n = 0.0185 d_a^{0.167} \quad \text{for } 185 < d_a/D_{50} < 30{,}000$$

Table 6 was referenced at flow depths of four feet, which corresponds to when each channel location begins to become submerged by the lower gradient tailwater and not produce as much scour potential. Depending on the specific location of each feature, this occurs at a different flow rate ranging from about 4,000 cfs to 10,000 cfs. 10,000 cfs is approximately the 1-year flood, or ordinary high water. The proposed substrate and selected *n* values used in the SRH-2D model to predict substrate stability and determine appropriate material sizing is presented in Table 7. These values are considered to be conservatively high for evaluating flood flows, which contain larger flow depths. High *n* values also result in relatively high calculated shear stresses. Because shear stress is being used to determine imported substrate sizes, the conservatively high *n* values are considered to be a base level safety factor for substrate stability.

Table 7: Manning *n* values for proposed conditions SRH-2D model

Substrate	D50 (inches)	Manning n Value
Existing/Native Alluvium	Varies	0.03
Imported Fine Alluvium	3	0.041
Imported Very Coarse Alluvium	12	0.061
Imported Boulder	36-48	0.07

3.3. Existing and Proposed Hydraulic Modeling Output Comparison

Proposed modifications to the channel will alter velocity and shear stresses which directly impact substrate mobility. In order to gain perspective on the degree and the locations of increased shear potential, SRH-2D modeling results were compared between existing and proposed conditions. Flow velocity and bed shear stress calculations were made for flow rates ranging from 890 cfs to 31,000 cfs, representing extreme low flows to the 10-year flood. As tailwater elevations increase for larger flow events, the project reach becomes submerged and shear stresses are reduced throughout the project reach with the upstream feature becoming submerged at approximately 13,000 cfs. Maximum values for velocity and bed shear stress were determined by evaluating all flow rates modeled and combining all calculation results at each node within the model for existing and proposed conditions. The existing and proposed maximum value maps were compared to one another to determine locations of increases and decreases. Results are presented in Figure 9. This evaluation was used to help determine proposed substrate sizes and apply a stability factor of safety of 2.0.

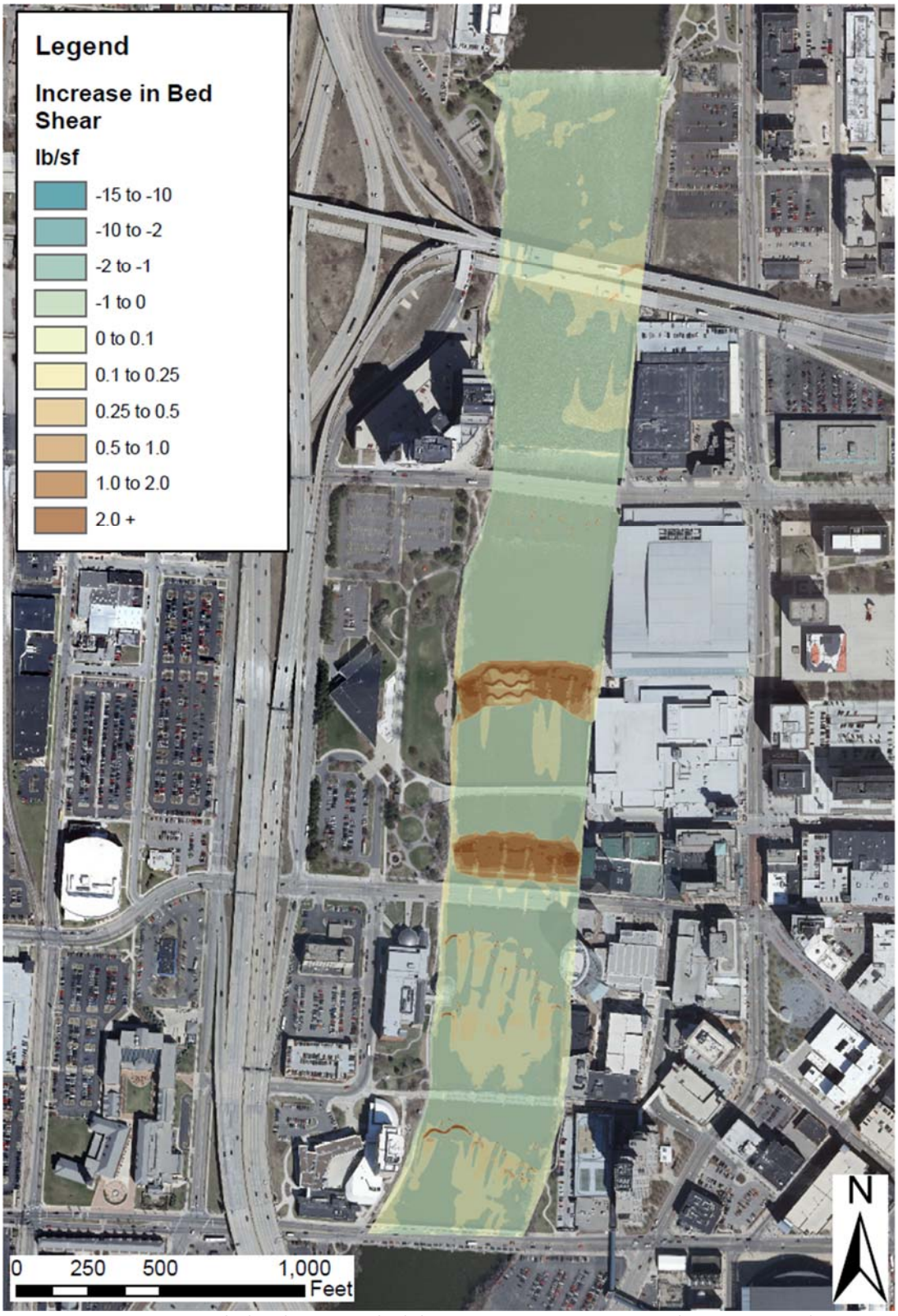

Figure 9: Increases in calculated maximum bed shear stress, comparing proposed to existing conditions

3.4 Substrate Stability Factor of Safety

A factor of safety of 2.0 was applied to the calculated boundary shear stresses to determine proposed substrate size-classes in order to promote substrate stability over the life of the project. Sediment size classes are distributed on a base-2 logarithmic scale; using the identified factor of safety will increase sediment sizes by one discretized classification in Table 4. Identified sizes from the proposed methodology will be set as the d30 of the well-graded imported substrate mixture.

The boulder arch structures will be constructed of placed boulder materials sized to exceed order of magnitude increases in mobilizing forces and account for scour stability and form drag; shear-stress material sizing will be more critical at the general grading of imported alluvium proposed in the construction of the riffles. The control structures and crests of all riffles will be constructed from riprap with d_{50} grain size of 12 inches. Substrate stability is less critical of the proposed grading which are not hydraulic controls and are either upstream or downstream of peak hydraulics; however, a minimum factor of safety of 2.0 has been used to size the proposed fill for these areas as well.

Factor of safety values were calculated over the project reach by dividing the incipient motion critical shear stress of the finished grade particle size by the calculated maximum shear stress predicted by the model over flows ranging from 2,500 cfs to 18,000 cfs, when all features are submerged by the low gradient tailwater.

Figure 10 presents the calculated factor of safety values throughout the project reach. There are limited locations of the channel with calculated factor of safety values slightly below 2.0; this is a result of increased Manning n values over substrate that was sized up to provide a factor of safety of 2.0 based on prior modeling results. The fact that these areas have a calculated factor of safety slightly less than 2.0 is an indication that Manning n values are conservatively high for substrate stability; continuing to increase the substrate size of these areas would also increase the calculated shear stresses, and would result in an over-coarse bed due to conservative assumptions of the Manning roughness parameter. The control structures for all features still contain at least a factor of safety of 2.0 across the entire channel. For these reasons, no stability concerns are anticipated based on substrate sizing, conservative modeling parameter assumptions, and calculated modeling results.

Factor of safety values were also calculated over existing substrate outside the limits of grading. The substrate sampling data collected by Materials Testing Consultants (MTC) in 2017 was used to determine particle sizing of the existing bed. Figure 8 presents a proposed substrate map; all areas without hatching are proposed to remain as native substrate.

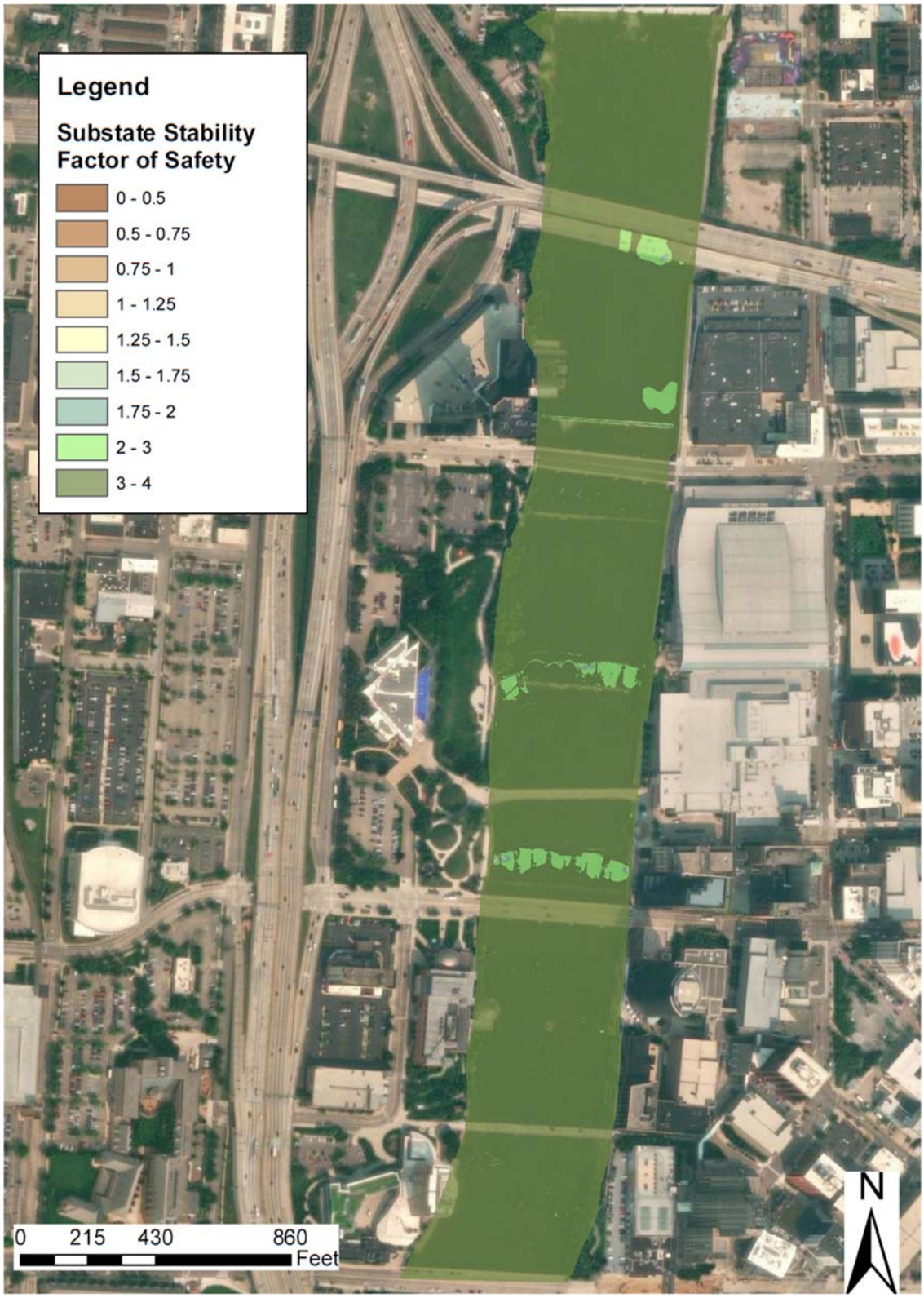

Figure 10: Substrate Stability Factor of Safety Map

3.5 Temporary Construction Conditions

The project is recommended to be constructed primarily in the flowing river without work isolation. Construction access would be provided by a network of low-elevation causeways which would reduce flow depths for construction equipment and provide a stable working pad. These causeways would be constructed of stable imported aggregate that would be removed from the channel after construction. The aggregate material has been sized to remain stable and would not influence flows to create increased scour potential over existing substrates. Therefore, mobilization of substrate is not a concern during these phases of construction, when no work isolation is present in the channel.

The west half of the proposed improvements at the Dam 2 location are proposed to be constructed within a cofferdam system. The cofferdam system, proposed to be constructed of aggregate bags, has been minimized in footprint area and height and would be overtopped at approximately 4,000 cfs. The cofferdam is anticipated to be required for approximately three weeks during July or August and would remain in the channel during any overtopping flows.

During isolation, the area of channel to the east of the cofferdam would experience increased scour potential resulting from the constriction of flow and increased flow velocities around the work isolation area. Maximum bed shear stresses in this location of the channel were calculated during a flow rate of 7,500 cfs, when shear stresses reach approximately 1.1 lb/sf. This condition may have the potential to mobilize up to 2.5-inch diameter substrate (Table 4). Estimated substrate sizes in this area of the channel are 2.7 to 3.4 inches (Table 2), indicating high likelihood that substrate would remain stable during peak scouring conditions if they were to occur. Peak scouring conditions were modeled during 7,500 cfs, which has a very low likelihood of occurrence during the months of July and August, with a daily percent chance of occurrence of 1.7%. Figure 11 displays a factor of safety map against substrate mobility during isolated conditions and peak scouring conditions. Factor of safety of less than 2.0 exist directly downstream of the isolation area in a very localized area.

Results indicate low likelihood for substrate mobility. However, if substrate were to mobilize during construction, modeling results indicate that it would deposit relatively quickly downstream of the isolation area, once the river returns to full flow width and calculated shear stresses are reduced. Any deposited substrates within the project reach would be monitored and could be addressed if needed during construction.

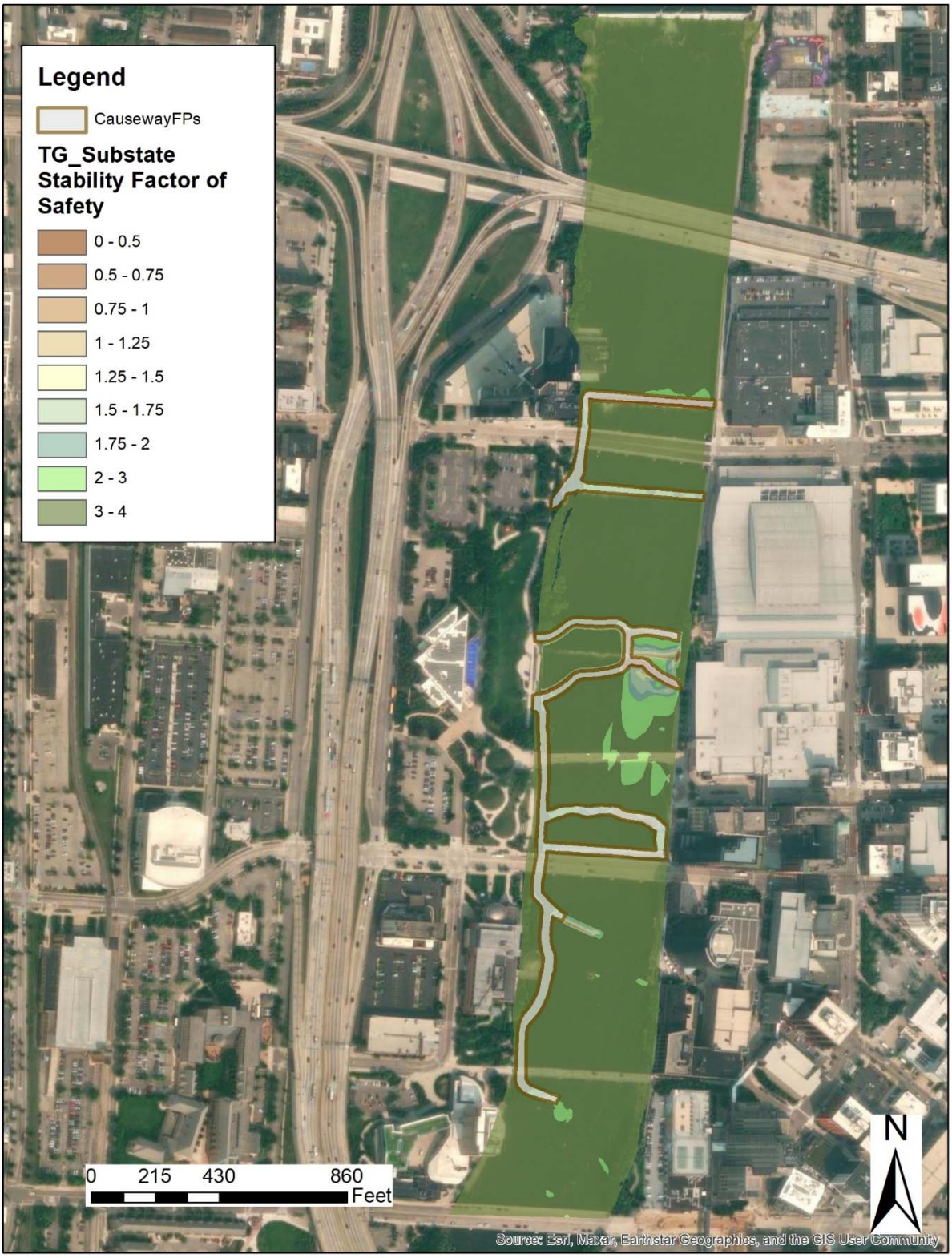

Figure 11: Substrate Stability Factor of Safety Map for temporary conditions

Section 4 – Transient Deposition and Scour

Local deposition and scour are transient functions of a natural channel which establishes a dynamic equilibrium between variable hydrology, the channel substrate, inflowing suspended sediment, and the hydraulics of the river. Transient deposition of sand naturally occurs in rivers with variable hydraulics, which are present in a rapid reach. This is due to the spatial and temporal variability in transport capacity that results from diversifying the bed material and elevation. These processes are not indicative of aggradation or degradation. Aggradation is the trend of continual deposition over time and throughout an entire cross section due to the inability of a reach to transport the inflowing sediment load. Aggradation of the inflowing sand sediment load is not anticipated due to the increased energy gradient of the flowing water throughout the project reach. Degradation results when the sediment transport capacity of the channel continuously mobilizes substrates over time. Avoiding ongoing degradation as a result of the project was done through sizing substrate materials that resist transport and by establishing grade control elevations of the hydraulic features to elevations high enough to minimize and avoid increased shear stresses on the existing channel bed upstream of the project.

A goal of the project is to enhance aquatic habitat. By doing so, flow diversity will also be enhanced, resulting in changes to flow depths, magnitude and direction of flow velocity, and substrate. Local deposition and scour of the bed load are part of maintaining diversity in the gradation of substrate. Local deposition and subsequent scouring are anticipated in certain areas of the proposed grading. The proposed channel is designed to progress from initial post-construction condition to reach a dynamic equilibrium of deposition and scour, promoting optimized natural river function.

The Grand River may be generalized as a sand bed system, transporting a total load of sand during moderate and high flows. Based on sampled bed substrate and bathymetric survey of the channel, sediment transport equations indicate that sand bedload initiates into the project reach from upstream at flow rates above 3,500 cfs. Transient deposition and subsequent remobilization of supplied load occurs in limited locations under existing conditions; the proposed hydraulics will change the locations of transient deposition. Transient deposition areas also exist upstream of 6th Street Dam; sand is deposited during moderate flow rates (3,500 cfs to approximately 10,000 cfs) and mobilized again during high flows (10,000 cfs and above). Under existing conditions, the majority of the sand supplied to the project reach transports beyond the downstream project boundary (Fulton Street). Transient deposition at localized low-velocity areas have been observed and modeled.

The complexity of the proposed design has potential to increase the number of locations of transient deposition. An evaluation of the proposed hydraulics has been completed to further evaluate locations, deposition rates, and frequency of remobilization.

4.1 Modeling Results

Individual potential transient deposition areas were identified based on the proposed hydraulics of the river. Each area was then evaluated by comparing flow velocity, the size of the deposition area, and fall velocities associated with a range sand particle size classes to determine the likelihood of local deposition occurring. The hydraulics associated with a flow rate of 3,500 cfs were used in the analysis; this is because 3,500 cfs is the lowest flow rate at which sand was determined to be supplied from upstream into the project. By using hydraulics associated with the lowest flow rate with an inflowing sand load, minimum depths and velocities were used to determine settling times for conservative estimations. The flow rate at which any sand deposited would be remobilized into the bedload again

was determined based on threshold shear stresses for sand. The results of this analysis are presented Figure 12 and Table 8. In general, identified areas are anticipated to exhibit local deposition of supplied bed load; however, these areas were modeled to remobilize at flow rates at or below approximately 10,000 cfs.

Volumetric sediment discharges in cfs were calculated for flow rates in the Grand River up to 10,000 cfs using bedload equations and the sampled bed gradation upstream of the project. During flow rates at and above 10,000 cfs, velocities become high enough to keep inflowing sand in suspension and to scour temporarily deposited sand. Using inflowing sediment discharge rates, an estimated maximum daily deposition depth was calculated for each deposition site, based on the specific site dimensions. The results of this evaluation are presented in Table 8. The values presented in Table 8 assume fall velocities associated with coarse sand (0.5 mm). Deposition times for each deposition area were calculated based on flow depth and compared to available depositional time as a factor of flow velocity and the length of each deposition area. Fall velocities associated with coarse sand assume 100% of the supplied sand load to a given transient deposition area settles out. Results are considered conservatively high for this reason. Some of the deposition areas would not experience any deposition if fall velocities associated with fine sand (10 mm) are used. Daily deposition depth values should be referenced with the second column in Table 8, which estimates the flow rate that will remobilize the sand bedload.

Transient sand deposition was also evaluated at areas under existing conditions and similar deposition rates were predicted by the modeling results. Based on existing conditions SRH-2D modeling results, medium to coarse sand is predicted to settle on the existing bed in fewer areas than the proposed conditions, but with similar rates and daily depth accumulation.

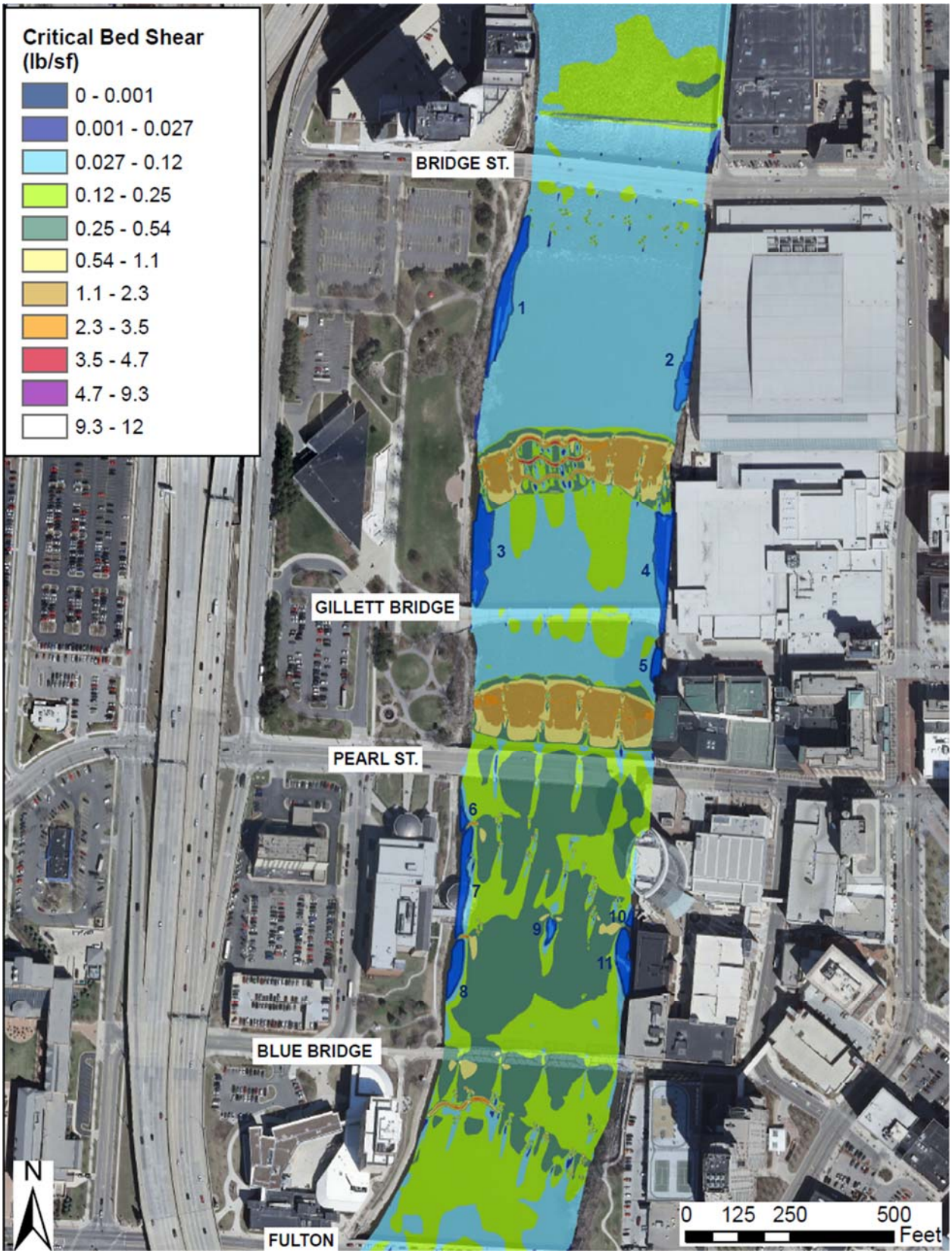

Figure 12: Transient deposition area location key.

Table 8: Transient deposition analysis

Proposed Conditions

Transient Deposition Area	Scouring flow rate (cfs)	Average flow depth at 3,500 cfs (ft)	Settling time for coarse sand (seconds)*	Average flow velocity at 3,500 cfs (ft/s)	Flow length of pool (ft)	Estimated maximum daily deposition depth (inches)
1	7,500	2.8	12.2	0.9	377	0.7
2	7,500	4.4	19.2	1.3	219	1.2
3	10,000	4.1	18.0	0.5	251	1.7
4	7,500	3.3	14.2	1.0	281	1.2
5	10,000	3.3	14.4	0.4	76	4.7
6	7,500	2.0	8.7	0.3	79	3.6
7	7,500	1.8	7.8	0.6	258	1.3
8	7,500	2.1	9.1	0.3	146	2.0
9	7,500	1.5	6.3	1.1	57	5.0
10	7,500	2.2	9.6	0.6	43	5.1
11	10,000	1.8	7.8	0.6	158	2.7

Existing Conditions

Leonard St EG	7,500	4.0	17.4	0.8	600	0.4
DS of Railroad Bridge	7,500	6.0	26.1	0.6	600	0.4
Quarry Hole DS of Dam	4,000	7.0	30.5	0.75	100	1.6
DS of Island Between Pearl and Blue Bridge	7,500	2.1	9.1	0.3	146	2.0
Behind typical bridge pier	5,000	3.0	13.1	1.5	30	5.2
Fulton - US131 west bank	2,500	5	21.8	2	450	0.0

** Assumes no vertical flow velocity*

The transient deposition of bedload would function similarly under proposed conditions as existing conditions; however, due to the increased hydraulic diversity, as well as substrate size necessary to provide a naturally functioning rapid environment, an increase in number of locations of transient deposition is anticipated under proposed conditions. Similar to existing conditions, sand sized deposits would periodically be remobilized and transported beyond the downstream project boundary and assimilated in the river system during regular high flow events. Once the channel is exposed to complete hydrologic cycles post construction, a dynamic equilibrium between hydraulics and the channel substrate is anticipated and deposition areas would gradually transition to coarser substrate near annually higher velocity areas of the channel.

Section 7 – Conclusion

Long-term aggradation or degradation through the project reach is not anticipated to occur due to the transport limited supply reach, the relative increased energy throughout the project, and proposed stable gradation of imported/placed substrate. The project would function as a threshold reach, conveying the inflowing sand sediment loads to the downstream reach over a typical annual hydrograph. No long-term changes to inflowing or outflowing sediment are proposed or anticipated. The risk of long-term degradation will be minimized and avoided by importing material into high energy areas that is large enough to resist mobilization across all flow rates and anticipated hydraulic stress. Two-dimensional hydraulic modeling and industry standard sediment transport equations are among the tools utilized to locate these high energy areas.

Proposed improvements and substrate enhancement have been designed and evaluated to maintain a minimum factor of safety against substrate mobility of 2.0 based on critical shear and incipient motion analyses.

The potential for increased bed mobility during construction has also been evaluated. Although the river would have increased potential to mobilize substrate during construction, substrate sampling data and hydraulic modeling results indicate a low probability of sustained mobilization and a high likelihood that mobilized particles would deposit within the project reach if they do mobilize.

Local deposition and scour may occur periodically, and the project design allows for some localized changes in the bed elevation and composition to develop a dynamic equilibrium. While the urban project reach will never be an entirely natural channel, the developed dynamic equilibrium state allows natural channel functions to occur. Dynamic channel equilibrium would allow for natural channel function while maintaining designed hydraulics. The local deposition of sand from the inflowing bedload has been shown to re-mobilize at flow rates at or below approximately 10,000 cfs which occur each year on average; therefore, impacts to flooding from ongoing local aggradation would be avoided.

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APPENDIX E

Other Supporting Information

Bridge Scour Evaluation; June 2024

Bridge Scour Evaluation
GRAND RIVER REVITALIZATION LOWER REACH PROJECT
GRAND RAPIDS, MICHIGAN

Bridge Scour Evaluation of the Lower Reach Project

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City of Grand Rapids

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June 2024

Grand Rapids WhiteWater

RIVER RESTORATION.ORG

CITY OF GRAND RAPIDS

This document entitled Bridge Scour Evaluation: Grand River Revitalization Lower Reach Project, Grand Rapids, Michigan was prepared by RiverRestoration.org LLC (RiverRestoration) for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.

Approved by
Scott Prins, P.E.

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1. EXECUTIVE SUMMARY

Bridge piers within the Grand River at Grand Rapids, MI have been evaluated under existing, post-project, and temporary construction conditions associated with the Grand River Revitalization Lower Reach Project (Project). These evaluations indicate that the post-project conditions would result in changes to scour potential at the bridges within the project area. Changes to scour potential have been concluded to result in similar scour patterns at bridges as compared to existing conditions, resulting in low risk to pier stability. Modeling results demonstrate an increase in scour potential resulting from higher calculated stream power at I-196. However, calculated increases in stream power remained below critical stream power to induce scour beneath the bridge, as calculated by the MDOT scour evaluation performed in 2016 (MDOT, 2016). Refer to section 4 for a complete discussion.

Temporary conditions models identified increased pier scour potential at Gillett Pedestrian Bridge and Pearl Street Bridge that would occur during construction. Evaluations and conclusions for each bridge are discussed herein.

2. INTRODUCTION

Proposed restoration efforts as part of the Project will reconfigure the existing Grand River in Grand Rapids, Michigan from a grade-controlled backwater system to an enhanced, diverse flowing rapid environment. Four existing grade-control structures (channel spanning, low-head “beautification” dams) are proposed to be replaced with stable river enhancements that provide benefits for recreation, navigation, habitat, and aesthetics. Figure 1 illustrates the bridges spanning the Grand River through downtown Grand Rapids and an aerial overview of the site. The construction area is indicated with the dashed orange line.

The project has implications for hydraulic conditions around the foundations and substructure of bridges crossing the Grand River. Local scour depths at the bridges are a function of these hydraulics. Project impacts on bridge pier and abutment scour are analyzed and discussed in this report. Bridge infrastructure geometries, orientation, and channel bed substrates are detailed for each structure. Hydraulic models have been developed to quantify parameters which affect local bridge scour. Parameters are quantified for existing, proposed, and temporary construction conditions. The full range of flows historically present at the project site are considered.

Hydraulic Engineering Circular No. 18 (HEC-18) provides guidelines for evaluation of scour at river-spanning bridges. All analyses performed herein follow HEC-18 guidelines, which are the current state-of-practice for bridge scour evaluation.

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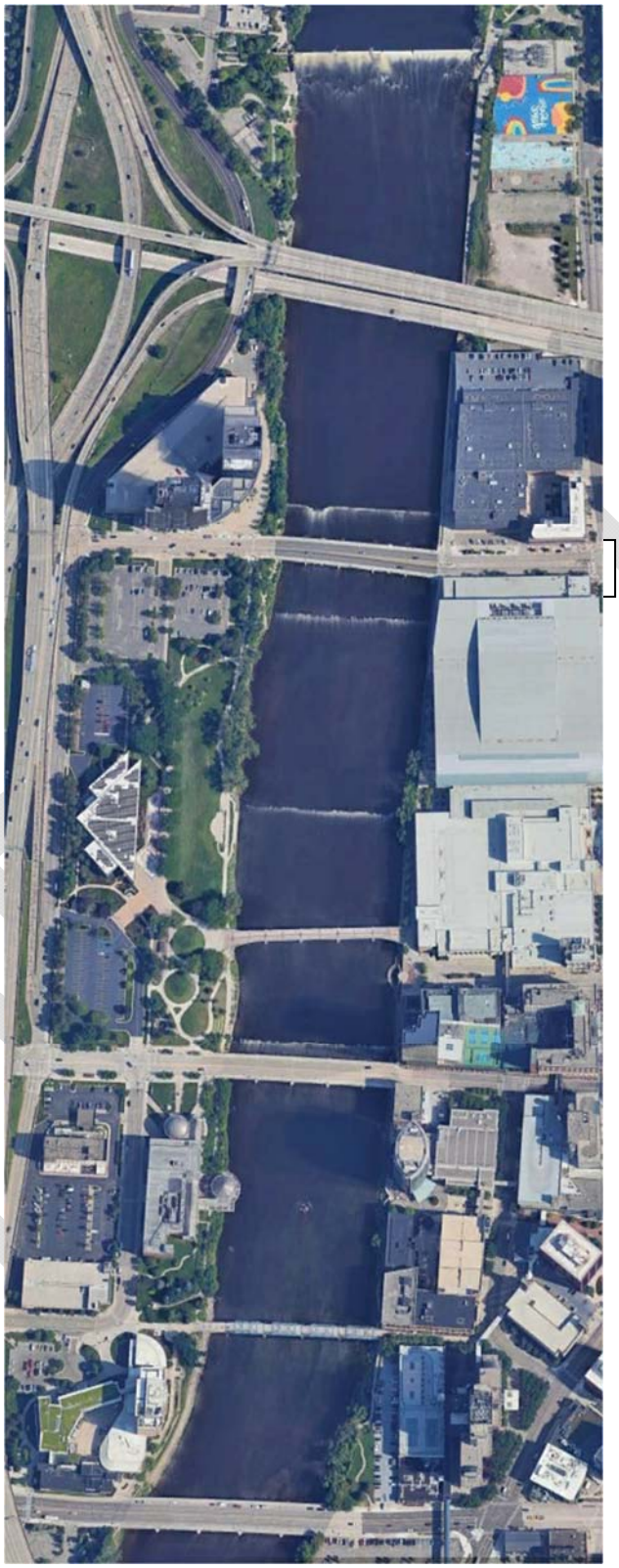

Figure 1. Overview of project area (orange) with identified bridges (Google, 2023)

3. TOTAL BRIDGE SCOUR

Scour at bridges comprises three components: 1) long term degradation of the riverbed, 2) contraction scour at the bridge opening, and 3) local scour at the bridge abutments and piers.

Long Term Degradation

Long-term degradation is caused by reach-scale changes to the river system and can be incited by natural or human-made causes. Degradation scour does not typically initiate from a bridge crossing itself, but bridges may be affected by it. An example would be a downstream head-cut migrating upstream which undermines a foundation. Other instances may include substantial changes to the system hydrology or sediment discharge. The Grand River throughout the project exhibits characteristics of vertical stability. The existing system is a threshold channel which does not exhibit hydraulics capable of bedload transport. The river above and below Grand Rapids is a very mildly sloped channel, while the channel within the project area is relatively steeper. Increasing discharges create tailwater conditions which submerge project area elevations at high flow rates. This submergence acts to reduce velocities and boundary shear stresses and serves as a degree of protection against bed mobilization.

Contraction scour

Contraction scour occurs where bridge geometries or abutments encroach upon the river channel, creating a localized narrowing of the channel cross-section and acceleration of flow. Accelerated flow increases sediment transport and scour potential. The Grand River throughout the project area has primarily been confined between concrete floodwalls and levees. Bridges span the entire river from floodwall to floodwall. Thus, there are no approaches which encroach the floodplain and there are no instances where the river flow is constricted through a bridge opening from a wider floodplain. Contraction scour is not present under current conditions within the project area and is not affected by project actions.

Local Scour

Local scour occurs around bridge foundations, specifically abutments and piers. The primary mechanism for this type of scour is from localized flow acceleration around bridge structures and the resulting formation of turbulent currents at the base of abutments and piers. Abutments within the project area are generally contained within flood walls and do not interact with the flow. Designed river-habitat improvements incorporate grading which produces hydraulic conditions that avoid concentrated hydraulics in the vicinity of bridge infrastructure. However, project actions may alter hydraulic characteristics which drive local pier scour at specific flow rates.

Of the three main scour components, long-term degradation, contraction scour, and local scour, potential for long-term degradation was identified at I-196 and the local scour generated by the bridge piers was identified as a potential area of concern within the project area and have been evaluated and are discussed herein.

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4. LONG-TERM DEGRADATION POTENTIAL AT I-196

Within the project area, four low-head concrete grade-control structures between Fulton Street and I-196 (low-head dams) act to locally dissipate energy and maintain mild hydraulic gradients between. The complete grade-control function of low-head dams 1, 2, and 3 would be replaced with constructed riffles and boulder arches, designed to remain stable and distribute the energy dissipation along the channel profile.

However, the grade control function of low-head Dam 4 is proposed to be removed without equivalent replacement. Only ~25% of the grade control function of Dam 4 is proposed to be replaced by the project. This is due to the project constraint of avoiding and minimizing increases in modeled tailwater elevations at 6th Street Dam (referred to as 4th Street Dam in some documents) as a means to avoid impacts to the effectiveness of the dam as a barrier to sea lamprey. Modeled conditions were based on conservatively high Mannings 'n' values for the purpose of being conservative in water surface elevation predictions. However, conservatively low Mannings 'n' value models predict post project conditions will establish higher velocities and increased scour potential of the existing bed upstream of the project, between 6th Street Dam and Bridge Street. These models reveal the potential for hydraulic jumps to form under I-196. This hydraulic change has been evaluated and compared against substrate sampling data (MTC, 2017) and existing core sampling and scour evaluations (MDOT, 2016). Increases in calculated stream power indicate that there may be increased potential for long-term degradation of the riverbed near I-196 under post-project conditions.

Rapidly varied flow of a hydraulic jump can be highly erosive. The erosive potential of a hydraulic jump is based on the theory of Stream Power, wherein the entire energy dissipation of the hydraulic jump is assumed to be conservatively applied to the channel bed in equation 4.7 (HEC-18):

Equation 4.7:

$$P = \gamma q S_f = \gamma q(\Delta E)$$

where: P = Instantaneous stream power, (W/m2) ; γ = Unit weight of water, (9,800 N/m3) ; q = Unit discharge, (m3 /s per meter width) ; S_f = Slope of the energy grade line, ft/ft (m/m) ; ΔE = Energy loss per unit distance in direction of flow, ft/ft (m/m)

As part of their scour evaluation for the recent I-196 pier extension project, AECOM calculated the critical stream power necessary to initiate scour though erodible bedrock, which is a function of bedrock properties, at each bridge pier. These critical stream power calculations were referenced to compare calculated peak stream power against to evaluate potential of erodibility through long-term degradation. The lowest critical stream power calculated from MDOT findings for the 2016 scour report was 8,739 W/m^2; erodibility and factors of safety are all evaluated herein against this value as a conservative assumption.
The reason Equation 4.7 was evaluated is that energy loss can be concentrated at a single point in a hydraulic jump. Because the proposed changes of the project lower the grade control elevation downstream of I-196, conservative assumptions were modeled to evaluate maximum energy losses under the bridge. This was done by first running an SRH-2D model with Manning n values for the entire proposed grade mesh down to 0.02 (lower than calibrated values) as a way to evaluate minimum potential tailwater elevations

downstream of the bridge, and therefore maximum potential energy losses in the reach, which is concentrated under the I-196 bridge. This model calculated super-critical flows in various spots beneath the bridge at several flow rates, which were not calculated in the model with higher Manning n assumptions.

To assess the potential increased scour potential resulting from hydraulic jumps which may occur beneath the bridge, conservative assumptions were also placed on the ΔE term of the equation. To evaluate the potential for a hydraulic jump occurring, the entire headloss from upstream to downstream of super-critical flows to was assumed to be spent over 1 meter of channel bed for all flow rates that calculated super-critical flow conditions (using the 0.02 Manning model). This is the reason calculated stream power in Table 1 are higher for flow rates up to 10,000 cfs, all of which calculated areas of super critical flow under the low Manning assumption model. Some energy of a hydraulic jump may be expended in turbulence rather than applied to the substrate, for this reason as well as the conservative assumptions, the results in Table 1 are considered conservatively high.

The calculated stream power and resulting factors of safety against scour are compared for Equation 4.7 in Table 1. Conservative modeling and calculation assumptions show that the project changes have potential to increase scouring conditions beneath I-196; however, calculated stream power remain below critical stream power calculated by MDOT by a minimum factor of safety of 2.0.

Table 1: Estimation of Scour due to Hydraulic Jump, using Equation 4.7 of HEC-18 Manual

Flow Rate (cfs)	Existing Conditions		Proposed Conditions	
	Stream Power (W/m2)	Factor of Safety Against Scour(1)	Stream Power (W/m2)	Factor of Safety Against Scour*
3,900	109	80	2,244 (2)	4
5,000	184	48	2,877 (2)	3
7,500	446	20	3,836 (2)	2
10,000	734	12	4,475 (2)	2
13,000	1,182	7	1,932	5
18,000	1,542	6	1,542	6
26,000	1,727	5	1,727	5
31,000	2,005	4	2,005	4

(1) Minimum critical stream power calculated from MDOT 2016 scour report (8739 W/m^2) divided by calculated stream power.

(2) Modeled areas of super-critical flow.

5. POTENTIAL FOR LOCAL PIER SCOUR

Mean-flow velocities, turbulent velocities, boundary shear stresses, and stream power at bridge piers are influencing factors for local scour. The extent of scour is dependent upon pier shape, flow characteristics, and local bed substrate. Figure 2 illustrates a profile schematic of pier scour hydraulic parameters, flow distributions, and typical scour geometry.

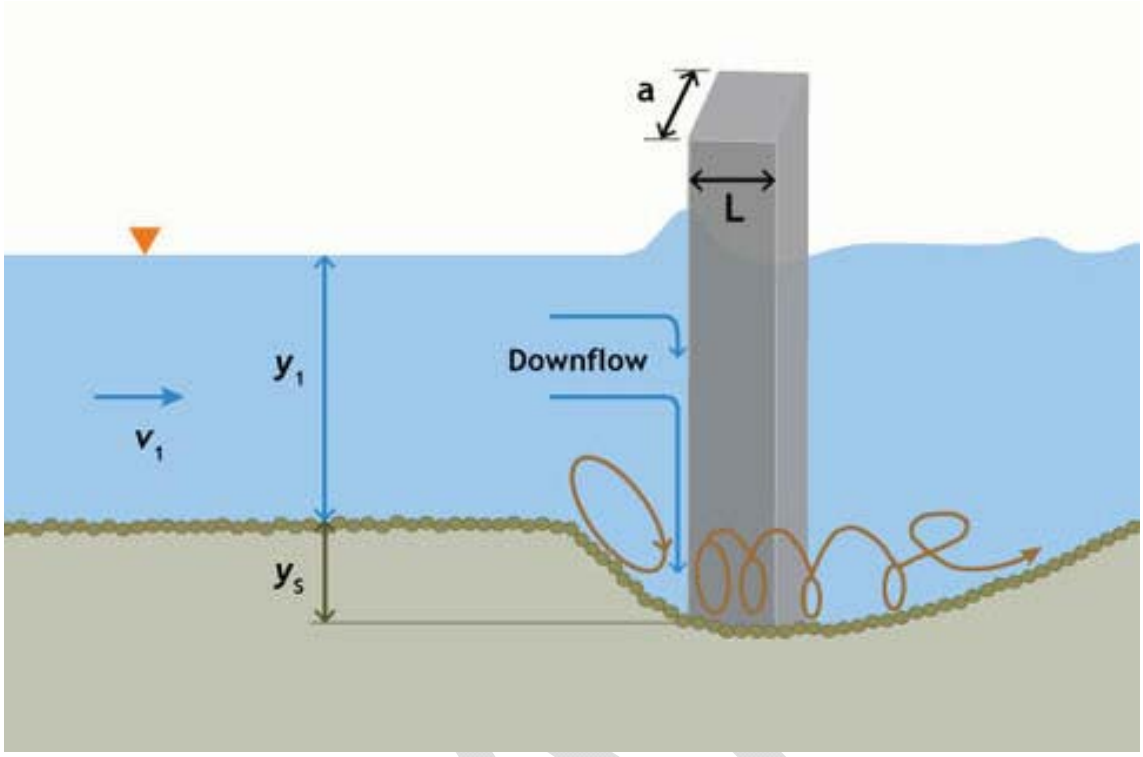

Figure 2. Definition sketch for pier scour (FHWA, 2012)

Richardson and Davis (2001) developed a relationship to estimate bridge-pier scour using sand-bed laboratory flume data presented as Equation 1.

$$\frac{y_s}{y_1} = 2K_1K_2K_3K_4 \cdot \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43} \qquad (1)$$

where:
y_s = estimated scour depth [L];
y_1 = approach flow depth [L];
a = pier width [L];
Fr_1 = approach Froude number;
K_1 = correction for pier shape;
K_2 = correction for flow angle of attack;
K_3 = correction for bed condition

The parameters of Equation 1 affected by proposed project actions include scour depth (y_1) and approach Froude number (Fr_1). Remaining parameters, which include the pier shape (K_1), pier width (a), flow angle of attack (K_2), and bed condition (K_3) are based on existing pier geometries and localized substrates which are not significantly influenced by proposed alterations at flows resulting in the greatest scour potential. Parameters of Equation 1 were identified for each of the bridges by a prior consultant as part of the Grand Rapids Flood Protection System Project.

Equation 1 estimates scour in sand bed systems with D_{50} particle sizes less than 2 mm and D_{95} less than 20 mm. Substrate sampling within the project area and visual observation indicates that the reach would be considered a coarse-bed system (MTC, 2017). For coarse-bed systems, Equation 1 is multiplied by a correction factor, (K_4) for bed armoring. K_4 values range from 0.4 when the velocity upstream of the pier is less than what is required to mobilize the particle size at the pier to 1.0 for sand-bed systems with no bed armoring. The substrate in the reach has been sampled and surveyed within the main channel near proposed grading; however, less detailed information has been able to be collected in the immediate vicinity of each bridge pier. Because the evaluation presented here is a relative comparison and calculated scour depths are only being evaluated relative to existing conditions, a representative value of $K_4 = 0.7$ has been assumed for all scour depths calculations for existing, proposed, and construction conditions to evaluate areas of increased scour potential resulting from proposed actions. Absolute values for calculated scour depths are not considered accurate and all conclusions are based on relative changes in scour potential compared to existing conditions. Table 1 summarizes scour parameters of Equation 1, and general substrate characteristics, d_s, in the bridge vicinity.

The project would not have an impact on hydraulics upstream of 6th Street Dam or downstream of Fulton Street Bridge; therefore, only bridges between Fulton Street and I-196 were evaluated.

Table 2. Bridge-scour parameters

Location	Pier Width, a (ft)*	K_1	K_2	K_3	K_4	d_s
I-196 WB	14.0	1.0	1.0	1.1	0.7	bedrock
I-196 EB	7.4	1.0	1.0	1.1	0.7	bedrock
Bridge St	9.5	1.0	1.0	1.1	0.7	cobble
Gillett Bridge	7.0	1.0	1.0	1.1	0.7	fine cobble
Pearl St	8.0	1.1	1.1	1.1	0.7	coarse cobble
Blue Bridge	8.0	1.1	1.0	1.1	0.7	coarse cobble
Fulton St	9.0	1.1	1.9	1.1	0.7	coarse cobble

* Maximum pier width

Existing, post-project, and temporary construction conditions were first evaluated using one-dimensional hydraulic modeling (HEC-RAS), which complies with current engineering standards and provides data most readily used in the HEC-18 methods. Bridge-pier scour risk typically increases with rising flow rates and associated velocities and flow depths. Flood flows ranging from the 2-year flood (18,000 cfs) up to the 500-year flood (65,000 cfs) were modeled for the existing, post-project, and temporary construction conditions using HEC-RAS. The modeled flow rates and respective return intervals are presented in Table 3.

The most recent large flow event that all bridges have been subjected to in their presently reported configuration is 35,100 ft^3/s. This flood flow occurred on 4/21/2013 and corresponds to a return rate of approximately 23 years.

Table 3: HEC-RAS Modeled Flow Rates

Flow Rate (cfs)	Return Interval
18,000	2-yr
26,000	5-yr
31,000	10-yr
38,000	25-yr
44,000	50-y
50,000	100-yr
65,000	500-yr

5.1 POST-PROJECT CONDITIONS SCOUR

The first evaluation performed was to evaluate flood flows using the HEC-18 procedure (Equation 1) to compare calculated scour depths. Existing and post-project conditions were hydraulically modeled using the Effective HEC-RAS, as provided by Fishbeck with the approved CLOMR models included on August 4, 2023 and detailed in the Hydraulics Report (RiverRestoration, 2024). The methodology for bridge pier scour analysis used extracted hydraulic data from the upstream bridge cross section to perform scour calculations using Equation 1. Table 4 presents calculated scour depths under post-project conditions along with relative percent increases compared to existing conditions in parenthesis. The calculated depths are considered approximate, and this evaluation is only meant to be a relative comparison to existing conditions.

Results of one-dimensional existing and proposed flood conditions modeling indicate that relative differences between maximum calculated scour depths are on the order of modeling accuracy. Peak scour depths were calculated at the 500-yr flood across all locations and maximum increases in calculated scour depths during any flow rate were less than 0.5%, indicating minimal effects to large flow events, which are typically the largest scour-producing flows.

Table 4: Calculated post-project conditions scour depths and percent increase compared to existing conditions.

	Calculated Scour Depth in Feet (Percent Increase)						
Bridge	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**500-yr**
I-196 WB	12.3 (-0.1%)	12.8 (0.1%)	12.9 (0.2%)	13.2 (0.4%)	13.3 (0.3%)	13.2 (0.3%)	13.5 (0.4%)
I-196 EB	7.2 (-0.1%)	7.7 (0.1%)	7.9 (0.2%)	8.1 (0.2%)	8.3 (0.3%)	8.3 (0.3%)	8.6 (0.4%)
Bridge Street	8.3 (-0.7%)	9 (-0.4%)	9.4 (-0.2%)	9.7 (0%)	10 (0%)	10.1 (0.1%)	10.6 (0.1%)
Gillett Bridge	6.3 (-0.2%)	6.9 (0%)	7.1 (-0.1%)	7.5 (-0.1%)	7.6 (-0.2%)	7.7 (0%)	8.1 (0%)
Pearl Street	8.3 (-0.2%)	9.1 (-0.1%)	9.5 (0.1%)	9.9 (-0.2%)	10.2 (0%)	10.4 (0.1%)	11 (0%)
Blue Bridge	7.5 (0%)	8.2 (-0.2%)	8.6 (-0.2%)	9 (0%)	9.3 (0%)	9.5 (0%)	10.1 (0%)
Fulton Street	14.5 (0%)	16 (0%)	16.8 (0%)	17.6 (0%)	18.2 (0%)	18.8 (0%)	20 (0%)

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5.1.1 PIER SCOUR IN ERODIBLE ROCK (I-196 CROSSING)

The I-196 bridge crossing is within the area of channel, upstream of the proposed changes, that may experience increased scour potential from the hydraulic changes under post-project conditions. It also sits on exposed, or very shallow bedrock. For these reasons, the procedure outlined in Section 7.13 of the HEC-18 manual "Pier Scour in Erodible Rock" was referenced to evaluate changes to scour potential at this bridge. This is similar to the procedure performed by AECOM (for MDOT) to evaluate bridge scour prior to the recent I-196 bridge pier extension project completed in 2020 (MDOT, 2016).

This process evaluates the potential for bedrock to erode by comparing the stream power of the approach flow to the critical stream power necessary to initiate scour, which is a function of bedrock properties. Peak stream power is a function of discharge and energy loss at the location of scour. Stream power for this evaluation was calculated using Equation 7.39 from the HEC-18 manual:

Equation 7.39:

$$P_a = 7.853\ \rho\ (\tau\ /\rho\ )^{3/2}$$

where: P_a = Stream power of approach flow, W/m2 ; ρ = Mass density of water, 1000 kg/m3 ; τ = Bed shear stress of approach flow, N/m2 or Pa

Critical stream power at each bridge pier was calculated by AECOM, based on core samples near each pier, for the scour evaluation performed by MDOT in 2016. These values were used to compare calculated peak stream power against to evaluate potential of erodibility. The lowest critical stream power calculated by MDOT on the existing riverbed was 8,739 W/m^2; erodibility and factors of safety are evaluated herein against this value as a conservative assumption.

Critical stream power at all other bridge piers was more than twice as much as this minimum value (MDOT, 2016). The MDOT analysis used Equation 7.39 to calculate the stream power of the approach flow during the 100-yr flood and compared it against the critical stream power to make a determination on the erodibility and scour potential at the bridge piers.

Modeling results for the Project indicate that the proposed changes of the project would increase scour potential at I-196 for flow rates up to approximately 13,000 cfs and generally matching existing conditions flow rates above 13,000 cfs. For this reason, the scour evaluation performed for I-196 considered flows as low as the annual average flow of 3,900 cfs. Two-dimensional hydraulic modeling results were referenced to determine what flow rate produced peak stream power at the location of the I-196 bridge crossing under existing and post-project conditions.

Equation 7.39 increases with increasing calculated bed shear stresses; therefore, the maximum calculated bed shear stress from the SRH-2D models were entered into the equation for each flow rate evaluated. The resulting calculated stream power for each flow rate is presented in Table 5. For existing conditions, flow rates above 13,000 cfs backwater the I-196 location and reduce calculated bed shear stresses, resulting in peak stream power occurring at 13,000 cfs. Under post-project conditions, modeling results indicate that

peak bed shear stress (and therefore, calculated stream power) would occur at approximately 7,500 cfs and increases in stream power compared to existing conditions were calculated for flow rates up to 13,000 cfs. However, maximum calculated stream power remained well below the minimum calculated critical stream power determined by MDOT, resulting in minimum factors of safety against bedrock scour of 64 and confirming the conclusions of the MDOT scour evaluation (MDOT, 2016).

Table 5: Stream Power Evaluation, using Equation 7.39 of HEC-18 Manual

Flow Rate (cfs)	Existing Conditions		Proposed Conditions	
	Stream Power (W/m2)	Factor of Safety Against Scour(1)	Stream Power (W/m2)	Factor of Safety Against Scour*
3,900	20.8	420	122 (2)	72
5,000	26.5	330	126 (2)	69
7,500	39.2	223	136 (2)	64
10,000	50.3	174	123 (2)	71
13,000	55.6	157	70.2	124
18,000	35.4	247	35.4	247
26,000	30.9	283	30.9	283
31,000	37.3	234	30.0	292

(1) Minimum critical stream power calculated by MDOT (8660.1 W/m^2) divided by calculated stream power.

(2) Modeled areas of super-critical flow.

5.2 TEMPORARY CONSTRUCTION CONDITIONS SCOUR

The Recommended Construction Sequencing Report provides details for construction strategies and sequencing (RiverRestoration, 2024) and recommended construction access and care of water plan is included in the "T Sheets" of the design drawings. All in-river construction work is expected to be performed during flow rates of less than approximately 3,900 cfs; construction activities would stop, and all personnel and equipment removed from the river during flow rates greater than approximately 4,000 cfs. Limiting construction to lower flows allows construction activities to occur in the wet, reducing the need for expansive work isolation areas, but also allowing flow conditions to influence construction schedule to a larger degree.

Causeways of imported clean coarse aggregate would be installed along the west bank to access the Dam 1, 3, and 4 construction areas, as well as areas downstream of Pearl Street. The Dam 2 construction area would be accessed directly from the staging area in Ah-Nab-Awen Park and would be isolated by a cofferdam on the west side of the river.

Temporary construction conditions will have two general configurations; the first being with the work at the west side of Dam 2 isolated with a cofferdam and the second being after the cofferdam has been

removed. Both conditions have been evaluated for potential impacts to bridge scour using the same process used to evaluate post-project conditions.

Similar to the evaluation of post-project conditions, results of one-dimensional modeling indicate that relative differences between maximum scour potential are on the order of modeling accuracy. Peak scour depths were calculated at the 500-yr flood across all locations and maximum scour differences during any flow rate were less than 0.5% for temporary construction conditions, indicating minimal effects to large flow events, which are typically the largest scour-producing flows. The first condition, with Dam 2 isolation in place is compared in Table 6 and second temporary condition, after isolation has been removed, is compared in Table 7.

Table 6: Calculated temporary construction conditions scour depths with Dam 2 isolation in place and percent increase compared to existing conditions

	Calculated Scour Depth in Feet (Percent Increase)						
Bridge	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**500-yr**
I-196 WB	12.3 (-1.5%)	12.8 (-1%)	12.9 (-0.8%)	13.2 (-0.5%)	13.3 (-0.4%)	13.2 (-0.2%)	13.5 (-0.2%)
I-196 EB	7.1 (-1.2%)	7.6 (-0.9%)	7.8 (-0.6%)	8.1 (-0.5%)	8.2 (-0.4%)	8.2 (-0.4%)	8.6 (0%)
Bridge Street	8.3 (-1.1%)	9 (-0.8%)	9.3 (-0.6%)	9.7 (-0.4%)	9.9 (-0.4%)	10.1 (-0.2%)	10.5 (-0.2%)
Gillett Bridge	6.3 (0.6%)	6.9 (0.4%)	7.2 (0.4%)	7.5 (0.2%)	7.7 (0.2%)	7.8 (0.2%)	8.1 (0.1%)
Pearl Street	8.4 (0.8%)	9.2 (0.7%)	9.6 (0.7%)	10 (0.5%)	10.3 (0.5%)	10.4 (0.6%)	11 (0.4%)
Blue Bridge	7.5 (1.1%)	8.3 (0.7%)	8.6 (0.7%)	9.1 (0.7%)	9.3 (0.7%)	9.6 (0.5%)	10.2 (0.5%)
Fulton Street	14.5 (0%)	16 (0%)	16.8 (0%)	17.6 (0%)	18.2 (0%)	18.8 (0%)	20 (0%)

Table 7: Calculated temporary construction conditions scour depths after Dam 2 cofferdams have been removed and percent increase compared to existing conditions

	Calculated Scour Depth in Feet (Percent Increase)						
Bridge	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**500-yr**
I-196 WB	12.3 (-1.3%)	12.8 (-0.9%)	12.9 (-0.6%)	13.2 (-0.3%)	13.3 (-0.4%)	13.2 (-0.1%)	13.5 (-0.1%)
I-196 EB	7.2 (-1%)	7.6 (-0.7%)	7.8 (-0.4%)	8.1 (-0.4%)	8.2 (-0.3%)	8.3 (-0.1%)	8.6 (0.2%)
Bridge Street	8.3 (-1%)	9 (-0.7%)	9.3 (-0.5%)	9.7 (-0.3%)	10 (-0.2%)	10.1 (-0.1%)	10.5 (-0.1%)
Gillett Bridge	6.3 (0.4%)	6.9 (0.3%)	7.2 (0.3%)	7.5 (0.2%)	7.7 (0.2%)	7.8 (0.2%)	8.1 (0.4%)
Pearl Street	8.4 (0.7%)	9.2 (0.6%)	9.6 (0.8%)	10 (0.6%)	10.3 (0.6%)	10.4 (0.4%)	11 (0.5%)
Blue Bridge	7.5 (1.1%)	8.3 (0.8%)	8.6 (0.8%)	9.1 (0.7%)	9.3 (0.5%)	9.6 (0.5%)	10.2 (0.5%)
Fulton Street	14.5 (0%)	16 (0%)	16.8 (0%)	17.6 (0%)	18.2 (0%)	18.8 (0%)	20 (0%)

5.2.1 EFFECTS OF TWO-DIMENSIONAL HYDRAULICS DURING TEMPORARY ISOLATED CONDITIONS

During the isolation of the west side of the channel at the Dam 2 location, the hydraulics of the river will be influenced by the presence of the cofferdam. For this reason, SRH-2D modeling results have been evaluated at a range of lower flow rates to determine level of risk of increased scour potential during construction, specifically Gillett Bridge, immediately downstream of the isolation area.

To maximize the efficiency of work within the isolation system, which would be overtopped during flow rates greater than approximately 4,000 cfs, the isolated work would be done during July and August, when minimum annual flow rates have historically been recorded in the project area. Performing isolated work during this low flow period would also minimize potential for increased scour potential at the bridge piers of Gillett pedestrian bridge, directly downstream of the isolated work area.

Through construction sequencing and planning, the project has minimized the potential for increased scour potential at bridges within the project area. However, based on historic gaged flow data, there will still be a small probability, based on historic gage data, that some of the bridge piers of Gillett Bridge may experience increased scour potential, resulting in calculated scour depths similar to those calculated for the 100-yr flood under existing conditions. Although this probability is very low, and has been minimized through construction sequencing, the City and the design engineer have agreed that temporary scour protection should be installed at the three eastern bridge piers prior to work isolation.

6. DISCUSSION AND RECOMMENDATIONS

The following discussion and recommendations assume that all bridge piers within the project area are currently maintained with adequate scour protection to withstand the 100-yr flood event. It is recommended that all bridge piers be inspected by the owner and contractor to verify the assumption that they have been maintained to withstand hydraulics associated with the 100-yr flood event.

The bridge scour evaluation presented here concludes that, based on the comparison of existing condition hydraulics to proposed condition hydraulics within the project reach (Fulton Street to Bridge Street), permanent scour protection is not required as a result of the project. Relative differences between maximum scour potential are on the order of modeling accuracy.

Because the project lowers the grade control downstream of I-196, more scour potential is expected at the I-196 Bridge piers at flow rates up to 13,000 cfs. Conservative modeling assumptions indicate potential for super-critical flows and hydraulic jumps to occur in areas beneath the bridge. Conservative stream power calculation assumptions show that maximum calculated stream power remains below critical stream power determined by MDOT (MDOT, 2016) with minimum factors of safety of 2.0. The evaluation at I-196 concludes that, based on the findings and conclusions of the MDOT scour evaluation in 2016, potential increases in stream power beneath I-196 may result from the project; however calculated increases remain below critical stream power to induce scour beneath the bridge. MDOT has reviewed this report, and the project team has discussed the I-196 scour evaluations with them. Through this coordination, MDOT confirmed they have no further questions or concerns with the scour analysis methodology at I-196 (MDOT, personal communication, June 3, 2024). The City will continue to work with MDOT to address any future concerns on the hydraulics.

HEC-RAS 1-D evaluations of temporary construction conditions show that any increases in calculated pier scour depths remain within the modeling accuracy and would maintain a Factor of Safety against scour.

However, SRH-2D evaluations during work isolation highlight potential risk of increased scour potential at Gillett Bridge. Work isolation at the Dam 2 location has been sequenced to occur during the historically low flow period of July/August, when there are minimal probabilities of flows exceeding maximum scour-inducing flows. Although low, there will remain a risk that these flows occur while the isolation system is in place. Therefore, temporary scour protection has been recommended for the eastern three bridge piers of Gillett Bridge. The temporary scour protection included in the recommended care of water plan is for either 9" D_{50} riprap or grout-filled bags per HEC-23 standards. The total footprint of temporary scour protection would be 2x pier width (14.4 ft) around each pier, per design guidelines. Scour protection would be removed prior to completion of the project. Access to install and remove the temporary scour protection would be provided from the causeway along the west bank of the river, either by tracking directly on the riverbed or a low causeway, if necessary to reduce flow depths. Refer to the T Sheets of TOC No. 3 Design Drawings for more details on these recommendations.

7. SUMMARY

Analysis of the hydraulic influence on bridge scour was performed for existing and proposed conditions of the Grand River at Grand Rapids, MI. Hydraulic modeling and data analysis using the standard engineering guidelines of HEC-18 indicate that proposed project actions will minimally affect the largest scour producing flows (100-yr and 500-yr return flood, differences ~ 0.5% or less).

Increased scour potential is anticipated during lower flow rates (up to 13,000 cfs) at I-196; however, is not expected to erode the primarily bedrock streambed.

Two-dimensional modeling of temporary conditions highlighted the (low probability) of bridge scour concerns at Gillett Bridge during work isolation at the Dam 2 location. Temporary scour protection has been recommended.

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APPENDIX E

Other Supporting Information

OMRRR Report
May 2024

Operations, Maintenance, Repair, Rehabilitation, and Replacement
GRAND RIVER REVITALIZATION PROJECT
GRAND RAPIDS, MICHIGAN

Operations, Maintenance, Repair, Rehabilitation, and Replacement

Prepared for:
City of Grand Rapids

Prepared by:
RiverRestoration
P.O. Box 248
Carbondale, CO 81623

May 2024

This document entitled Operation, Maintenance, Repair, Rehabilitation, and Replacement report: Grand River Revitalization Project, Grand Rapids, Michigan was prepared by RiverRestoration.org, LLC for the account of City of Grand Rapids (Client). The material in it reflects the professional judgement of RiverRestoration in light of the scope, schedule, and other limitations stated in the document and in contract between RiverRestoration and Client.

Approved by
Scott Prins, P.E.

1.0 Introduction

River projects may be subjected to fluvial, sediment transport, ice and other environmental forces that may impact the function of a built project and require action. However, the dynamic nature of a river may also be allowed for in design and some changes to the built project under the environmental forces may not require action. Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) efforts are forecasted to restore a project to as-built conditions when action is deemed necessary.

For the Grand Rapids Revitalization Project, the proposed grading is anticipated to adjust to post-construction hydraulics and some localized scour and deposition may result, along with slight shifts in boulder and riprap. Changes that may require action include those that threaten public safety or infrastructure. Public safety may include flood threats, bank access, or adverse hydraulics for water-based recreation. Excessive scour may threaten bridges, floodwalls, utilities or the banks of river front properties.

The design of River Restoration projects seeks to emphasize minimal long-term OMRR&R. Development of OMRR&R cost estimates account for expected upkeep of project features for as long as the project exists. For this project, a 50-year lifetime was assumed. The objective of OMRR&R procedures is to maintain structures or project features to "as-built" conditions, or conditions that provide for acceptable project performance consistent with project objectives.

- **Operation** includes regular monitoring, inspections, data collection and reporting. These procedures should be conducted regularly to evaluate design goals and constraints throughout the life of the project. A maximum interval of 5 years is recommended for operational procedures. Operational procedures are recommended to be performed during and after larger floods, significant droughts, ice jams, and other processes outside of average annual hydrologic events.
- **Maintenance** is for routine, planned and scheduled upkeep of project features, equipment, or supplies necessary to maintain proper functionality of project elements. Maintenance is not anticipated to be required for the design elements of the Project.
- **Repair** is for unscheduled correction resulting from unforeseen circumstances that are outside of the design assumptions for the project. These include but are not limited to environmental events and vandalism.
- **Rehabilitation** is to correct un-anticipated hydraulics, shifting, wear and tear, weathering, or materials degradation to improve project performance. Rehabilitation includes resetting features, augmenting features with additional materials, or refurbishing of features or components.
- **Replacement** includes the removal, demolition and disposal, and replacement of project features or components that cannot be repaired or rehabilitated.

In-stream OMRR&R may require design permitting, temporary access to the channel, and temporary care of water.

Table 1 OMRR&R Schedule for elements of the Grand River Revitalization Project

ELEMENT	Operation	Maintenance	Repair	Rehabilitate	Replace
	Years	Years	Years	Years	Years
Boulder Arch Structures	5	N	15	50	N
Riprap Substructures	5	N	15	50	N
Constructed Riffles with Emergent Boulders	5	N	15	50	N
Bank Vane Structures	5	N	15	50	N
Scattered Habitat Boulders	5	N	15	50	N

2.0 Grade Control Structures

Boulder and riprap structures have been designed to provide grade control throughout the project reach. These structures are expected to adjust and settle in the fluvial environment and minor fluvial adjustment is considered beneficial to the success of the project; however, major shifts in structures that cause adverse effects such as loss of hydraulic control, erosion, bridge scour or adverse hydraulics may periodically need to be addressed. Grade control structures are expected to have OMRR&R costs associated with potential repair and rehabilitation, which may include resetting boulders with large machinery accessing the damage site by tracking on the riverbed or augmenting structures with additional imported material delivered by tracked equipment or barges when hydraulic conditions allow barge access. Costs may be concentrated in a single year, especially if a major flow or ice event impacts multiple structures. The structures are designed to be functional in a fail-safe mode until the repair or rehabilitation can be scheduled, likely in a low water season. Temporary spikes in turbidity may occur during riverbed disturbances associated with these activities.

2.1 Boulder Arch Structures

Boulder arch structures will be constructed by placing boulder into a tightly stacked boulder matrix. The boulder matrix includes stable fill in void spaces. Structures are designed to resist overturning and sliding; however, minor movement may be expected due to changes in morphology, scour or deposition. Potential repairs may be required to remove debris, or to reset material that has been impacted by debris, ice or significant erosion. Rehabilitation is expected to consist of resetting or augmenting the proposed features to achieve desired hydraulic performance throughout the life of the project. Additional material may augment the matrix where necessary to re-establish finished grade or refill and stabilize voids. Work would require access by a large track vehicle on the bed of the river channel and access from the shoreline and resetting of boulders or augmentation of additional boulder matrix material in the wet and possibly flowing water.

2.2 Riffle Feature Substructures

Riffle Feature Substructures are designed to maintain stable grade control for the project reach by controlling upstream water surface elevations and distributing hydraulic gradient throughout the reach. Structures are designed to resist overturning and sliding; however, minor movement may be expected due

to changes in morphology, scour or deposition. Changes in grade control may impact hydraulics, sediment transport, fish passage and other design features in an adverse way. Boulders are recommended for Riffle Feature Substructures and would have the least associated OMRR&R; however, Substructures may be constructed out of riprap or alluvium per owner's preference with relative increased OMRR&R respectively. Potential repairs may be required to remove debris, reset material that has been impacted by debris or ice, or augment structure in response to inconsistencies between post-project conditions and design assumptions. Rehabilitation is expected to consist of resetting or augmenting the proposed features to maintain proper hydraulic performance throughout the life of the project. Additional material may be replaced where necessary to re-establish finished grade. Work would require access by a large track vehicle on the bed of the river channel and access from the shoreline and resetting of riprap or augmentation of additional material in the wet and possibly flowing water.

3.0 Bridge Scour Protection

Bridges in the project reach may be subject to slightly different scour conditions than the existing conditions. Current bridge scour inspection and maintenance schedules should continue and be added one year after work is performed and again after any major flood or ice event. The rehabilitation of post project scour protection is not anticipated to be different than the current procedures and no additional cost is assumed herein. Any flow patterns that are directed at pier fronts and creating a scour concern should be reconfigured and adjusted to flow though the openings without a significant angle of attack on the piers. This may require tracked equipment to access the river and excavate or augment boulder structures in the wet and flowing river. This may result in temporary increases in downstream turbidity.

4.0 Alluvial Riffle Structures

The imported alluvium that will comprise riffle structures has been designed to remain locally stable with a factor of safety of 2 based on modeled bed shear stresses and particle size incipient motion evaluations. The finished grade of the project is expected to morph with the fluvial environment and locally scour and deposit until a stable equilibrium is established.

4.1 Local Deposition and Scour

Local deposition and scour of alluvial material in Riffle Structures will likely occur and a dynamic equilibrium between scouring hydraulics and the new riverbed would be established. Local deposition or scour is not anticipated to require maintenance; however, if unforeseen events occur or the level of local scour is determined unsafe in any location, heavy equipment may have to access the river channel to restore desired grades with stable material. This work may require track equipment to drive on the riverbed in the wet channel and access from the shoreline.

4.2 Debris Removal

Deposits of large woody debris and other debris occur in the existing channel and are likely to also occur under post-project conditions. There is a relatively higher likelihood of debris becoming hung up on the Alluvial Riffle Structures due to relatively larger area and shallower flow depths compared to other parts of the channel. Repairs may be required on a case-by-case bases to address any debris that becomes hung up. Repairs may require removal from the river channel similar to existing conditions. Removal of woody debris will likely be a combination of chain sawing the debris in place (likely within the flowing water) and allowing the smaller logs to float downstream. In some cases, heavy equipment may have to access the river channel to remove large logs or other major debris. This work may require track equipment to drive on the riverbed in the wet channel and access from the shoreline.

4.3 Aggregation of Substrate Near Fulton Street

The reach break near Fulton Street has the potential to aggrade gravel bars that would be unable to transport into the reach downstream of US-131. The project is designed to minimize and avoid this potential aggregation through stable sizing of substrate; however, monitoring of gravel deposits near Fulton Street is still recommended. A deposit that requires action would be one that impacts flood risk. A deposit substantial enough to impact flood risk has been modeled to be extremely unlikely. However, if a significant deposition of substrate does form, survey and engineering services would be required to determine if an increased flood hazard is developing. If determined necessary, the materials would be accessed by heavy equipment tracking on the bed of the river and removing the deposit to be hauled offsite and disposed in an upland area.

4.4 Ice Jamming

Ice jamming is not anticipated to be significantly different than the existing conditions. Ice jamming problems are anticipated to be concentrated downstream of Fulton Street the same as existing conditions. However, as a precaution ice formation and jamming should be monitored and may require maintenance similar to existing conditions, such as mechanically removing (or in emergencies with blasting) of jams and problem ice formations.

All individual substrate particles, including boulders may shift and adjust locally. The collapse of an ice jam can deposit significant weight of ice on a riverbed during a rapid drawdown. This is impossible to predict, not cost effective to design for, currently occurs under existing conditions, was noted in 2005 by anglers that had mapped the riverbed, and is only a temporary local phenomenon and not a continual process that forms downstream bars. Ice damage would be evaluated after an event and require repair if resulting in hydraulic hazards or degradations.

APPENDIX E

Other Supporting Information

Recommended Construction Sequencing and Methods; June 2024

Recommended Construction Sequencing and Methods
GRAND RIVER REVITALIZATION PROJECT
GRAND RAPIDS, MICHIGAN

Recommended Construction Sequencing and Methods for the Lower Reach Project

Prepared for:
Grand Rapids White Water

Prepared by:
RiverRestoration
P.O. Box 248
Carbondale, CO 81623

June 2024

Grand Rapids WhiteWater

RIVER RESTORATION.ORG

CITY OF GRAND RAPIDS

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Section 1 – Introduction

The following construction sequencing has been developed through coordination with the construction management adviser for the City and regulatory agencies as the most feasible means for construction that also minimizes direct impacts to the existing channel.

All in-river construction work is expected to be performed during flow rates of less than approximately 3,900 cfs. Limiting construction to lower flows allows construction activities to occur in the wet, reducing the need for expansive work isolation areas. Causeways of imported clean coarse aggregate would be installed along the west bank to access the Dam 1, 3, and 4 construction areas, as well as areas downstream of Pearl Street. The Dam 2 construction area would be accessed directly from the staging area and would be isolated by a cofferdam on the west side. Refer to Figure 1 (attached) for the layout of temporary construction access and construction areas. Refer to Section 3 and the construction design drawings for the proposed improvements at each construction area.

Section 2 – Construction Areas and Sequencing

Construction sequencing has been separated into four categories. These categories would generally follow each other sequentially; however, concurrent work between categories has been described where applicable.

Category 1: Mobilization (~8 weeks)

- All work would be outside the river and completed prior to commencing in-river work or July 1st, whichever come later.
- Work includes establishing staging areas, installing BMPS and contractor facilities, and importing and stockpiling materials

Category 2: Preparatory Work in River (~6 weeks)

- Installation of access causeway to each work area (refer to Figure 1)
- Install temporary scour protection at Gillett Bridge
- Installation of in-river BMPs

Category 3: Initial In-river Construction (~10 weeks)

- Begins with installation of work isolation (aggregate bag cofferdam) at the Dam 2 Construction Area.
- Extends through the completion of the (isolated) west side of the Dam 2 Construction Area
- Concurrent work activities may include:
    - Any category 2 work downstream of Dam 2 which has not yet been completed.
    - Fish and mussel relocation activities within isolated area
    - Construction of any proposed improvements downstream of Dam 2

Category 4: Final In-river Construction (~9 weeks)

- Begins with the removal of work isolation (aggregate bag cofferdam) at the Dam 2 Construction Area.
    - Dam 4 to be removed immediately after Dam 2 construction is complete.
- Extends through completion of all proposed improvements and removal of all temporary access causeways
- Concurrent work activities may include:
    - Extension of upstream causeway at Dam 2 Construction Area to 593' elevation.
    - Category 2 work for Dams 3 and 4 Construction location after completion of Dam 2 upstream causeway to 593' elevation.
    - Removal of Dam 3 and installation of proposed improvements at Dam 3
    - Completion of east side of Dam 2 Construction (i.e. full completion of proposed improvements at Dam 2 Construction Area)
    - Removal of Dam 4 and installation of proposed improvements at Dam 4 after the full completion of proposed improvements at Dam 2.
    - Completion of all proposed improvements downstream of Dam 2
    - Inspection of hydraulic performance of completed improvements
    - Removal of all temporary construction access causeways and in-river BMPs

Section 3 – Description of Construction Activities

Dam 2 Construction Area

Within the work isolation area, Dam 2 would be removed, and the west half of the proposed diversified hydraulic structure would be constructed. The cofferdam would remain in the river until construction within it is complete; all equipment and personnel would be removed from the channel and the site flooded prior to flow events greater than approximately 3,900 cfs.

Once the west side is complete, the cofferdams would be removed and the proposed improvements on the east side would be constructed, using previously installed causeways to access. On the east side of the river, Dam 2 would be demolished and removed, and the proposed riffle structure would be constructed. The cofferdams and causeways would be removed following the completion of Dam 2 feature construction.

Dam 1 Construction Area

The low-head dam would be demolished and removed, and the proposed riffle structure would be constructed. Temporary causeways upstream and downstream of the constructed riffle would be removed following construction.

Dams 3 and 4 Construction Area

Installation of the access causeway and construction of proposed improvements to Dam 3, including the removal of the dam, would not occur until the cofferdam within the Dam 2 construction area is removed and the contractor is confident the Dam 2 feature will be completed within the same construction season. The installation of the access causeway and the removal of Dam 4 would not occur until the Dam 2 feature has been fully constructed.

Causeways to, and along, Dams 3 and 4 would be installed and the dams demolished and removed. The channel upstream of the dams would be regraded per plans. Emergent habitat boulders would also be placed within the Dam 3 removal and regraded area. Temporary causeways would be removed following construction.

Dams Removal Means and Methods

- Other than the western half of Dam 2, all dam removal would be performed under un-isolated conditions.
- Operating from established causeways and working from east to west, 20-30 ft long sections would be removed at one time.
- The upstream face of the dam would be exposed by temporarily moving the causeway material at the face of the dam to the other side of the causeway while work is performed.
- Excavate to bottom of concrete on upstream side of 20-30 ft section of dam.
- Use a hydraulic concrete breaker with compressed air unit, mounted on an excavator, to break concrete into 24-48” pieces.
- Load the broken concrete into articulated off-road dump trucks and relocate the concrete to the park staging area.
- Load the concrete into OTR dump trucks and haul to disposal site
- Contractor will visually monitor turbidity and adjust water quality control BMPs as needed.

Construction Areas downstream of Pearl St.

Two emergent habitat boulder fields and a series of bank vane structures would be constructed between Pearl and Fulton Streets. Both areas would be accessed from a causeway extending from Ah-Nab-Awen Park to the construction areas. Emergent habitat boulders on the west side would be placed from the causeway, while boulders on the east half of the river would be placed while tracking in the river. Boulder vanes would be constructed upstream and downstream of Grand Rapids Public Museum Carousel and on the east bank near the JW Marriot Hotel. Between Blue and Fulton Street, a diversified boulder arch structure would be constructed on the west side of the river and emergent habitat boulder field on the east side.

Following completion of all proposed improvements and final inspection, all temporary causeways, construction equipment, and BMPs would be removed from the river.

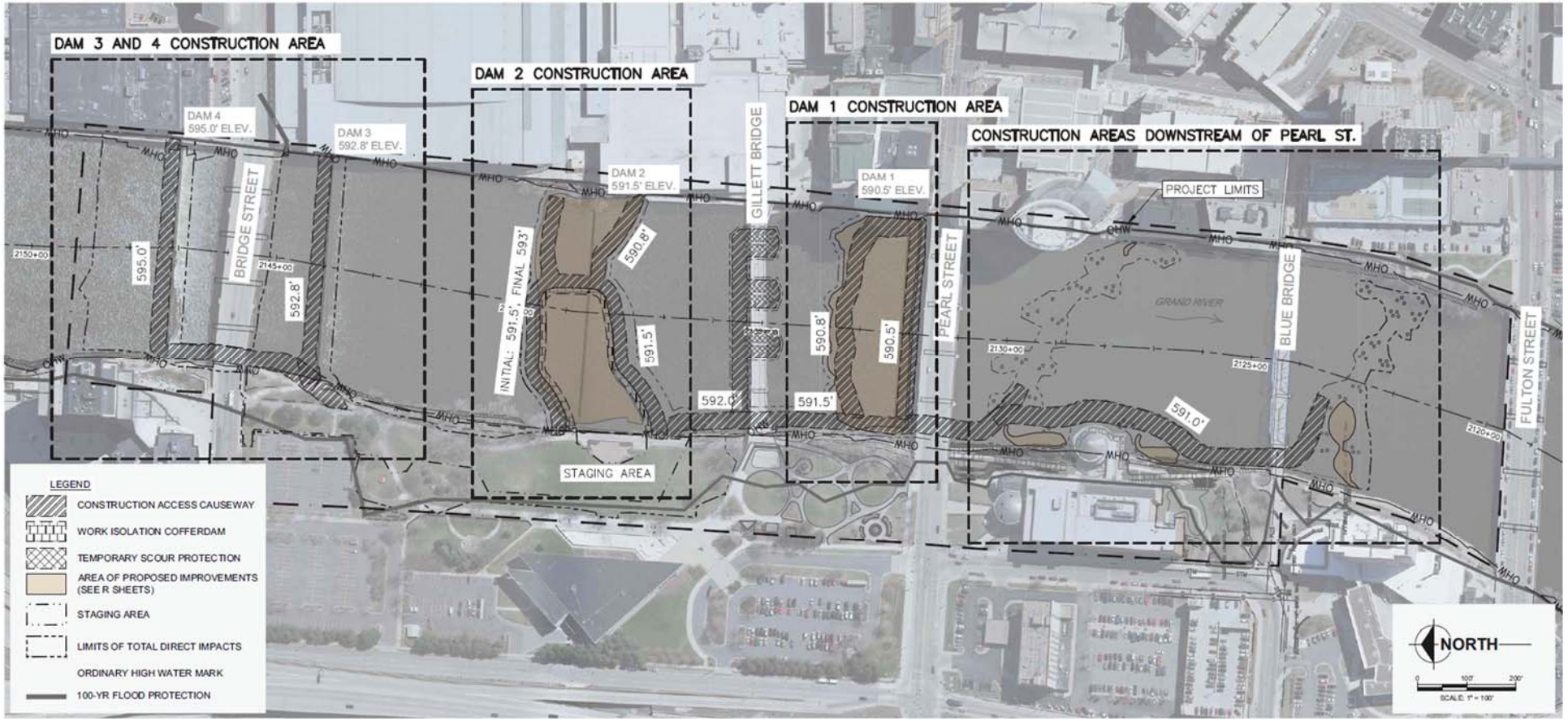

Figure 1: Construction Area Map

APPENDIX E

Other Supporting Information

Grand River Revitalization 60% GMP Bid Item Summary Cost Estimate 4/14/24

Grand River Revitilization - GMP Estimate

Biditem	Description	Bid Quantity	Unit	Bal Price	Total Cost	Unit Cost	Total Cost	Sum Group 2
104100	MOBILIZATION	1.000	LS	249,375.00	249,375.00	187500	$187,500.00	SP
105100	OWNER'S FIELD OFFICE	24.000	MO	5,000.00	120,000.00	5000	$120,000.00	Sub
105200	SECURITY GATE	2.000	EA	5,000.00	10,000.00	5000	$10,000.00	Sub
105300	PROJECT SIGNAGE	5.000	EA	1,000.00	5,000.00	1000	$5,000.00	Sub
106110	REMOVE WALK/ FLATWORK	2,060.000	SY	13.50	27,810.00	13.5	$27,810.00	Sub
106120	REMOVE C&G	80.000	LF	12.00	960.00	12.00	$960.00	Sub
106130	REMOVE SIGNS	5.000	EA	200.00	1,000.00	200.00	$1,000.00	Sub
106140	REMOVE BOLLARDS	2.000	EA	250.00	500.00	250.00	$500.00	Sub
106150	STRIP & STOCKPILE TOPSOIL	3,667.000	SY	10.00	36,670.00	10.00	$36,670.00	Sub
106210	REPLACE WALKWAY	18,540.000	SF	6.00	111,240.00	6.00	$111,240.00	Sub
106220	REPLACE C&G	40.000	LF	30.00	1,200.00	30.00	$1,200.00	Sub
106230	REPLACE SIGNS	5.000	EA	400.00	2,000.00	400.00	$2,000.00	Sub
106235	REPLACE BOLLARDS	2.000	EA	750.00	1,500.00	750.00	$1,500.00	Sub
106240	REPLACE TOPSOIL	3,667.000	SY	10.00	36,670.00	10.00	$36,670.00	Sub
106250	FURNISH & INSTALL TREES	18.000	EA	750.00	13,500.00	750.00	$13,500.00	Sub
106260	STAGING AREA, AH-NAB-AWEN PARK, CONSTRUCTION	1.000	LS	170,345.13	170,345.13	170,345.13	$170,345.13	Sub
106280	STAGING AREA, AH-NAB-AWEN PARK, RESTORATION	1.000	LS	77,681.74	77,681.74	77,681.74	$77,681.74	Sub
106300	STAGING AREA, NORTH MONROE, CONSTRUCTION	1.000	LS	32,814.13	32,814.13	32,814.13	$32,814.13	Sub
106400	STAGING AREA, NORTH MONROE, RESTORATION	1.000	LS	28,108.92	28,108.92	28,108.92	$28,108.92	Sub
106500	CONSTRUCTION FENCE, TEMP	3,000.000	FT	10.50	31,500.00	10.50	$31,500.00	Sub
106600	CONSTRUCTION FENCE, PROTECTIVE	500.000	FT	9.00	4,500.00	9.00	$4,500.00	Sub
200000	SECTION 2 - EARTHWORK	1.000	LS	0.00	0.00	0.00	$0.00	Sub
201100	TREE, REM, 6 INCH TO 18 INCH	2.000	EA	375.00	750.00	375.00	$750.00	Sub
201200	TREE, REM, 19 INCH TO 36 INCH	13.000	EA	1,300.00	16,900.00	1,300.00	$16,900.00	Sub
201300	TREE, REM, 37 INCH OR LARGER	2.000	EA	2,000.00	4,000.00	2,000.00	$4,000.00	Sub
202100	SOIL EROSION & SEDIMENTATION CONTROL & PLAN	1.000	LS	66,500.00	66,500.00	50000	$50,000.00	SP
202200	STORM WATER OPERATOR'S INSPECTIONS	26.000	EA	400.00	10,400.00	400	$10,400.00	Sub
202300	DUST CONTROL	1.000	LS	85,040.17	85,040.17	63939.98	$63,939.98	SP
202350	SWEEPING	312.000	HR	200.00	62,400.00	200	$62,400.00	Sub
202400	SILT FENCE	2,600.000	FT	2.50	6,500.00	2.50	$6,500.00	Sub
202500	EROSION CONTROL WATTLE	1,000.000	FT	13.30	13,300.00	10	$10,000.00	SP
202600	INLET PROTECTION FABRIC DROP	8.000	EA	140.00	1,120.00	140.00	$1,120.00	Sub
203100	DEMOLISH LOW-HEAD DAM #1	1.000	LS	49,373.06	49,373.06	37122.6	$37,122.60	SP
203200	DEMOLISH LOW-HEAD DAM #2	1.000	LS	48,425.08	48,425.08	36,410.25	$36,410.25	SP
203300	DEMOLISH LOW-HEAD DAM #3	1.000	LS	38,025.46	38,025.46	28590.57	$28,590.57	SP
203400	DEMOLISH LOW-HEAD DAM #4	1.000	LS	62,274.16	62,274.16	46,822.68	$46,822.68	SP
204200	EXCAVATION, CLEAN RIVERBED MATERIAL	11,945.000	CY	*75.50*	901,847.50	56.08	$669,921.11	SP
204250	OVEREXCAVATE CLEAN RIVERBED MTL	500.000	CY	122.33	61,165.00	91.97	$45,985.00	SP
204300	EXCAVATION, DISPOSAL OF UNSUIT RIVERBED MTL	100.000	CY	129.26	12,926.00	97.19	$9,719.00	SP
204600	VERIFY/ SPOT CHECK GRADING ACCURACY OF ALLUVIUM	29,500.000	SY	2.25	66,375.00	1.69	$49,855.00	SP
205100	PIP EXISTING WETLANDS & TEMP FENCE	1,000.000	FT	45.56	45,560.00	34.26	$34,260.00	SP
206100	CONTAM MTL, STORAGE, HANDLING & DISPOSAL	1.000	DOL	25,000.00	25,000.00	25,000.00	$25,000.00	Sub
207110	PROJECT CLEANUP	1.000	LS	42,346.60	42,346.60	31839.55	$31,839.55	SP
300000	SECTION 3 - BASES	1.000	LS	0.00	0.00	0.00	$0.00	Sub
301200	FURNISH RIPRAP CORE SUBSTRUCTURE	3,500.000	TON	114.99	402,465.00	86.46	$302,610.00	SP
301250	FURNISH RIPRAP FOR DAM UNDERCUT	998.000	TON	168.83	168,492.34	126.94	$126,686.12	SP
301300	FURNISH COARSE ALLUVIUM	15,500.000	TON	*188.00*	2,914,000.00	147.29	$2,282,995.00	SP
301350	FURNISH FINE ALLUVIUM	1,100.000	TON	211.40	232,540.00	158.95	$174,845.00	SP
301400	FURNISH BOULDERS	3,821.000	TON	207.81	794,042.01	156.25	$597,031.25	SP
400000	SECTION 4 - DRAINAGE FEATURES	1.000	LS	0.00	0.00	0.00	$0.00	Sub
401100	PIP MAINTAIN STORM WATER OUTFALL	20.000	EA	800.00	16,000.00	800.00	$16,000.00	Sub
500000	SECTION 5 - STRUCTURES	1.000	LS	0.00	0.00	0.00	$0.00	Sub
501100	PLACE COARSE ALLUVIUM	15,500.000	TON	32.09	497,395.00	24.13	$374,015.00	SP
501200	INSTALL FINE ALLUVIUM AT EAST WALL	1,100.000	TON	86.35	94,985.00	64.92	$71,412.00	SP
502100	PLACE RIPRAP, CORE SUBSTRUCTURE	3,500.000	TON	44.55	155,925.00	33.50	$117,250.00	SP
502150	PLACE RIPRAP BACKFILL @ DAM REMOVAL	998.000	TON	41.27	41,187.46	31.01	$30,947.98	SP
502200	PLACE BOULDER @ BOULDER DROP STRUCTURES	2,245.000	TON	182.84	410,475.80	137.37	$308,395.65	SP
502300	PLACE SELECT BOULDER (AT RIFFLE DAMS)	16.000	TON	825.49	13,207.84	620.21	$9,923.36	SP
502400	PLACE HABITAT BOULDERS AND RIFFLES	1,160.000	TON	542.61	629,427.60	410.04	$475,646.40	SP
502700	PLACE SCOUR PROTECTION, PERMANENT, GILLET	1.000	TON	28,995.16	28,995.16	21,781.06	$21,781.06	SP
600000	SECTION 6 - INCIDENTAL CONSTRUCTION	1.000	LS	0.00	0.00	0.00	$0.00	Sub
601100	PRECONSTRUCTION DOCUMENTATION	1.000	LS	644,000.00	644,000.00	644,000.00	$644,000.00	Sub
602100	PLACE COFFERDAM, STAGE 1(AGG BAG DAM 2)	1.000	LS	*687,350.50*	687,350.50	531,921.95	$531,921.95	SP
602400	REMOVE COFFERDAM, STAGE 1	1.000	LS	93,094.48	93,094.48	69,976.21	$69,976.21	SP
602700	DEMOBILIZATION FOR 3,500 CFS EVENT	1.000	DOL	50,000.00	50,000.00	50,000.00	$50,000.00	Sub
602800	RESTORE 3,500 CFS EVENT	1.000	DOL	50,000.00	50,000.00	50,000.00	$50,000.00	Sub
603100	ACCESS RAMP, BRIDGE ST. TO PARK	1.000	EA	42,934.95	42,934.95	32281.92	$32,281.92	SP
603400	TEMP ACCESS CAUSEWAY FOR LOW-HEAD DAM 1	3,650.000	CY	188.31	687,331.50	141.57	$516,730.50	SP

Grand River Revitilization - GMP Estimate

Biditem	Description	Bid Quantity	Unit	Bal Price	Total Cost	Unit Cost	Total Cost	Sum Group 2
603500	TEMP ACCESS CAUSEWAY FOR LOW-HEAD DAM 2	3,460.000	CY	*295.00*	1,020,700.00	238.26	$824,379.60	SP
603600	TEMP ACCESS CAUSEWAY FOR LOW-HEAD DAM 3	950.000	CY	206.00	195,700.00	154.86	$147,117.00	SP
603700	TEMP ACCESS CAUSEWAY FOR LOW-HEAD DAM 4	2,000.000	CY	207.32	414,640.00	155.86	$311,720.00	SP
603800	TEMP ACC C-WAY AH NAB AWAN PK W-BANK 2137-2123+	770.000	CY	181.67	139,885.90	136.58	$105,166.60	SP
604100	CARE OF WATER PLAN	1.000	LS	15,000.00	15,000.00	15,000.00	$15,000.00	Sub
604200	CARE OF WAT PUMP FILT & DIS A I AREA 2139+00-D2	1.000	LS	187,143.17	187,143.17	140,584.90	$140,584.90	SP
604300	CARE OF WATER PUMP FIL DISCH AREA 2132+ -2137+	1.000	LS	0.00	0.00	0.00	$0.00	Sub
604400	CARE OF WATER PUMP FIL DISCH AREA 2125+ -2132	1.000	LS	0.00	0.00	0.00	$0.00	Sub
604500	CARE OF WATER PUMP FIL DISCH AREA 2141+ -2148	2.000	LS	0.00	0.00	0.00	$0.00	Sub
604600	TURBIDITY CURTAIN	4,000.000	FT	51.50	206,000.00	38.68	$154,720.00	SP
604700	OIL BOOM	1,000.000	FT	27.04	27,040.00	20.32	$20,320.00	SP
605100	MAINTAINING TRAFFIC, (ESTIMATED DAYS)	1.000	LS	40,000.00	40,000.00	40,000.00	$40,000.00	Sub
605200	DETOUR SIGNING, (ESTIMATED DAYS)	1.000	LS	10,000.00	10,000.00	10,000.00	$10,000.00	Sub
606100	RIPRAP, TEMP SCOUR PROTECTION GILLETTE BR	250.000	TON	160.79	40,197.50	120.81	$30,202.50	SP
607100	REMOVE, STORE & REINSTALL LT POLE (PROT BASE)	22.000	EA	600.00	13,200.00	600.00	$13,200.00	Sub
608100	PROTECT TREE	20.000	EA	180.00	3,600.00	180.00	$3,600.00	Sub
608200	SULFUR APPLICATION	34,000.000	SF	0.40	13,600.00	0.40	$13,600.00	Sub
608300	ROOT PRUNING	1.000	LS	3,500.00	3,500.00	3,500.00	$3,500.00	Sub
609100	TURF ESTABLISHMENT	7,500.000	SY	4.00	30,000.00	4.00	$30,000.00	Sub
609200	TURF WATERING	25.000	EA	1,200.00	30,000.00	1,200.00	$30,000.00	Sub
609300	WEED CONTROL	1.000	LS	1,200.00	1,200.00	1,200.00	$1,200.00	Sub
610110	CONTRACTOR SURVEY (SURVEY ONLY)	1.000	LS	234,310.76	234,310.76	176173.5	$176,173.50	SP
611200	MOB, FISH COLLEC & MUSSEL TRANSL, ST2 2025 I AR	1.000	DOL	100,000.00	100,000.00	100,000.00	$100,000.00	Sub

Direct Cost Total:	$13,962,169.92	$11,116,969.16	
Self Perform:	**$6,852,027.62**		SP
Sub:	$7,110,142.30		Sub
Direct Cost Total:	$13,962,169.92		
Indirects:	$3,139,600.92		
	$17,101,770.84		
Managemnt Fee:	$2,565,265.63		
Builders Risk:	$66,160.17		
Corp Liability:	$198,480.52		
CM Staffing:	$302,474.08		$3,442,075.00
Contigency:	$1,710,177.08		
Bond:	$109,062.53		
Total:	**$22,053,390.85**		

APPENDIX E

Other Supporting Information

Impacts to Fish Passage in the Grand River Between Bridge Street and Fulton Street; February 2024

Impacts to Fish Passage in the Grand River between Bridge Street and Fulton Street in Grand Rapids, Michigan



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FEBRUARY 2024

ENCOMPASS
Socio-ecological Consulting

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Appendix A. Project area features, velocity, and substrate of the current design.

Appendix B. The project area with depth and depth-averaged velocity at 2500, 3900, 5000 and 7500 cfs.

Appendix C. Depth and velocity heatmaps of project area during difficult hydraulic conditions depicting 15 swimpaths. Figures display the depth, velocity and percent of swimming distance expended for a fish traveling along each of the swimpaths.

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1.0 INTRODUCTION

The City of Grand Rapids is pursuing to improve aquatic habitat in the Lower Grand River where it flows through downtown Grand Rapids, Kent County, Michigan (GVMC, 2011). Goals of the project include developing a river design that is aesthetically and functionally natural as possible, within the constraints of a large urban river, and to achieve fish passage and aquatic habitat enhancement targets as determined by the Michigan Department of Natural Resources (MDNR) and the project team. The lower reach of the Grand River Revitalization project is located on the Grand River mainstem in the City of Grand Rapids, Michigan from approximately 40 meters (131 ft) upstream of Bridge Street to Fulton Street (Figure 1-1).

1.1 Purpose of the Document

The purpose of the fish passage report is to review the design plans for the Grand River Revitalization project and evaluate the passage of desirable fish species in the lower reach project area. A fish passage report was previously submitted in 2020 (ESC 2020), for a permit application that was withdrawn in March 2023. Following the withdrawal, a new design (proposed design) was developed during focused and frequent consultation between Grand Rapids WhiteWater (GRWW), the City of Grand Rapids (CGR), Michigan Department of Environment, Great Lakes and Energy (EGLE) and MDNR. One of the primary objectives for the proposed design was to maximize fish passage and aquatic habitat while minimizing impacts. This evaluation report focuses on the proposed design where habitat elements were removed while others were added.



1.2 Proposed Action

The stated purpose of revitalizing the rapids in Grand Rapids is described in the Biological Assessment (Dunn 2024) as, "To restore the rapids, improve public safety, restore aquatic habitat diversity and suitability for native Great lakes fish and mussel species, and enhance river access and use." This action includes removing the four low head dams which are barriers to several species of fish, and to construct habitat features known to successfully pass fish. The proposed features of the action include riffles, boulder drop structures, bank vane structures,

and emergent habitat boulders that are found in many nature-like fishway designs and the historic condition of the rapids. In fall of 2023, the design was modified to avoid and minimize impacts to freshwater mussel and fish species. Appendix A (modified from Dunn 2024) shows the current design that was coordinated with EGLE and MDNR and evaluated in this report. The current design has reduced the construction and permanent impacts from the previous while incorporating elements that have successfully been used to pass fish in Michigan. Changes that were incorporated into the current design are described as follows (Dunn 2024):

Between Blue Bridge and Fulton Street

- The boulder wave structure on the west side of the channel was replaced with an augmented boulder vane structure with a reduced footprint and surrounding scattered boulders.
- The previous design included a recovery pool downstream of the wave that has been removed from the design. A small scour pool is included directly downstream of the vane structure, similar to other Michigan projects that have implemented weir or Aadland (2010) rock arch designs.

Between Pearl and Blue Bridge

- The hydraulic feature in this area, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with scattered boulder and a series of bank vane structures to provide slack water near designated access points on the bank.
- The recovery pool of the previous design has been removed.

Between Gillett and Pearl Street (Location of Dam 1)

- The hydraulic feature at Dam 1, which included a boulder wave structure on the west side connected to a constructed riffle structure on the east, has been replaced with a single constructed riffle with emergent habitat boulders and moved downstream to have more overlap with the Dam 1 removal footprint.
- The recovery pool of the previous design has been removed.

Between Bridge St and Gillet (Location of Dam 2)

- The hydraulic feature at Dam 2, which included a boulder wave structure on the west connected to a constructed riffle structure on the east, has been replaced with a hydraulic feature that combines constructed riffles on either side of the river with a series of boulder drop structures in the center of the channel. The new hydraulic feature has a reduced footprint.
- The recovery pool of the previous design has been removed. Small scour pools are included directly downstream of the boulder drop structures, similar to other Michigan projects that have implemented W-weir or Aadland rock arch designs.

Between Bridge St and Gillet (Location of dam 3)

- The dam removal limits have been expanded, based on coordination with EGLE, to include a re-grading of the channel upstream of Dam 3
- Scattered habitat boulders are proposed to be placed within the dam removal footprint.

Location of Dam 4

- The dam removal limits have been expanded, based on coordination with EGLE, to include re-grading of the channel upstream of Dam 4.

2.0 AFFECTED ENVIRONMENT AND BIOLOGICAL RESOURCES

2.1 Lower Grand River Fishery

The project area provides an important and diverse recreational fishery for resident fish species including walleye (*Sander vitreus*), sucker spp., channel catfish (*Ictalurus punctatus*) and smallmouth bass (*Micropterus dolomieu*). Seasonal opportunities exist for migrating fish and include walleye and steelhead (*Oncorynchus mykiss*) in the Spring, and Chinook salmon (*Oncorynchus tshawytscha*) in the Fall. Maintaining, and maximizing, these fishing opportunities is important to all partners involved in the revitalization project. The fish community in the project area is highly diverse, includes many tolerant species, and has changed from its historic condition because of the reduction in rapid and riffle habitat. Many of the fish species in the project area are ubiquitous throughout the mainstem and not associated with swift water habitats. For an extensive review of the Grand River fishery see Hanshue and Harrington (2017).

Two State Threatened fish species are found in the project area. There is a small lake sturgeon (*Acipencer fulvescens*) population that persists in the project area and is only suspected to spawn near Plaster Creek (~1.25 mi. downstream of Fulton Street) and in the project area downstream of 6th Street dam. The Grand River population has been placed into the 'small declining' category based on a low suspected adult population size and declining population trajectory (Hayes and Caroffino 2012). The 6th Street dam is a barrier to historic spawning grounds of lake sturgeon (Hanshue and Harrington 2017) and incidental catch by fisherman occurs each spring. Lake sturgeon recruitment has been documented during two years of a five-year study that has occurred below the project area by a locally-based team of researchers during fall assessments (Grand Rapids Public Museum 2024). The river redhorse (*Moxostoma carinatum*) is a large-bodied sucker species found in the Grand River. There have been recent obseravations in the project area during their spring spawning period (S. Hanshue, MDNR personal communication).

3.0 FISH PASSAGE EVALUATION CONSIDERATIONS

The following sections describe criteria that were developed for the fish passage evaluation, the areas where analysis occurred, methods used for hydraulic model development, and details of fish passage evaluation procedures and results.

3.1.1 General Considerations

The proposed design uses design and construction criteria, that when achieved, will improve fish passage conditions in the Grand River for the diverse fish community. The proposed action includes rock arch rapids, boulder clusters, and small hooks which are design aspects found in nature-like fishways (Aadland 2010). Nature-like design principles have been published by many sources including MDNR, Aadland (2010), Newbury (2013, 2010) and have been successful in meeting fish passage objectives. Fundamental to the design of nature-like fishways is that they pass a broad range of species, emulate habitats found in natural systems, are resilient to a range of flows, and are stable through extreme conditions.

During consultation with MDNR specific design targets were developed and consistent with nature-like fishways, that if met, would result in environmental conditions that are within the swimming abilities of desirable fish species and should accommodate passage of the broader fish community. Specific design targets included and met in the proposed action:

- **Headloss per weir of ≤0.24 m (0.8 ft):** The proposed design, when not submerged by tailwater, would have a maximum headloss of 0.61 m (2 ft) with an average headloss of ~0.54 m (~1.8 ft). The dam 1 riffle starts to see reduced headloss of tailwater levels around 5000 cfs and the dam 2 feature around 7,500-10,000k cfs.
- **Boulder weir gap width between 0.15 – 91 m (0.5 – 3 ft):** Gaps between raised boulders on the crest of the boulder drops have a minimum spacing of 0.61 m (2 ft) with a maximum of 3.66 to 4.57 m (12 to 15 ft) where flow paths are desirable for boat passage.
- **Mild downslopes at riffles:** Constructed riffles have a target slope of 50:1 and the grading will not be steeper than ~45:1 over the riffles.
- **Center depth in deep pools at ≥1.68 m (5.5 ft):** Maximum pools depths are designed at 2.1 m (7 ft) while active and not submerged with an average depth (3,900 cfs) of 1.68 m (5.5 ft).
- **Minimum pool depth of 0.91 m (3 ft):** Minimum pools depths are designed at 1.07 m (3.5 ft).

The fish passage analysis provides a quantitative tool to assess if the design will meet fish passage objectives. Two species were identified as indicator species to use in the analysis because they are both important members of the native fish community, have considerable public interest, and represent different fish swimming groups and swimming performance abilities. For instance, the river redhorse has the same fatigue equation to walleye in the model used for analysis. This allows for evaluating walleye passage along with river redhorse and a suite of other species in the model. The decision was made to evaluate the two species during a range of hydraulic conditions and design features (riffles, weir features, etc.). **Important to this analysis is that fish passage was evaluated at the more extreme modeled conditions** assuming that if passage was achieved at locations and conditions of "worst case scenario" that passage would also be achieved at other locations with less challenging hydraulic conditions.

3.1.2 Fish Groupings Considered in Passage Evaluation

Walleye and lake sturgeon were the target fish species selected based upon a series of criteria, including 1) consultation with management agencies, 2) conservation status, 3) availability of peer-reviewed, locally applicable habitat use and swimming capabilities, and 4) known movement and/or migratory behavior.

3.1.3 Hydraulic Modelling

For modelling of flow velocity and flow depth, SRH-2D models were used. Calculations were based upon depth-averaged velocity and near-bottom velocity. SRH-2D solves two-dimensional dynamic wave equations to resolve depth-averaged hydraulics for a variety of scales and applications. The software has been widely implemented and validated. Applied to the Grand River, the model resolves hydraulic parameters (e.g. depth, velocity at a resolution of 0.15 m (0.5 ft) across the spatial domain of the river system.

Hydraulic conditions used in evaluation:
2,500 CFS: 75% exceeded average daily flow rate and a common summertime flow
3,900 CFS: 50% exceeded average daily flow rate
5,000 CFS: Near 25% exceeded average daily flow rate and within range of spring spawning flow
7,000 CFS: Near 10% exceeded average daily flow rate and mid- to higher range of spring spawning flow

The flows were selected in consultation with MDNR to account for temporal and environmental variability and to represent expected seasonal conditions encountered in the Grand River. Hydraulic model outputs for the project reach at the four evaluated discharges are presented in Appendix B.

3.1.4 Velocity

Two velocity values were computed; 1) depth-averaged velocity, and 2) near-bed velocity. Both velocity estimators have advantages and limitations but together provide utility for evaluating fish passage. Depth-averaged velocity is widely used for evaluating fish passage and assessing whether current velocity would pose a burst or exhaustive swim barrier. Its use here seems appropriate to characterize the variable local hydraulic conditions (i.e. velocity and depth), found across the project river channel. In some cases, near-bed velocity will also be presented using methodology developed by Vacher (2005) and with spreadsheets developed by EGLE and MDNR to calculate velocity at 80% depth using average velocity and average depth estimates. The velocity reduction in near-bed flows has been shown to provide significant benefit to fish when it is fully accessible (Jensen 2014). The use of near-bed velocity is only appropriate when a fish has adequate “headroom” or available depth to effectively use the reduced velocity near-bed layer. Therefore, near-bed velocity will be used in cases where adequate headroom exists and during times where average velocity may show a fish passage barrier. The average depth

calculations will be the primary velocity metric because it represents a more challenging passage scenario for fish than the near-bed velocity parameter.

3.1.5 Depth

Desired conditions for fish passage are maintained when deeper relative depths are available for a range of fish body sizes and life-stages. As body size increases for fish, so does the need for greater relative depths. Minimum depth design targets from comparable fish passage projects typically ranged from 0.23 to 0.31 m (0.75 to 1 ft) depth. The Little Rapids (Chippewa County, MI) project targeted a minimum of 0.31 m (1 ft) depth to accommodate spawning walleye (USDOC 2014) and the River Raisin (Monroe County, MI) project targeted minimum depths of ≥0.23 m (9 in) in the roughened boulder areas to accommodate walleye, lake sturgeon, and other target species (Cardno-JF New 2013). A minimum depth criterion of 0.31 m (1 ft) was suggested for spawning sturgeon by Threader et al. (1998). For this analysis the depth target was accordingly set at 0.31 m (1 ft) in the roughened boulder areas during springtime flows (approximately 5,000-7,500 cfs) to accommodate lake sturgeon movement during spawning.

4.0 ANALYSIS BACKGROUND

Prior to completing the fish passage analysis methodology, MDNR hosted a meeting with Encompass Socio-ecological Consulting (ESC), CGR and GRWW to discuss the methodology with a panel of fish passage experts from across North America. The purpose was to determine if the model was precautionary in its predictions and to gather recommendations for improvements. Following the meeting, the model was finalized, and data were analyzed using the procedure.

To evaluate the impact of the proposed design on fish passage, fifteen swimpaths were established across four reaches of the project area (Appendix C). Each swimpath was placed to begin downstream of a habitat feature and extend upstream until the hydraulic influence of the feature was passed. The project features were collaboratively evaluated by MDNR and ESC by reviewing heat maps across several discharges (2,500 – 7,500 cfs) with the intent of selecting difficult swimpath routes that were often the 'worst case scenario'. Accordingly, the difficult routes were assessed based on velocity and depth, and varied between site, channel feature and discharge. Locations were also selected to evaluate different types of channel features found in the project design. For example, in all project reaches are laterally positioned boulder clusters intended to provide conditions for successful fish passage and by evaluating one representative boulder cluster we could effectively extrapolate to other analogous features within the design.

The fifteen swimpaths were distributed across four project reaches in a downstream to upstream numbering (Appendix C):

Fulton Street to Blue Bridge: Swimpaths 11-15.

Analysis performed at 2,500 cfs because of relatively shallow depths and higher flow velocities. Evaluated features included boulder clusters, a mid-channel riffle, and nearshore riffles.

Grand Rapids Public Museum to Pearl Street: Swimpaths 7-10.

Analysis performed at 3,900 CFS because of relatively shallow depths and higher flow velocities on the rivers north side. Evaluated features included two small j-hooks and mid-channel/near-shore riffles.

Pearl Street to Gillett Bridge: Swimpaths 4-6.
Analysis performed at 5,000 cfs because of relatively shallow depths and higher velocities on the rivers west side. The 7,500 cfs condition was similar hydraulically but not selected because of deeper depths that would provide more headroom for fish to exploit near-bed velocities. Evaluated features included a mid-channel boulder cluster and riffles on the rivers west side.

Above Gillett Bridge: Swimpaths 1-3.
Analysis performed at 5,000 cfs because the conditions represent those during spawning migrations for walleye, salmon and sturgeon. The 7,500 cfs condition functioned similarly hydraulically but not selected because of deeper depths that would provide more headroom for fish to exploit near-bed velocities. Evaluated features included a modified W-weir with resting pool habitat, a mid-channel riffle, and a boulder cluster on the east side of the river.

To identify barriers to fish passage along swimpath routes an Excel model was developed (RiverRestoration and ESC) based on swimming performance curves from Katopodis and Gervais (2016). The code identified locations at which a fish shifted from passive to prolonged swimming mode based on stream velocity. Once the mode shift occurred a hydraulic barrier was identified, and an energetic function was applied that calculated the distance a fish was capable of swimming at prolonged or burst mode at a given velocity. Between each 0.5 m (1.64 ft) increment along the swim path the amount of energy expended, and a cumulative distance function calculated the percent of total distance remaining that a fish could travel. When the energy budget was expended over the hydraulic pathway, a complete barrier was identified.

To calculate the 0.5 m (1.64 ft) incremental distance, velocity/distance curves were fit using the fish swimming performance database "Icthyomechanics" from Katopodis and Gervais (2016) and validated these data with other relevant sources (Peake et al. 2011, Scruton et al. 1998, Castro-Santos 2005, Threader et al. 1998). The swimming performance variables used in the model included swimming speed (Body Lengths per Second) and time to fatigue statistics. The Ichthyomechanics database calculates swimming performance data by using taxonomic classifications to group fish species of similar swimming modes and swimming performances. Combining species into groups was found to improve the statistical analysis especially in cases of inadequate data and where inconsistent sampling methodologies occurred between studies. To evaluate walleye (and salmon) passage, distance curves were fit with total lengths of 0.38 m, 0.43 m and 0.51 m (15 in, 17 in, and 20 in) to be representative of spawning size fish. For the sturgeon group, two lengths were fit at 1.5 m and 1.86 m (60 in and 72 in). For each swimpath, the likelihood that 50% of a total length group would pass was used. The likelihood percentage was developed from the average distance a fish could travel at a velocity value and incorporated the

associated confidence bounds from Katopodis and Gervais (2016). The relationship between water velocity and estimated distance of travel for the walleye group and the sturgeon group is presented in Figure 4-1 for reference.

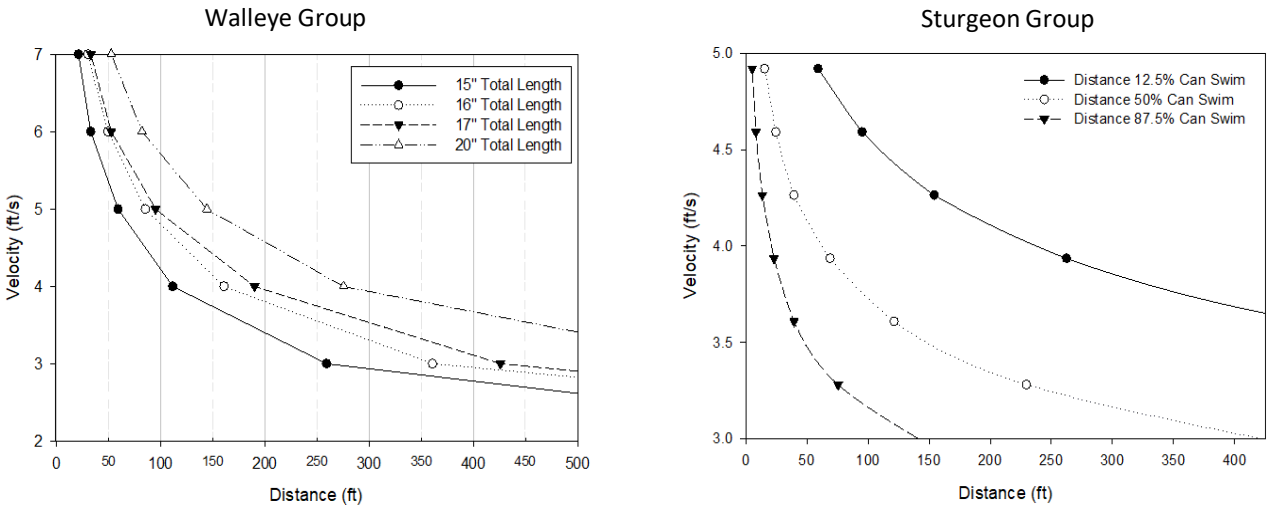

Figure 4-1. Relationship between water velocity (ft/s) and distance of travel (ft) for Salmon and Walleye group and Sturgeon.

5.0 RESULTS

5.1 Walleye Group Passage

A total of 15 swimpaths were analyzed using the model described above. Appendix C provides a depiction of each swimpath, velocity and depth values along the route, and a determination of passability based on the proportion of distance that a fish expended during upstream travel at 0.5 meter increments. Overall, the model predicted full passage at 10 of the 15 swimpaths for all three walleye length groups (Table 5-1).

Table 5-1. Estimated passage success for three length groups of walleye using average velocity at difficult swimpaths. A 'Y' designation indicates at least 50% of the population would pass.

			Total Length Groups		
Location	CFS	Swimpath #	0.38 m TL (15 in)	0.43 m TL (17 in)	0.51 m TL (20in)
Fulton Street to Blue Bridge	5,000	1	Y	Y	Y
		2	N	N	N
		3	Y	Y	Y
Grand Rapids Public Museum to Pearl Street	5,000	4	Y	Y	Y
		5	N	N	Y
		6	Y	Y	Y
Pearl Street to Gillet Bridge	3,900	7	Y	Y	Y
		8	N	N	Y
		9	Y	Y	Y
		10	Y	Y	Y
Fulton Street to Blue Bridge	2,500	11	N	N	Y
		12	N	N	N
		13	Y	Y	Y
		14	Y	Y	Y
		15	Y	Y	Y

The boulder cluster swimpaths (3, 6, and 14) were passable at each location for all walleye lengths. The backwater effect from the boulders, and decreased local flow where fish can rest, were discernable in the line graphs and showed a benefit to the modelled energy expended along the swimpaths. The depth along all swimpaths was >0.4 m except for Swimpath 6 when the path approached boulders, although deeper depths could be easily accessed by a fish if it's the path was altered slightly. Boulder clusters are a common design feature in each of the four reaches. Accordingly, passage of walleye and other similar species would be predicted to pass at each of the boulder cluster structures that were not analyzed.

Riffle feature swimpaths were placed at nine locations (Swimpaths 2, 4, 5, 8, 9, 11-13, 15) and at varying discharge conditions (Appendix C). Four of the eight swimpaths were estimated to have complete passage for all length groups of walleye, while two other swimpaths allowed passage of the largest length group. In Swimpath 2, a barrier to all length groups was due to a long travel distance at velocities near 1.5 m/s. For passage, fish would need to alter their route to exploit the lower sustained velocities near the riffle margins, use adjacent boulder areas, or exploit near-bed flows. In Swimpath 12, the barrier was largely produced by 2 m/s velocities at the crest of the weir structure, although fish could pass by accessing the margins of the crest where lower velocities exist. Even during low-flow conditions (2,500 cfs) the swimpaths maintained depths >0.4 m and would allow for fish to exploit reduced velocity near-bed flows.
Two swimpaths (7, 10) were positioned at near shore (margin) areas and used to evaluate small, j-hook structures in the design. The features are adjacent to the Grand Rapids Public Museum and just below the JW Marriott hotel. Both features produced conditions to pass walleye from all length groups. Below the proposed j-hook adjacent to the Grand Rapids Public Museum is a similar structure 83 m downstream where passage would also be expected.

A unique feature of the design is a modified W-weir (rock arch) design located between boulder clusters and constructed riffle features above the Gillett Bridge. Swimpath 1 was routed through the W-weir at the highest velocity and shallowest depth and passed over three-grade structures and three pools. The feature was passable for all length groups evaluated with a maximum of ≤50% energy reserves used during the swimpath. Over the middle weir feature the peak velocity reached 2 m/s, however because of the short distance, the fish could burst over the feature and into the recovery pool with little energy expenditure. This finding was consistent with how constructed rock arch structures are designed to function by providing hydraulic drop and resistance while allowing for a fish to pass with efficient bursts and recover in an upstream pool.

Although average velocity was the primary evaluation tool during the fish passage analysis, there were minimum depths along most of the swimpaths which exceeded 0.5 m. This amount of depth would allow adequate headroom for walleye to exploit a 0.15 m to 0.28 m (6 in to 11 in) near-bed area where reduced flows could be found. When near-bed velocities were placed into the model all 15 of the swimpaths were passable for all three size groups. The impact of near-bed flows on fish passage success is displayed for Swimpath 5 in Figure 5-1. In this example, using

average velocity calculations only the largest body sized fish was predicted to pass. However, when the near-bed velocity reduction was applied, all three body sizes were able to pass with only a small percentage of their ability to complete the swimpath used.

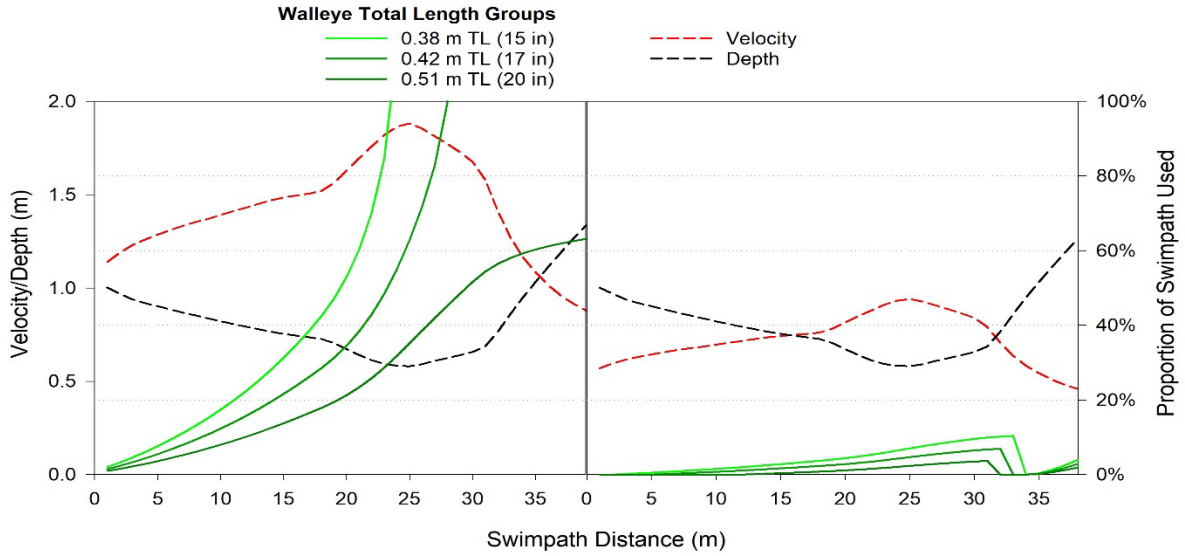

Figure 5-1. Comparison of fish passage success between depth averaged and near-bed velocities. Y-axis represents the amount of swimpath used and if 100% is reached a barrier to passage exists.

Based on these findings the proposed design is expected to function effectively to pass walleye and similar species at all habitat features. If a velocity barrier exists, near-bed velocities and less challenging routes are available.

5.2 Sturgeon Group Passage

Passage of lake sturgeon was evaluated at a boulder cluster and the W-weir. The model predicted full passage for both length groups at the boulder cluster swimpath (Swimpath 6) when using depth averaged flow velocity (5-2). As with the walleye group, the boulders provided discernable flow refugia in the line graphs by producing abrupt velocity reductions and an obvious benefit to the modelled energy expended along the route. The depth along the swimpath was greater than >0.5 m except when approaching a boulder. Deeper depths could be used by a sturgeon by altering its course slightly. The boulder cluster is a common design feature and found throughout the project area. Accordingly, passage of sturgeon would be likely at most analogous boulder features and provide upstream passage.

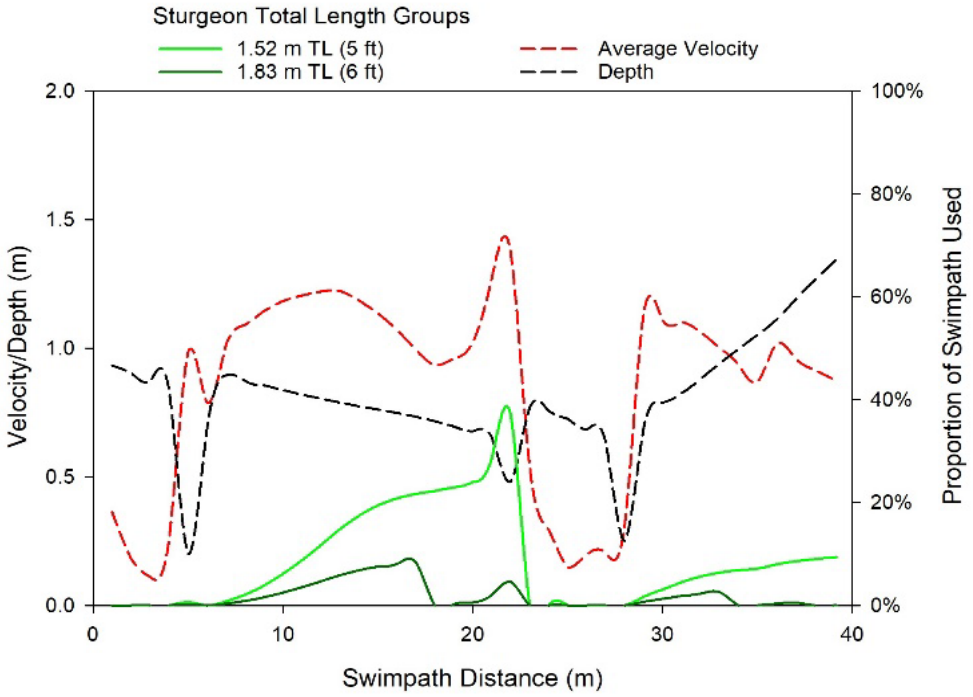

Figure 5-2. Fish passage success of lake sturgeon at boulder cluster (Swimpath 6). Y-axis represents amount of swimpath used – if 100% is reached a barrier to passage exists.

The Swimpath 1 route was used to evaluate W-weir passage and was found to be a barrier when using average velocity (Figure 5-3). The barrier was due to velocity over the middle weir crest briefly spiking to >2 m/s. Therefore, if using average velocity values, sturgeon would need to alter their route to the lower velocity areas found near the weir edges or the adjacent boulder clusters. However, using near bed velocity is an appropriate estimator for lake sturgeon if adequate depth is available for the large-bodied fish. The most challenging area along the swimpath is found at the middle weir crest with an average depth of 1.1 m (47.2 in) across a 3 m path where headroom would average 0.22 - .25 m (9-10 in). Peak velocities would be around 1.1 m/s, however, large recovery pools appropriate for sturgeon would be available immediately

above and below each crest for refugia (Daugherty et al. 2009). Sturgeon would be proficient at using the near bed conditions as they moved upstream by touching, or being close to, the river bottom where they would navigate their direction through subtle adjustments of their body in the current, and use small bursts to ascend barriers to an upstream recovery pool (Auer 2013). When using near bed velocity in the model both size groups were predicted to ascend the barrier with little energy expended (Figure 5-3). Other areas of the W-weir contain lower average and near-bed velocities with deeper depths and should provide passage at most locations.

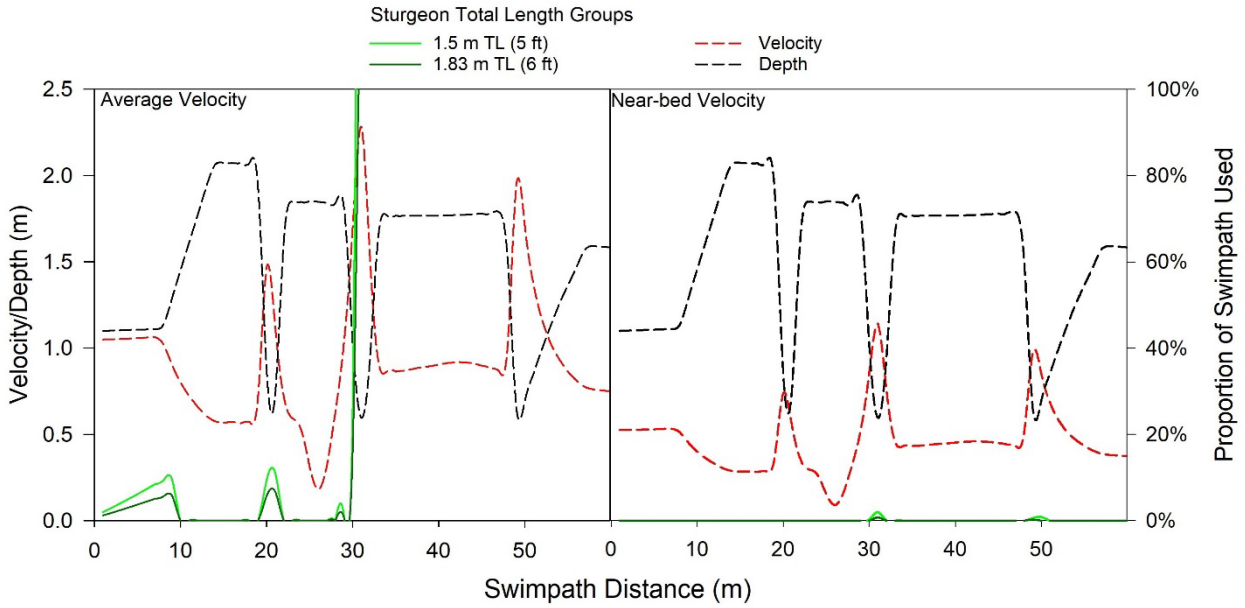

Figure 5-3. Comparison of fish passage success between depth averaged and near-bed velocities. Y-axis represents the amount of swimpath used and if 100% is reached a barrier to passage exists.

6.0 SUMMARY AND CONCLUSION

The findings of this report reinforce how the proposed design facilitates fish passage and that the naturalized design will function as predicted. Within the model used, fish passage was predicted to occur at most difficult hydraulic scenarios and for each of the design elements – boulder clusters, W-weir, and riffles. These findings also suggest that the design will allow a suite of other species to pass that have similar or greater swimming performance including the State Threatened river redhorse, other sucker species, and salmon. The current low-head dams provide a significant barrier to migration up to the 6th Street dam. The proposed design offers hydraulic conditions that facilitate fish passage for a broad group of species and at a wide range of flow conditions and incorporates natural features within the constraints of an urbanized channel.

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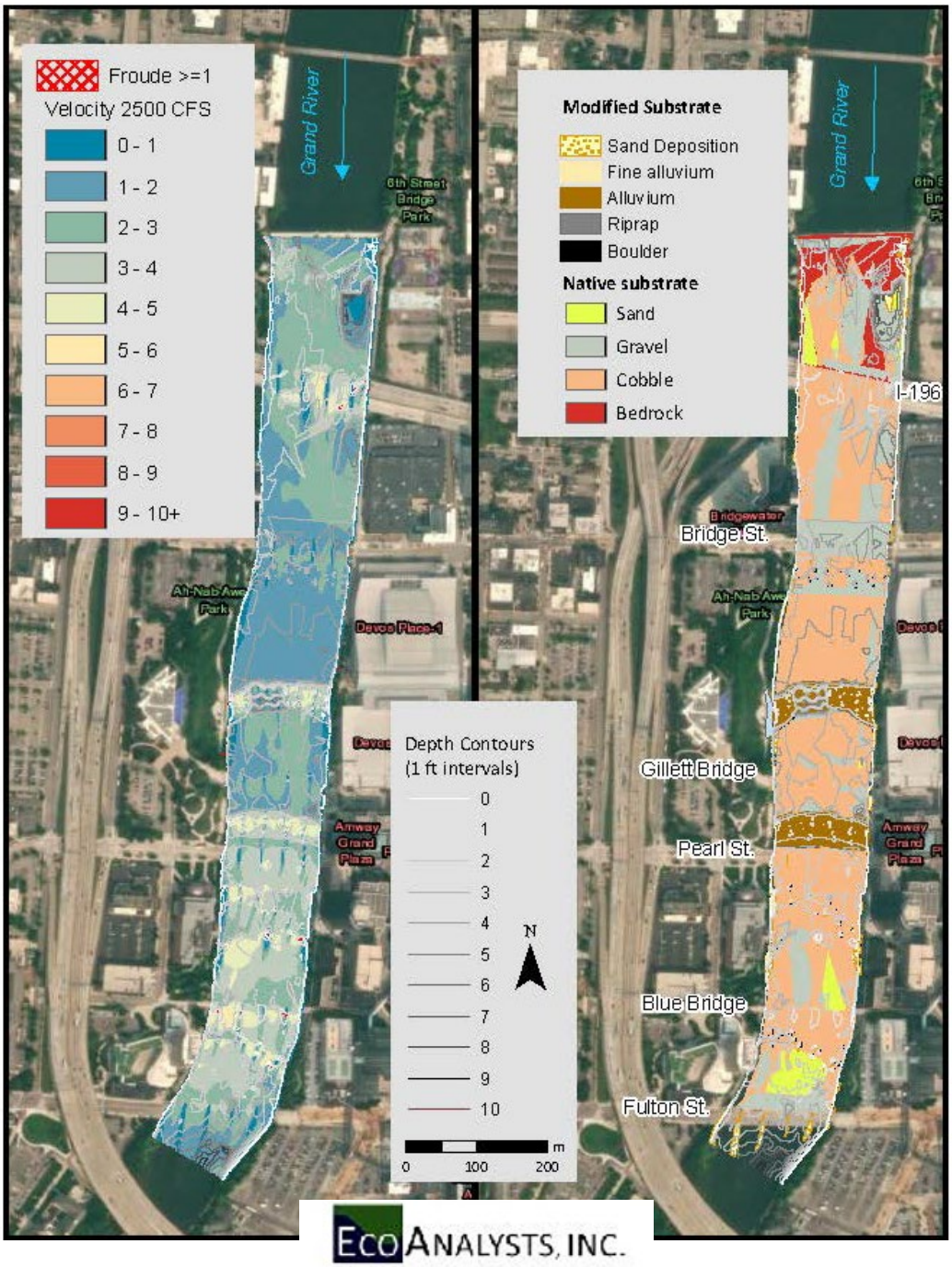
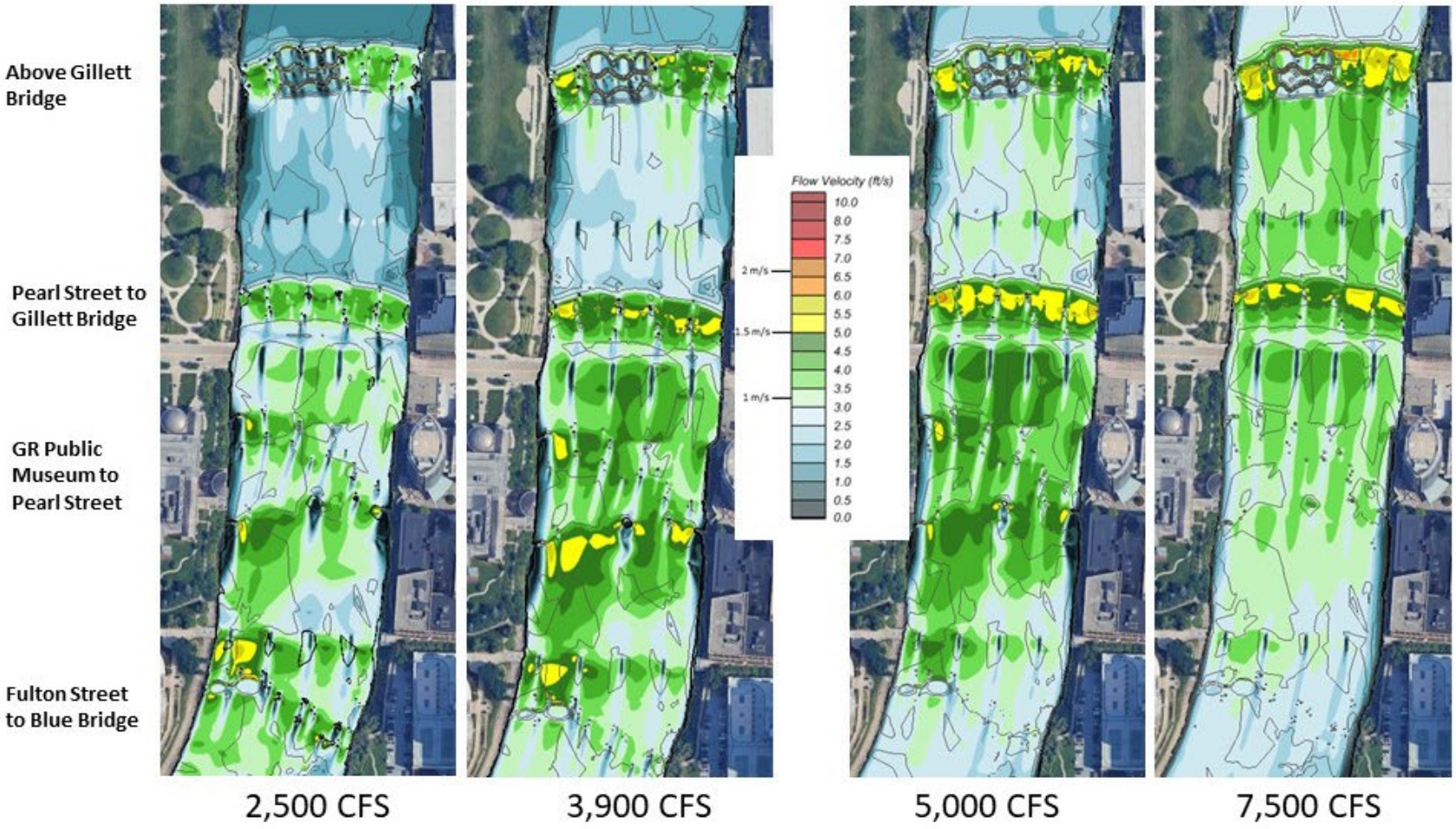
APPENDICES

Appendix A. Project area features, velocity, and substrate of the current design.

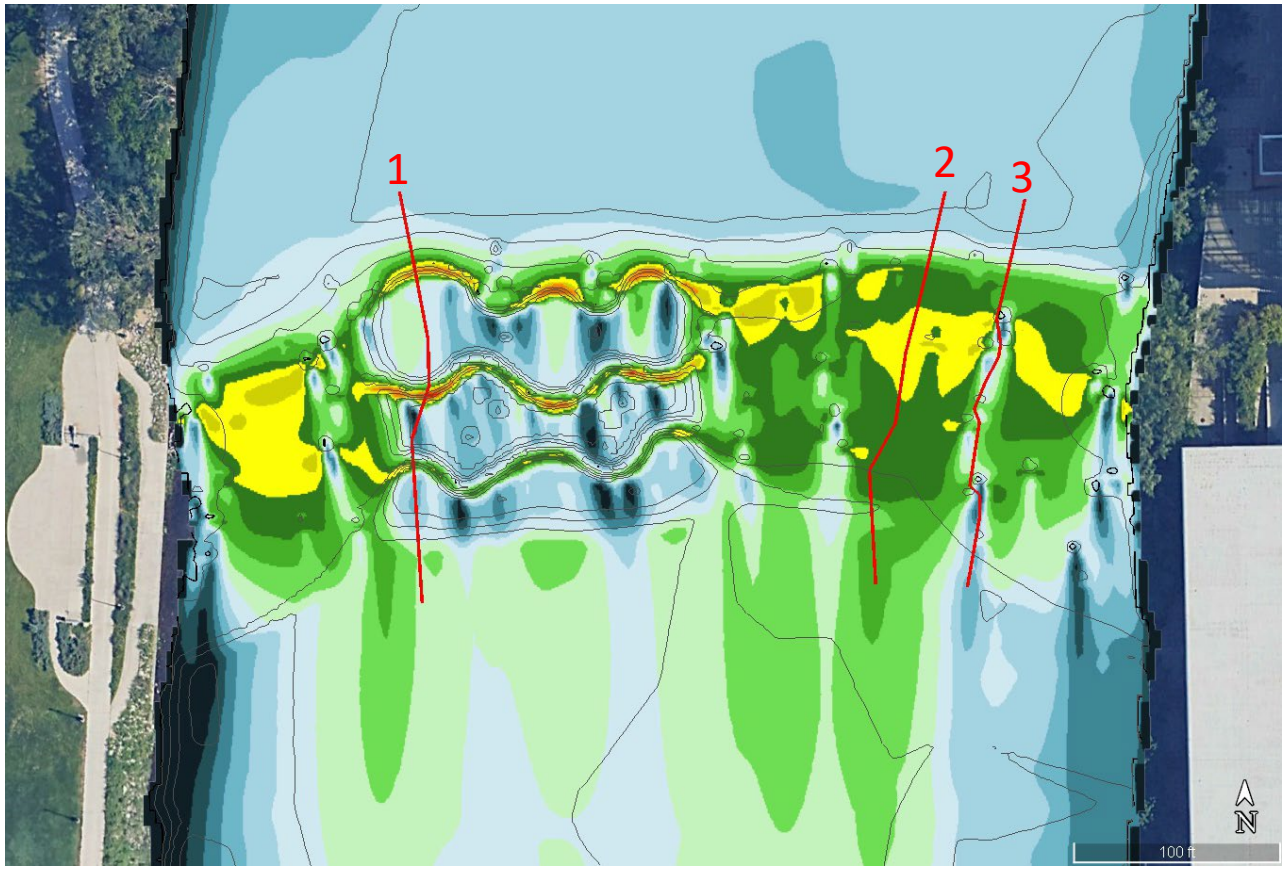


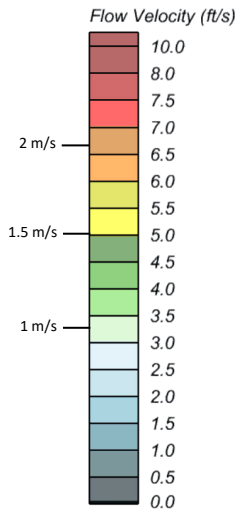
Appendix B. The project area with depth and depth-averaged velocity at 2500, 3900, 5000 and 7500 cfs.



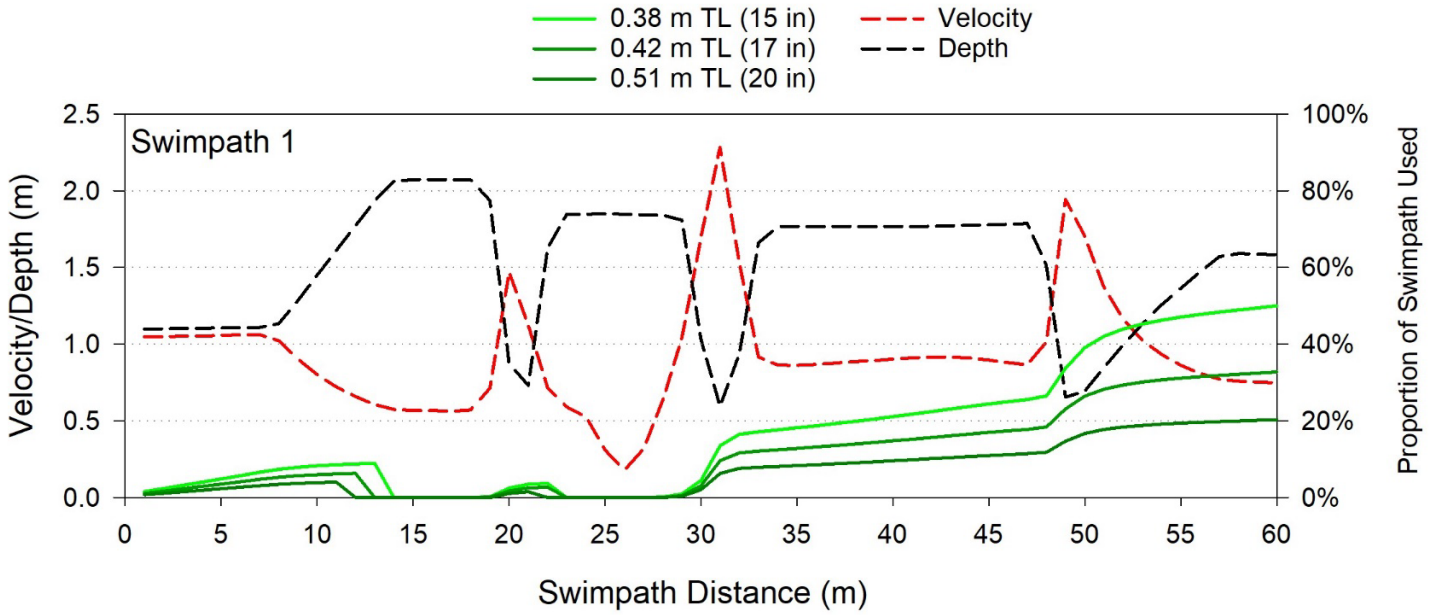
Appendix C. Depth and velocity heatmaps of project area during difficult hydraulic conditions depicting 15 swimpaths. Figures display the depth, velocity and percent of swimming distance expended for a fish traveling along each of the swimpaths.

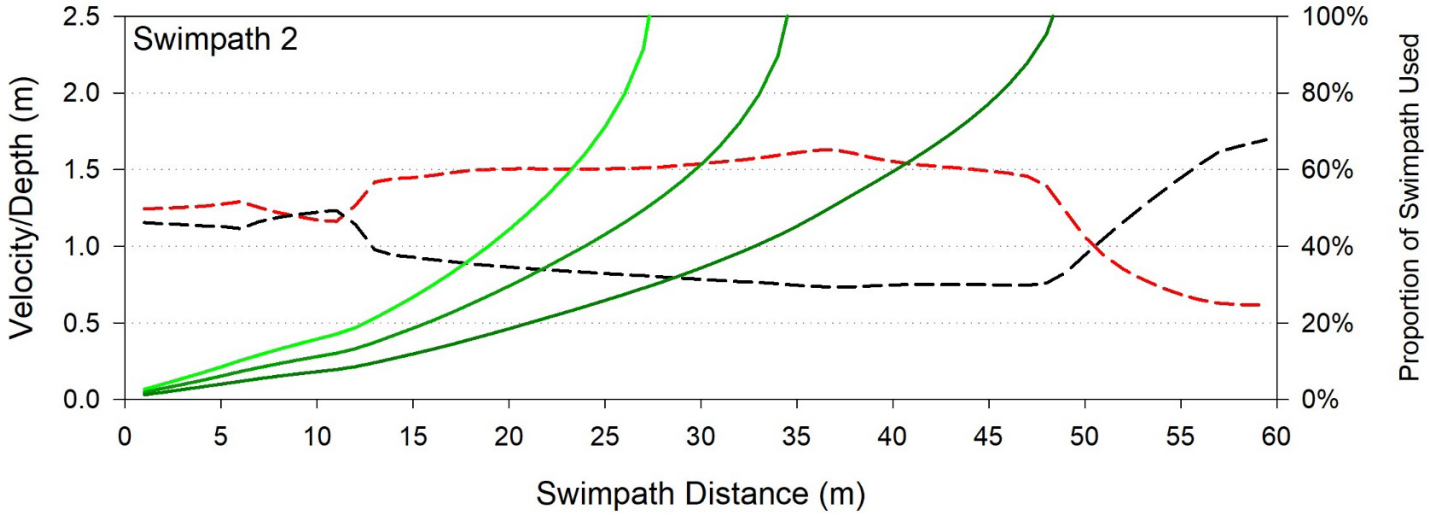
Above Gillett Bridge (W-Weir/Riffle/Boulder Cluster) 5,000 CFS

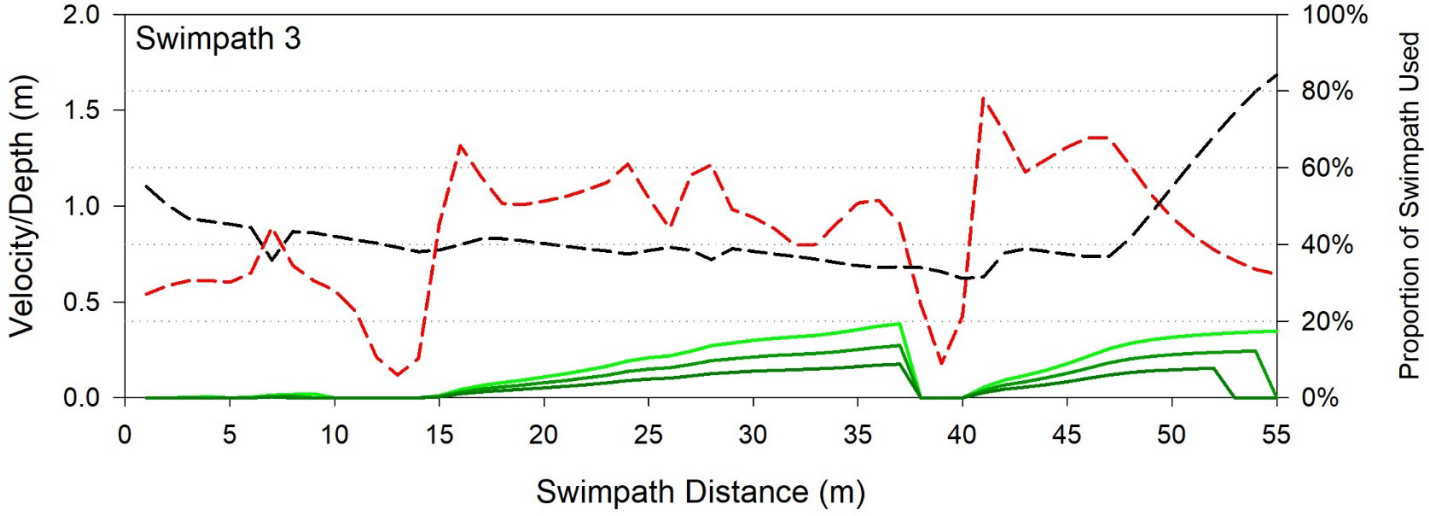




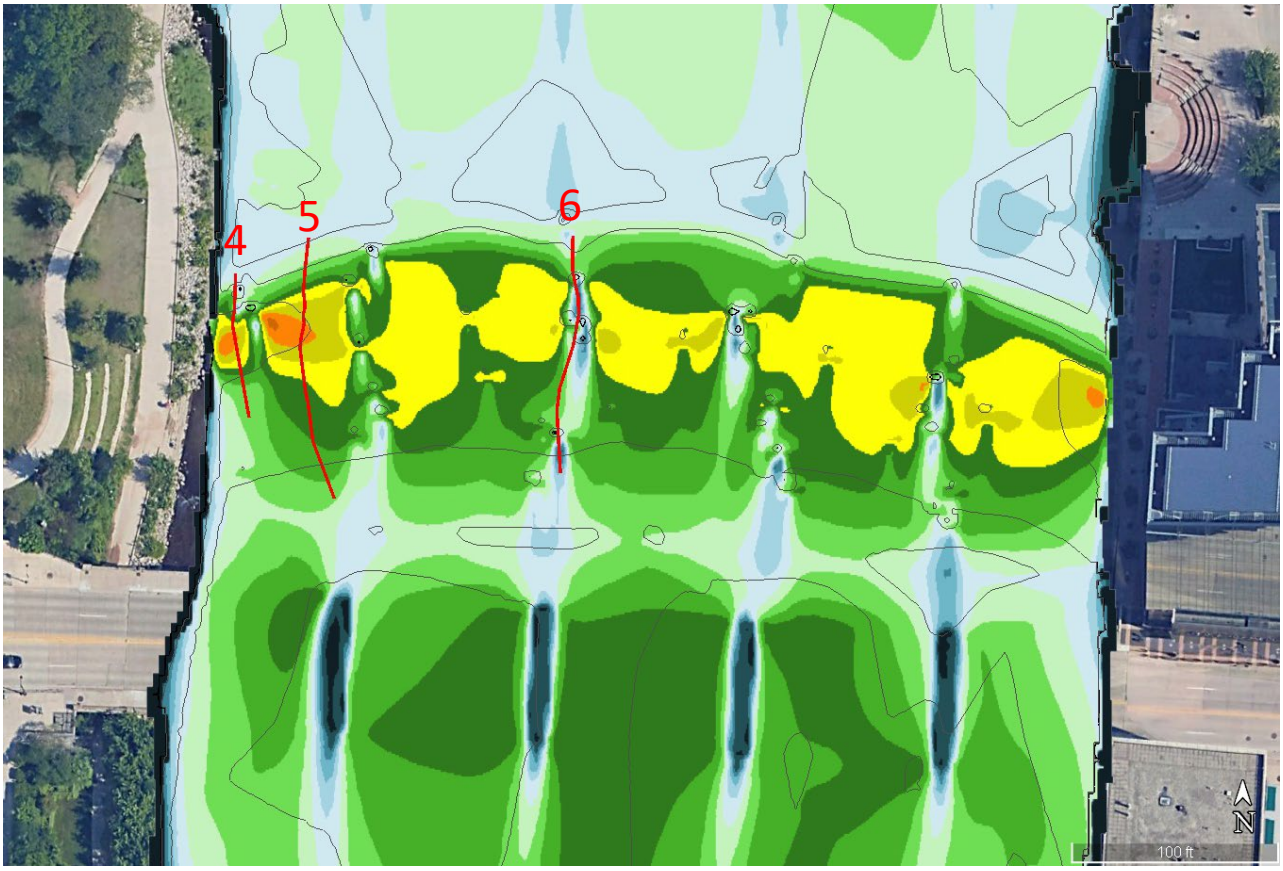
Swimpaths 1-3

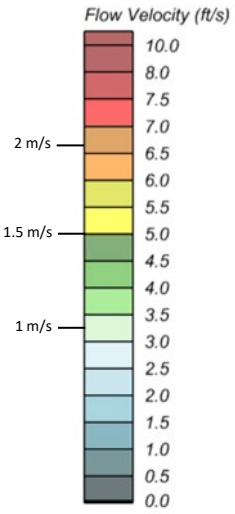




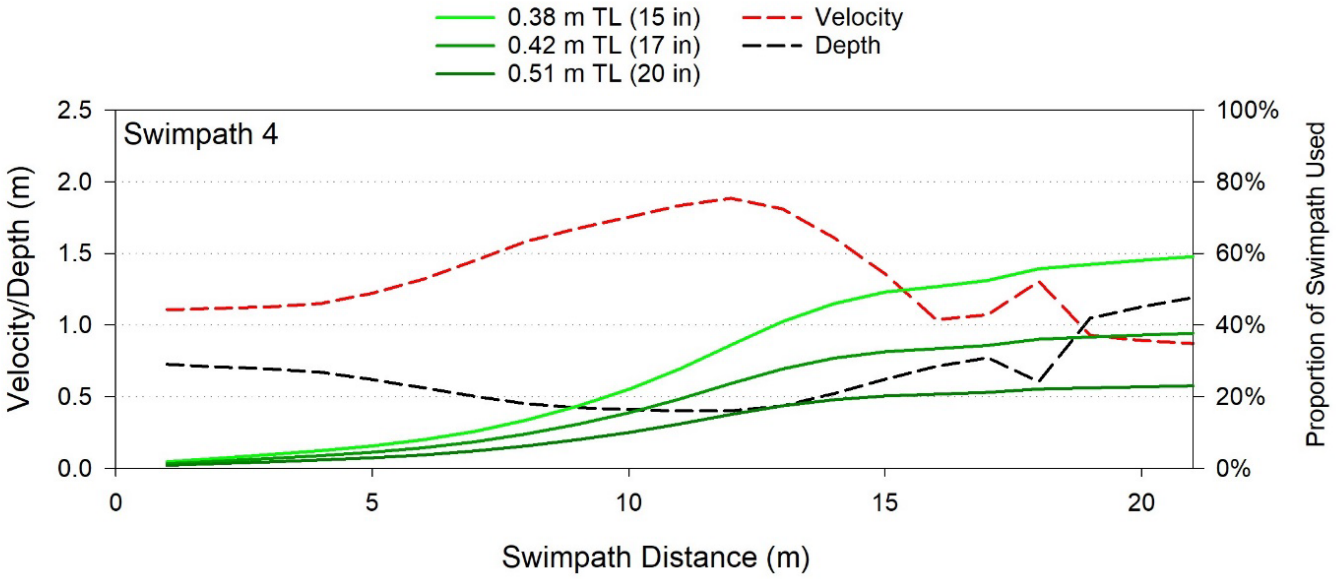


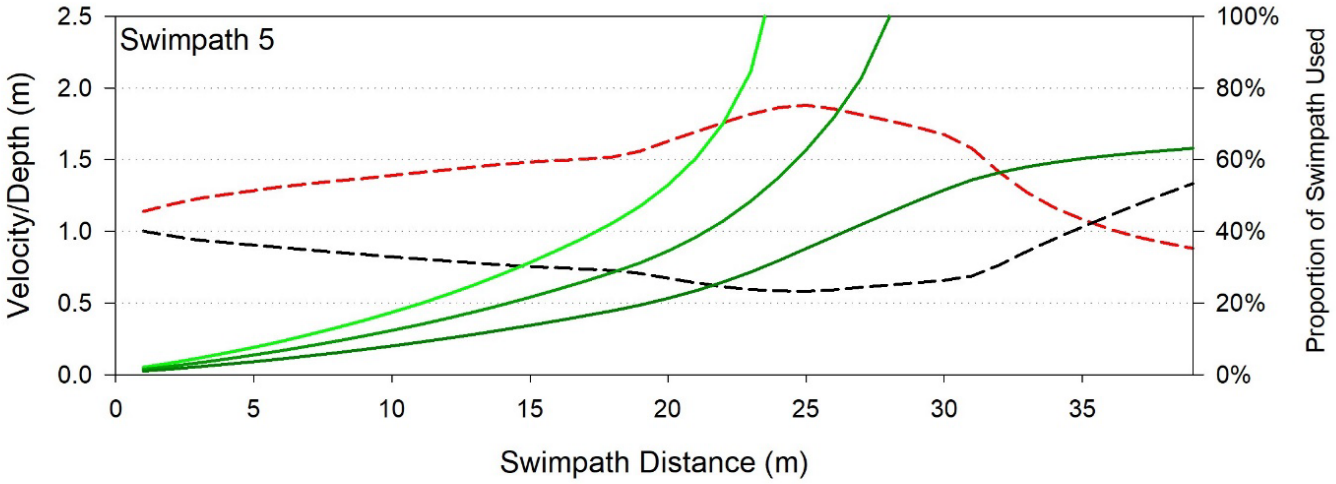
Pearl Street to Gillett Bridge (Riffle Structure/Boulder Cluster)
5,000 CFS

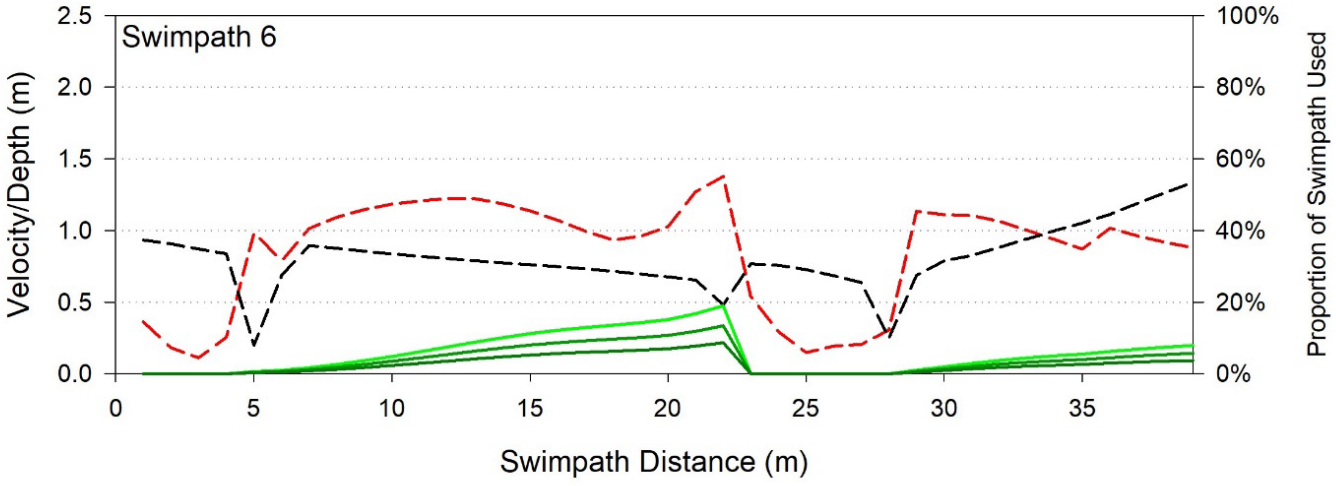




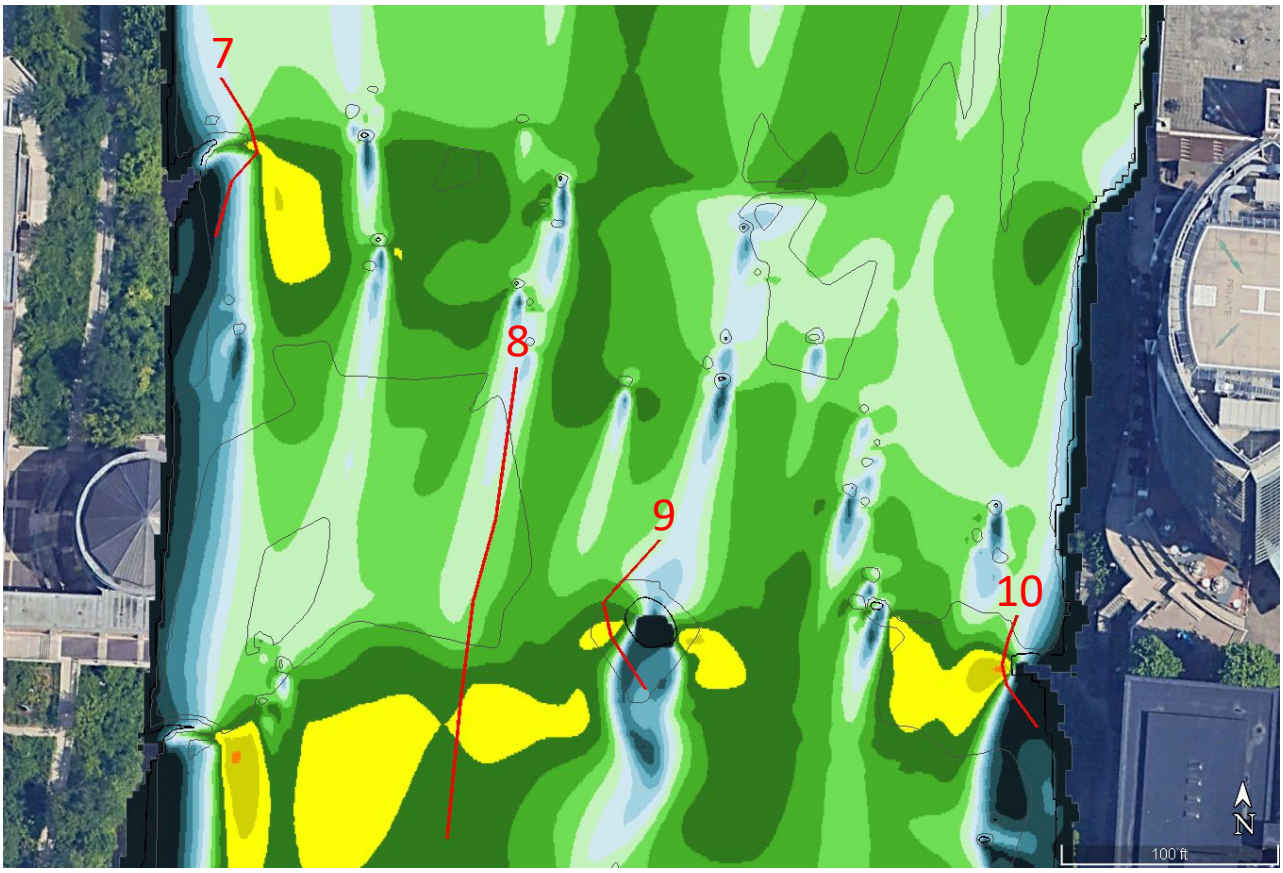
Swimpaths 4-6

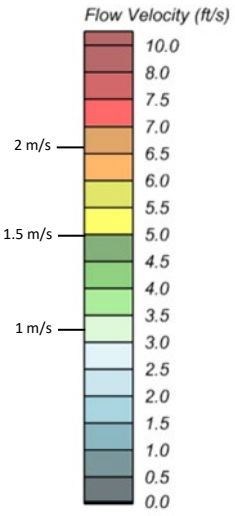




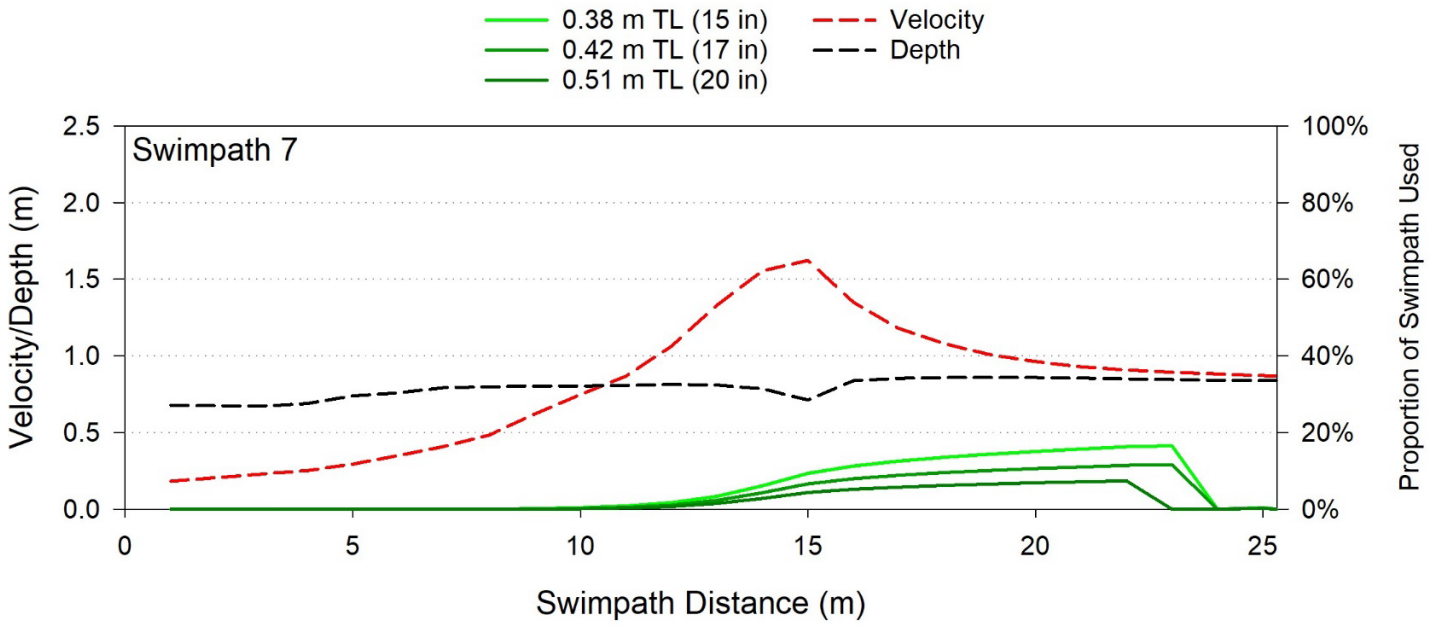


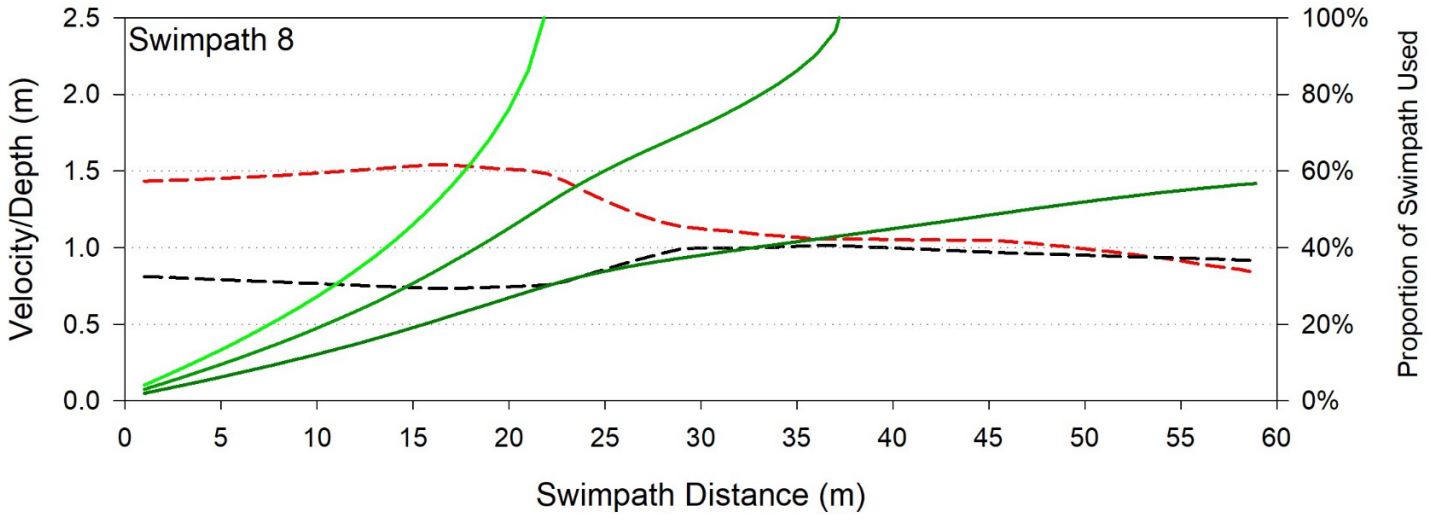
GR Public Museum to Pearl Street (J-hooks/Riffle)
3,900 CFS

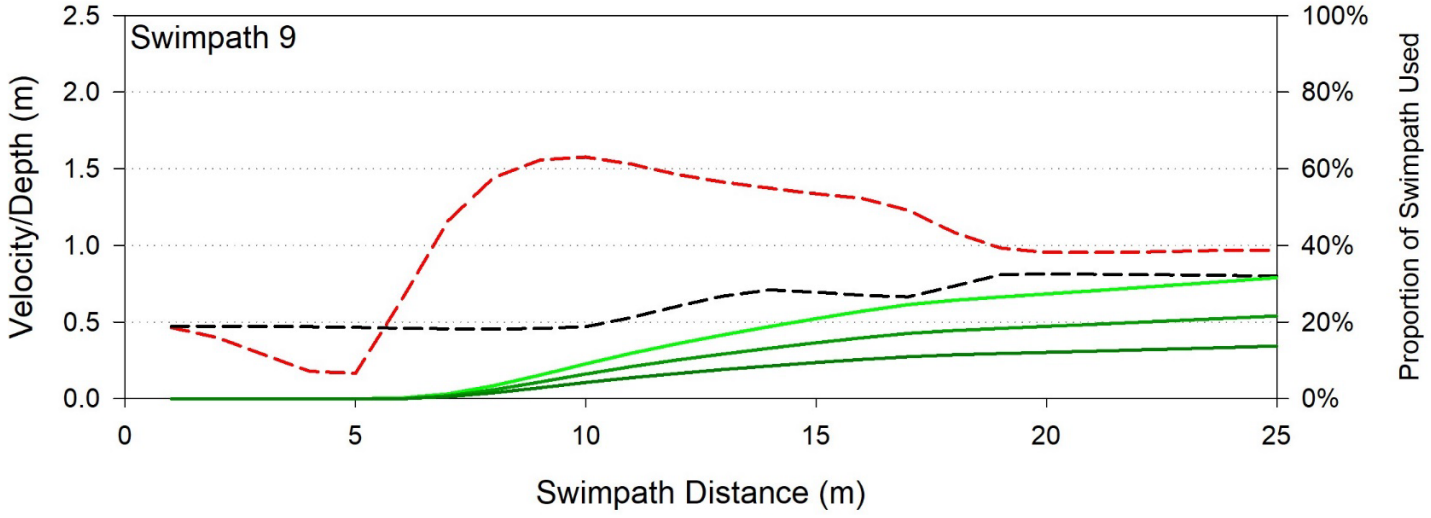




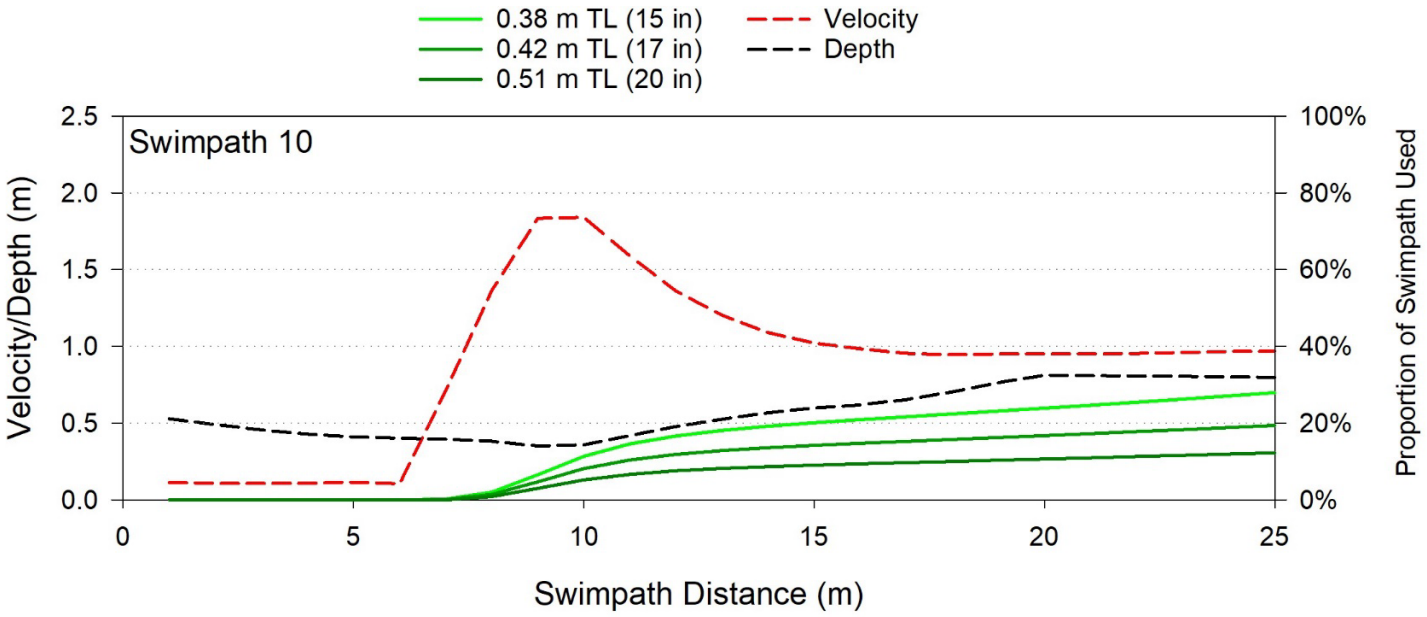
Swimpaths 7-9



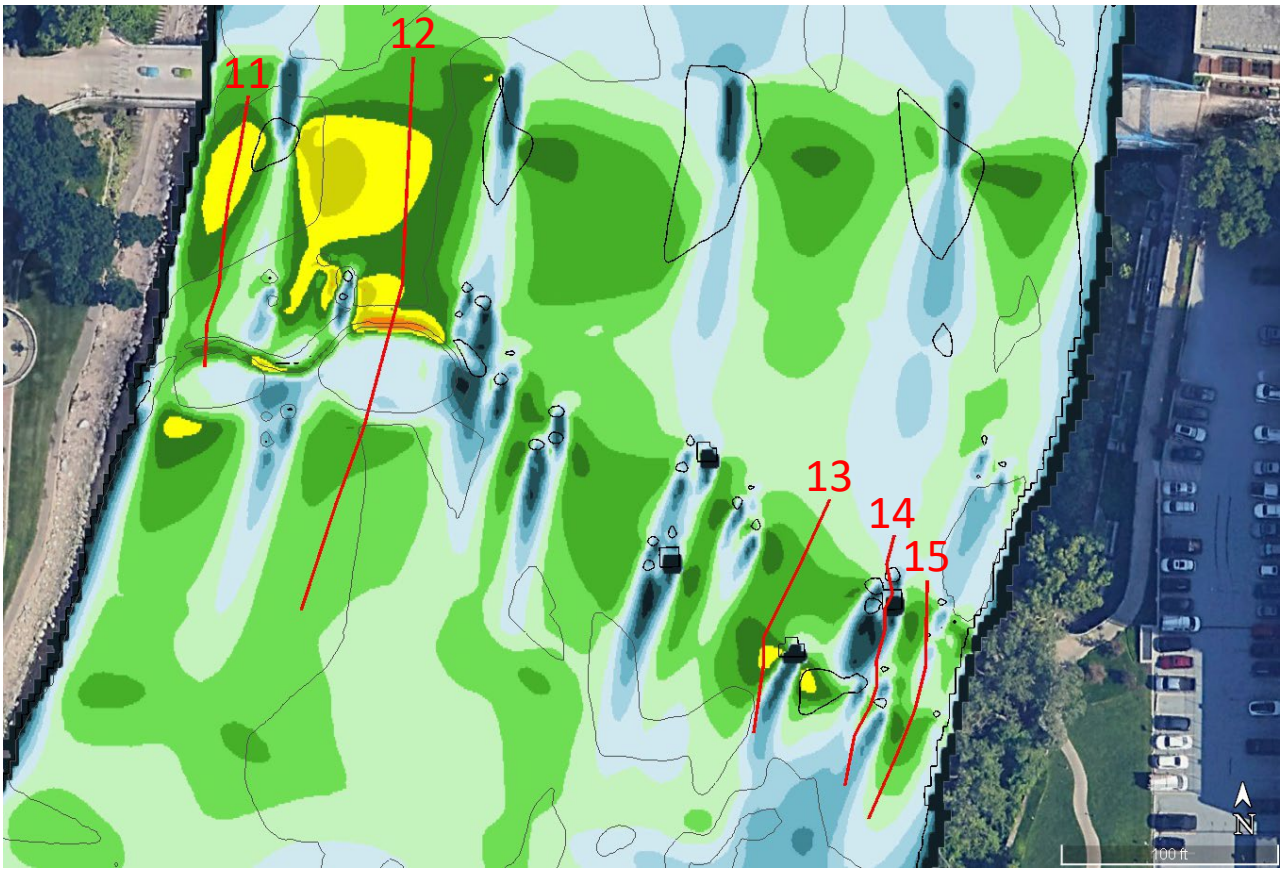


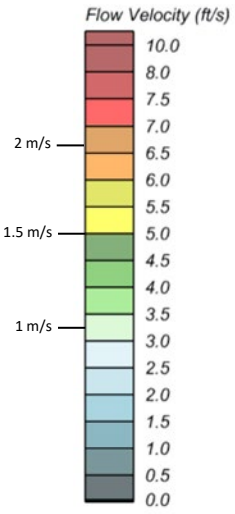


Swimpaths 10

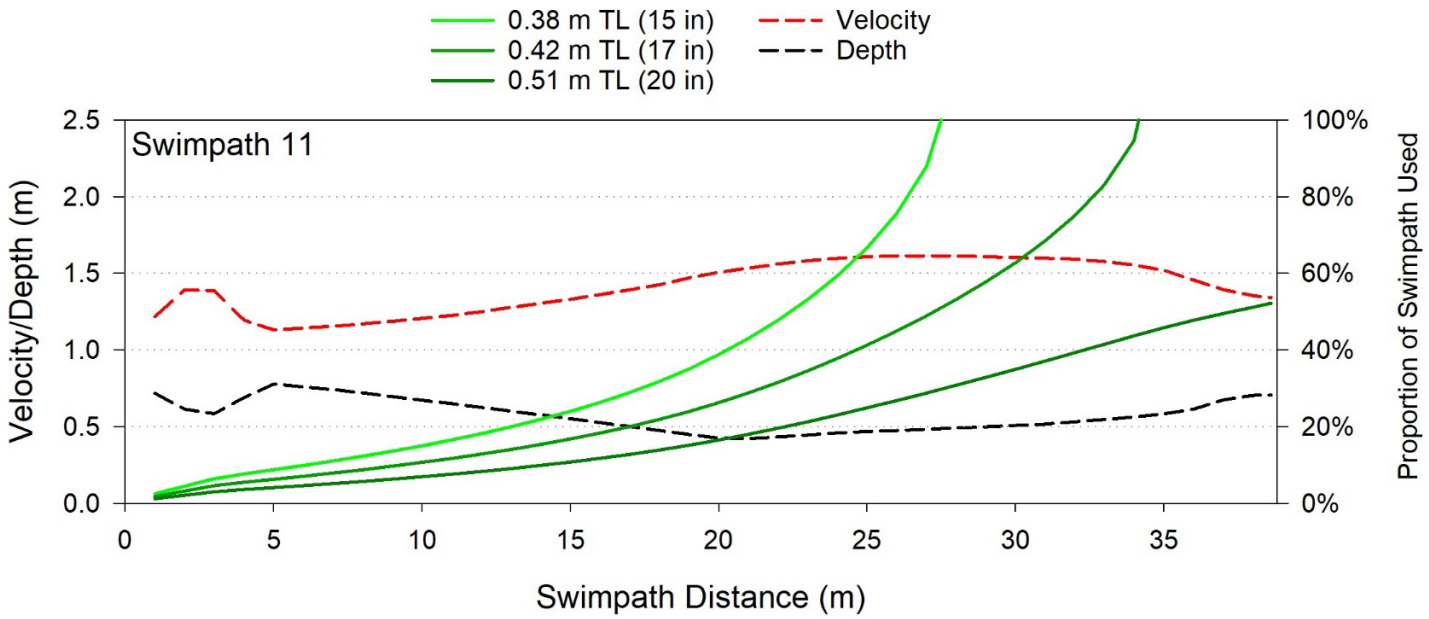


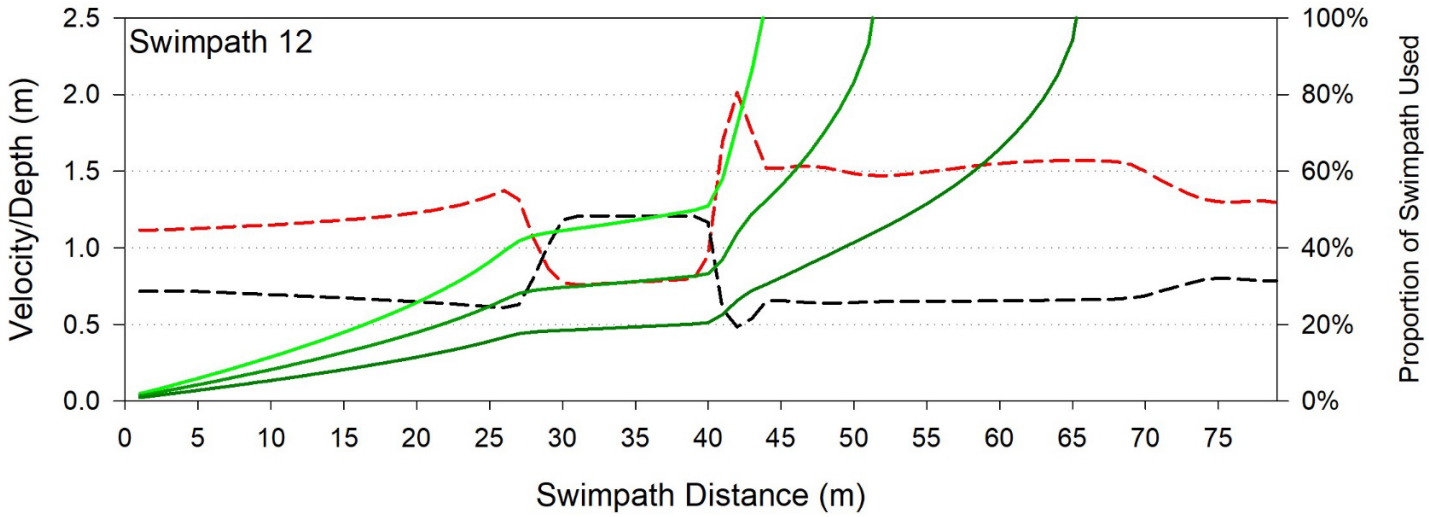
Downstream of Blue Bridge (Riffle/boulder clusters) 2,500 CFS

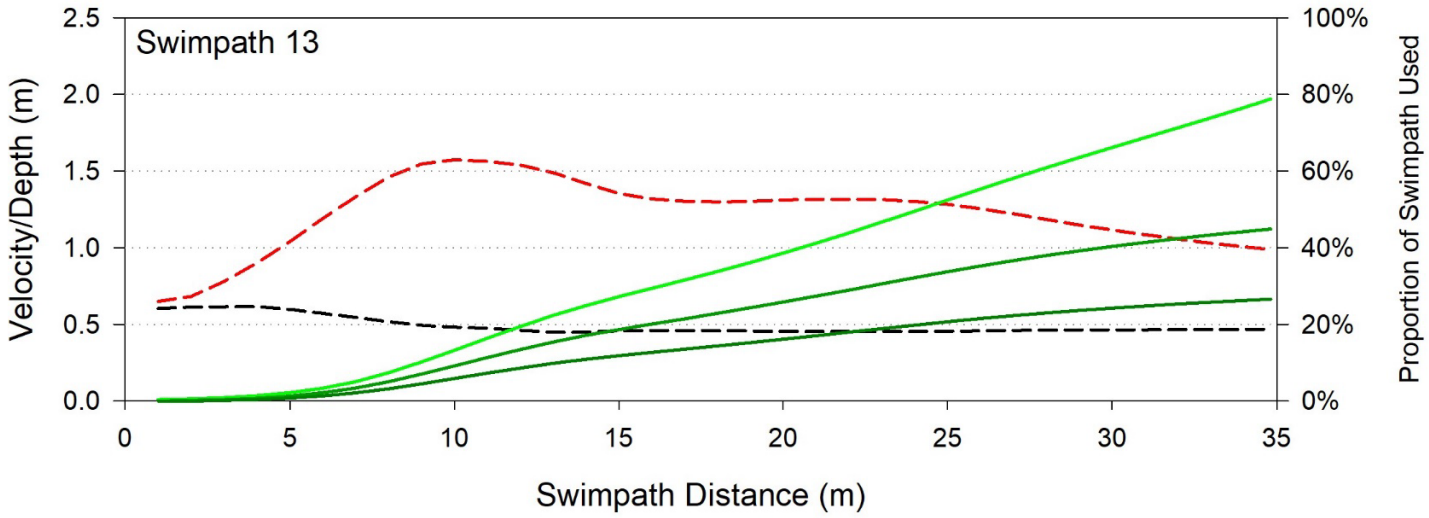




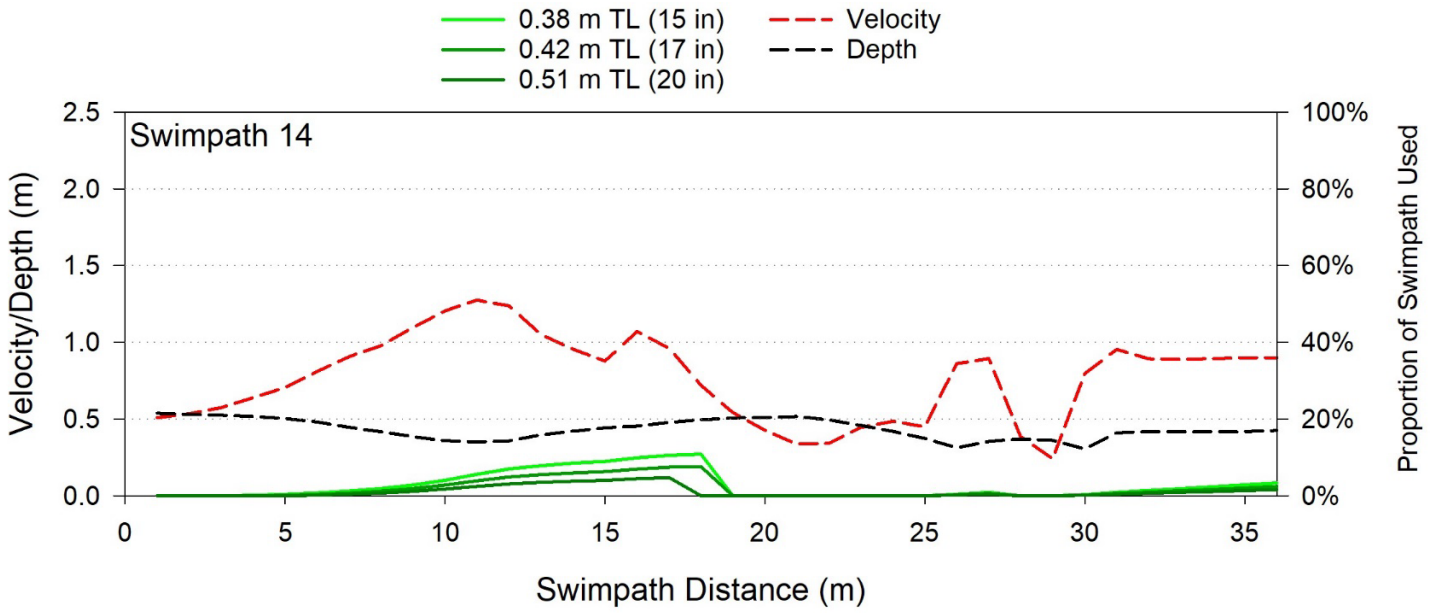
Swimpaths 11-13

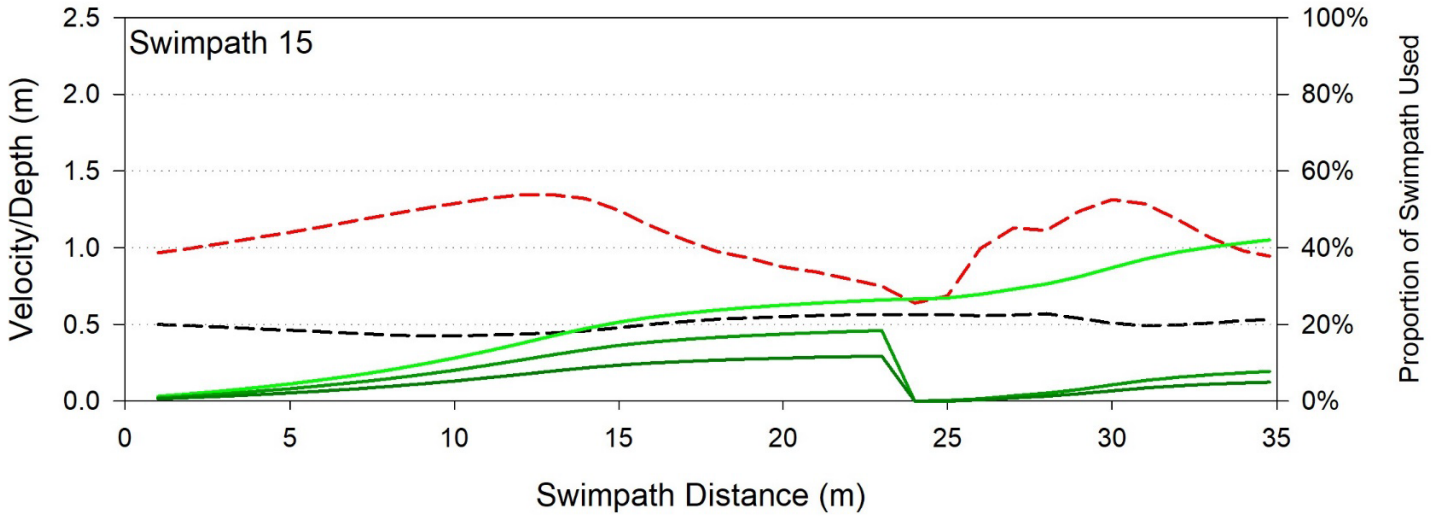






Swimpaths 14-15





APPENDIX E

Other Supporting Information

Grand River-Lower Reach Project Monitoring Plan 4/2024

Grand River- Lower Reach Project

City of Grand Rapids

MONITORING PLAN

April 2024

This monitoring plan describes the monitoring that will be conducted as part of the project.

Construction Monitoring

1. Ensure the project is constructed in compliance with the project's plans, specifications, and permit requirements using industry standard methods.
2. Visually monitor turbidity downstream of the project area. If turbidity is visible at the next City of GR bridge downstream of the project area, the City will work with the contractor to adaptively management the current operation and ensure best management practices are in place and functioning appropriately.

Post Construction Monitoring

1. Within a year of completion or as soon as flow conditions are suitable, in-channel hydrographic survey work will be conducted,
2. Prepare and Submit as-built information including:
    a. survey documenting as-built conditions where the bed and banks are altered and restored.
    b. survey of the water surface profile at normal flow through the project reach.
3. Conduct project inspections for a period of 2 years. Visual inspections of each structure will be conducted from the river's edge following bankfull discharge events meeting or exceeding 13,000 cfs to ensure the structures area still functioning according to the original design intentions.

APPENDIX E

Other Supporting Information

Cumulative Impacts Analysis
City of GR to EGLE
June 2024

OFFICE OF
CITY
ENGINEER

CITY OF GRAND RAPIDS

May 13, 2024

To: Michigan Department of Environment, Great Lakes, and Energy

RE: Cumulative Impacts Analysis
City of Grand Rapids Projects along the Grand River

To whom it may concern:

At EGLE's request, in connection with its review of the City's application for permits under Parts 301, 303, and 31 of the Natural Resources and Environmental Protection Act ("NREPA") for the Grand River Revitalization Project (the "Project"), the City of Grand Rapids compiled a list of projects planned along the Grand River on City-owned property or where the City may be the State permit applicant. EGLE also specifically asked the City to include the River for All projects on this list. The City has included the River for All (RFA) projects, though these projects are only in the City's Parks and Recreation 2022 Strategic Master Plan, and the specific design and schedule for implementation for most of them are currently unknown. The narrative of the projects and impacts shown below for the River for All projects are based on conceptual graphics, and future projects may be significantly different. Some of these projects may not receive funding and would not be built.

The following changes have been made since the previous version dated March 7, 2024 was submitted:

1. Updates for the Lower Reach Project Design
2. Miscellaneous typographical improvements

Maps and Figures showing the location of the projects are attached as Appendix A; a table of the projects and simplified activity information is attached as Appendix B; a narrative describing the projects and anticipated impacts from the projects is attached as Appendix C; and available design drawings are attached as Appendix D.

The projects on the list vary in status from purely conceptual renderings to permit-level design. Project status has been labeled as either "Master Plan only", "concept design", "active design" or "permitting". Definitions of each status are included in Appendix B. Only projects in the active design or permitting phases have progressed enough to be able to calculate any regulated activity. Impacts related to the Master Plan and concept design projects have been estimated based on current renderings or concept plans; these estimates are likely to change as design progresses. For projects in the active design phase, the City has included the estimated work in wetlands, bottomlands, and floodplains, but these estimates are subject to change prior to submittal of the permit application. The projects in the permitting phase have the State's permit application number included in the table so those project files may be easily

referenced. All other projects have a page number listed to indicate which page the drawing or set of drawings is in Appendix D.

Sincerely,



Tim Burkman, P.E.
City Engineer
City of Grand Rapids

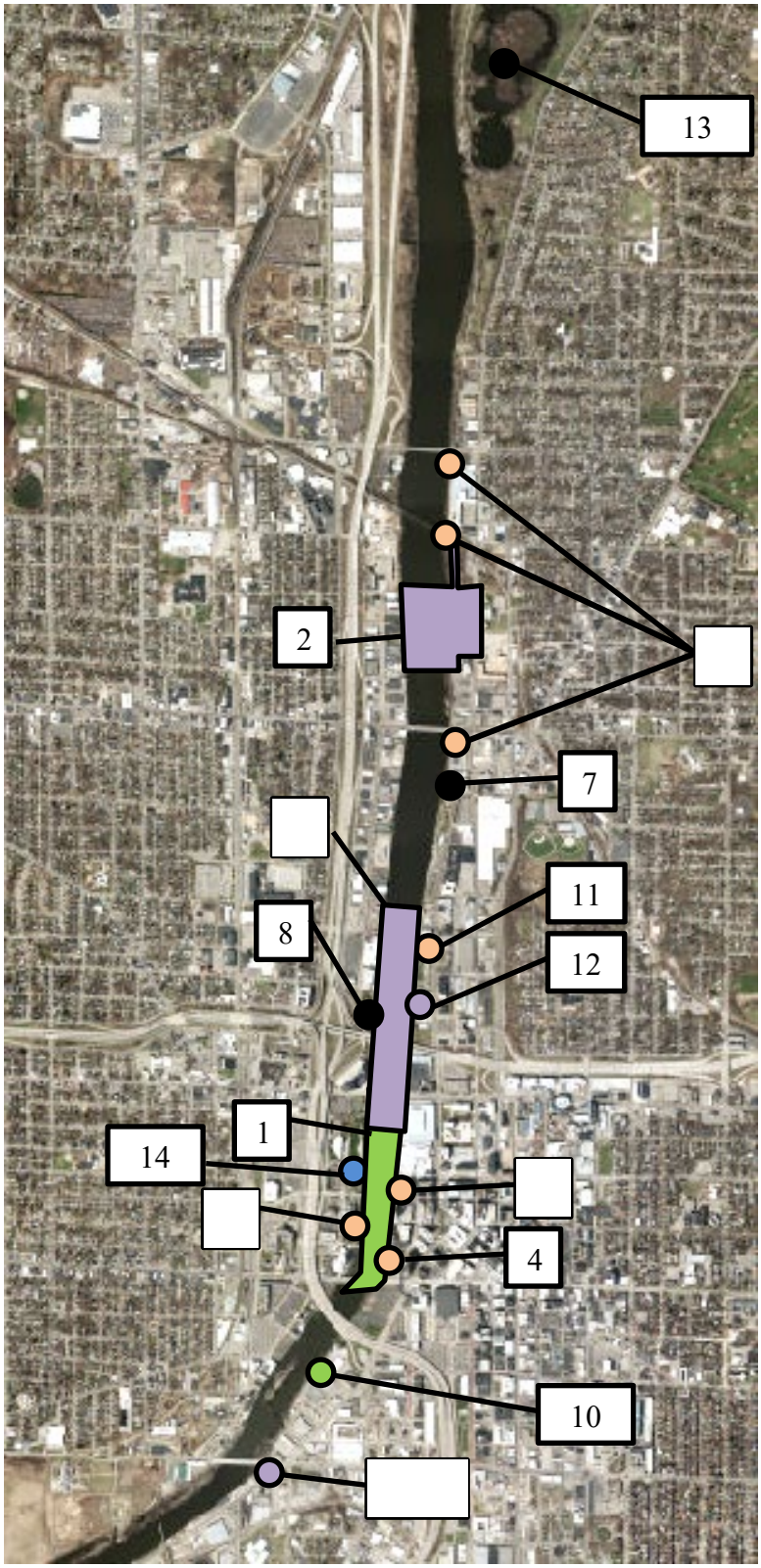
Encl.
Appendix A - City of Grand Rapids Projects on the Grand River Map
Appendix B – Table of Ancillary Grand River Projects
Appendix C – Narrative of Anticipated Impacts of Ancillary Grand River Projects
Appendix D – Drawings

Appendix A:
City of Grand Rapids' Projects on the Grand River Map

EGLE Permit Application
Date Revised: May 9, 2024

Site	Project Name
1	Lower Reach
2	Corps Project - including River for All (RFA) #2
3	Lyon Edge Project
4	East River Edge Sidewalk Project (Campau)
5	GRPM Riverfront – RFA #6
6	Leonard St. to Ann St. Trail - RFA #1
7	Coldbrook Water Pump Station -RFA #3
8	Fish Ladder Park RFA #5
9	Wealthy St Access
10	201 Market Ave
11	Canal Park
12	6th St. Park
13	Riverside Park
14	Ah-Nab-Awen Park - South

	Permitting Phase
	Active Design
	Concept Design
	Construction
	Master Plan Only



Appendix B
Table of Grand River projects

Appendix B - City of Grand Rapids - Table of Ancillary Grand River Projects

Updated: 6/20/2024

Site	Project	Permit / Submission Number [Or Page Number in Packet]	Current Status	Wetland Impact[1] (Acres)	Included in JPA	Earthwork Below OHWM (CY) Estimated Dredge[1]	Included in JPA	Estimated Fill[1]	Included in JPA	Permanent Stream Bottom Activity Area[1] (Acres) Estimate	Included in JPA	Earthwork within Floodplain (CY) Estimated Dredge[1]	Included in JPA	Estimated Fill[1]	Included in JPA	Estimated Mussel Take[1] Estimate	Included in JPA	T&E Species Evaluation
1	Lower Reach	HQ2-Y2FM-WS9TA	Active Design	0.01	0.01	12,880	14,244	20,020	15,755	11	7.1	1,230	1448	750	724	13,944	13,634	Formal Consultation Initiated
2	Corps Project - including River for All (RFA) #2	[1-7]	Concept Design	0.21		8,800		49,000		16		17,000		10,000		88,600		Estimate included in Report
3	Lyon Edge Project	WRP036257 v.1	Construction	0	0	0	0	0	0	0	0	459	459	609	609	-	0	MNFI & USFWS Inquiries Completed
4	East River Edge Sidewalk Project (Campau)	WRP036258 v.1	Construction	0	0	617	617	758	758	0	0	800	800	965	965	-	0	MNFI & USFWS Inquiries Completed
5	GRPM Riverfront – RFA #6	WRP037067 v.1	Construction	0	0	391	391	382	382	0	0	1,221	1221	1,067	1067	-	0	MNFI & USFWS Inquiries Completed
6	Leonard St. to Ann St. Trail- RFA #1	WRP040128 v.1	Construction	0.13	0	236	0	1044	0	0.32	1	68	381	1496	480	4,860	0	MNFI & USFWS Inquiries Completed
7	Coldbrook Water Pump Station - RFA #3	[8]	Master Plan only	0		300		75		0.03	2	800		500		85		Estimate included in Report
8	Fish Ladder Park - RFA #5	[9]	Master Plan only	0.25		500		400		0.08	3	700		400		620		Estimate included in Report
9	Wealthy St. Access	[10-12]	Concept Design	0.15		20		250		0	4	0		0		25		Estimate included in Report

1. Cells in this column are estimates based on current info of early stages of design. Values will likely change thru design.

Site	Project	Permit / Submission Number [Or Page Number in Packet]	Current Status	Wetland Impact[1] (Acres)	Included in JPA	Earthwork Below OHWM (CY) Estimated Dredge[1]	Included in JPA	Estimated Fill[1]	Included in JPA	Permanent Stream Bottom Activity Area[1] (Acres) Estimate	Included in JPA	Earthwork within Floodplain (CY) Estimated Dredge[1]	Included in JPA	Estimated Fill[1]	Included in JPA	Estimated Mussel Take[1] Estimate	Included in JPA	T&E Species Evaluation
10	201 Market Ave (expanded to include East River Edge Fulton to Wealthy)	HPZ-0BP4-6TQCH	Permitting	0.5	0.09	10000	1790	6000	2635	2	0.05	26500	17934	16000	4377	500	0	MNFI & USFWS Inquiries Completed
11	Canal Park	WRP040025 v.1	Construction	0	0	350	78	300	43	0.03	0.01	3800	4420	2200	3583	45	0	Estimate included in Report
12	6th St. Park	[13]	Concept Design	0.05		5000		3000		1		10000		6000		1,400		Estimate included in Report
13	Riverside Park	[14]	Master Plan only	TBD		TBD		TBD		0.5		TBD		TBD		2,440		Estimate included in Report
14	Ah-Nab-Awen - Indian Mounds	[15-17]	Active Design	0		0		0		0		56		128				None anticipated
	Totals (Rounded)	-		1.30	0.10	40,000	17,000	82,000	19,600	30	17.16	63,000	26,700	40,000	11,800	112,519	13634	

Status Definitions					
Master Plan only	These projects have schematic designs for the purpose of master planning; The attached rendering are for planning purposes only.	Active Design	Design and construction funding identified, plans & specifications are being developed, permit applications to be submitted within a year	Construction	The project has received a permit and is under construction or will be starting construction soon.
Concept Design	Consultant engaged to consider rough ideas. Project may or may not have funding. No timeline is available for construction	Permitting	Permit applications already submitted with the State	Complete	Construction is complete

1. Cells in this column are estimates based on current info of early stages of design. Values will likely change thru design.

Appendix C
Narrative of Anticipated Impacts from Grand River projects

This document describes the cumulative impacts on regulated aquatic resources which may result from other projects in the vicinity of the Lower Reach Project. All impacts discussed or quantified herein are based on information currently available at the time of permit submission. Impacts for projects not at permitting level were estimated based on assumptions. Impacts have been identified which may occur from projects the City of Grand Rapids has in permitting, active design, concept design, or in the Master Plan only. Potential impacts to aquatic resources discussed here include:

- Impacts on the Public's right to Navigate, Fish, and Fowl on the Grand River;
- Impacts on Bed Mobility, Downstream Turbidity, and Sediment Transport;
- Impacts on Wildlife and Habitat, including Threatened and Endangered Species;
- Impacts to Wetlands;
- Impact on Stream Function;
- Impacts on Modeled Flood Risk;
- Temporary Construction Impacts

Summary Project Narratives

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
This project would remove the four low-head dams, and place natural rock and boulders to install two expansive riffles with emergent boulders, three unique boulder arch structures, three boulder vane structures for access along the banks, and numerous scattered habitat boulders into the river. The project proposes the placement of approximately 5,000 tons of boulder and 15,000 tons of rounded alluvial rock.

In terms of adverse impacts to a regulated resource, the Project has been designed to have limited, temporary impacts. Specifically, construction of the Project will necessitate the following temporary adverse impacts: (i) the public's ability to navigate and recreate on the Grand River will be temporarily limited in certain areas due to temporary restrictions on river access during construction; (ii) there may be a temporary increase in bed mobility and downstream turbidity and sediment transport during construction; (iii) there will be temporary adverse impacts on aquatic wildlife; and there will be a temporary adverse impact to wetlands of 0.01 acres. The project will also have a seperate, permanent impact to wetlands of 0.01 acres.

Corps Project including RFA#2 (Concept Design):
The Great Lakes Fishery Commission has contracted with the U.S. Army Corps of Engineers (Corps) to conduct an Environmental Impact Statement (EIS) for the Corps project. Fourteen alternatives have been identified and will be considered for the project. Upon completion of the formal EIS process, the Great Lakes Fishery Commission will select the preferred alternative and issue a Record of Decision.

For the purpose of this analysis, the City and GRWW have analyzed the potential cumulative impacts for the City's preferred alternative, which is to remove the 6th Street Dam, construct an

adjustable hydraulic structure (AHS), and install diversified hydraulic features in the Grand River. The proposed AHS would incorporate a portage route connecting the upstream and downstream sides of the barrier for navigation. Similar to the Lower Reach Project, once constructed, the Corps Project alternative evaluated here is anticipated to have positive impacts on regulated resources.

The proposed site of the AHS, as evaluated for this application, is adjacent to the River for All (RFA) Site #2, the decommissioned Water Department Storage Yard. River for All Site #2 will be decommissioned as a storage yard for the City of Grand Rapids Water Department and is re-envisioned as a riverfront park. Currently, this site is being considered for access and staging for the construction of the proposed AHS. The existing site is primarily a compacted gravel parking lot/storage yard with ancillary structures for water main and storm water pumping stations. The former railroad bed serves as the top of the flood protection system, but the flood protection is envisioned to be relocated and increased as part of the project. When completed, river access will dramatically increase and transform this site into a regional recreation hub. Concept Design plans for RFA Site #2 call for:

1. An elevated canopy trail to connect pedestrians to the forested canopy above and protect wetland habitat below.
2. A lodge for year-round educational and cultural events.
3. Increase the flood protection system to 100-year base flood elevation plus 3 feet.
4. Potential repurposing of the water storage tank providing a unique space for large events and daily use.
5. A logjam inspired nature playground.
6. A dedicated drop-off area to accommodate large group access and circulating river traffic.
7. River terraces provide additional access to the water's edge
8. 600 lineal feet of new shared use trail.
9. Removal of railroad berm and terraced site to allow access into and out of the river as well as creating a naturalized edge and additional flood storage.
10. River landing provides a safe and accessible public river access space.
11. A large universally accessible walk provides river recreation opportunities to the north and south of the AHS.
12. Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project will include removal of stairs and amphitheater to create a passive and active recreational area, connection of existing routes, and pedestrian safety improvements related to vehicular traffic in Lyon Square.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
This river edge sidewalk has been undercut by river flows, and the area is not currently open to the public as it presents public health and safety concerns. This project will restore the stability and safety of the trail and improve safe access to the river edge from the proposed paved multi-use trail.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
This project will remove existing sidewalk and install a new trail down to the river's edge to improve access. The project will also add a new access to the east side of the museum and will include a dual-purpose step/seating area and outdoor classroom. The improvements will allow unrestricted access for all people and add native vegetation to improve aesthetics, and create aquatic and wildlife habitat

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project has been refined to be an upper non-motorized pathway on the top of a flood protection berm. This project is proposing to provide freeboard to reach FEMA's NFIP accreditation levels above the 100-year base flood elevation.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
The project seeks to transform a property with mostly surface parking lots and storage buildings, which drain directly to the Grand River, into a prominent public recreation and outdoor education amenity. This existing site has a concrete floodwall limiting access to the river.

The new site layout will be an opportunity to provide education on the importance of best management practices related to stormwater and the positive changes happening along the Grand River and its tributaries. This site will be a critical hub for river and trail access. Envisioned improvements include the following:

1. Removal of approximately 150 lineal feet of concrete floodwall allowing access into and out of the river as well as creating a naturalized edge and additional flood storage.
2. Interpretation of Coldbrook Creek to demonstrate the channel's historic alignment and educate the public on the other hidden streams in the area.
3. Flexible plaza spaces adjacent to the building provide areas for outdoor learning, events, and cultural activities, such as canoe building with the Anishinaabe and programmed outdoor recreation activities could be pursued here.
4. Mixed use redevelopment above the 100-year floodplain is anticipated at the corner of Leonard Street and North Monroe Avenue with plazas oriented towards the river.
5. A large multipurpose lawn provides flexible space with an option for future bus drop off
6. ADA and small parking lot is located onsite.
7. An emergency access boat ramp.

Fish Ladder Park – RFA #5 (Master Plan only):
Fish Ladder Park has been identified as an important community gathering spot and the fish ladder structure is an iconic piece of functional art. The park would continue to serve these purposes and the project seeks to enhance and improve the site to function with any future changes to the river. If or when the 6th Street Dam is removed, the Fish Ladder structure would be modified to continue to provide fish passage, and improvements would be implemented within the surrounding park, which would continue to be a primary hub for fishing access. Envisioned improvements include the following:

1. Viewing deck located north of the Fish Ladder.
2. Existing fish ladder structure will remain for rapids viewing and fish observation.

3. Increase the flood protection system to 100-year base flood elevation plus 3 feet.
4. Changing room, restroom, and fish cleaning station.
5. Flexible plaza and adjacent parking area to accommodate small events.
6. Sloped event lawn next to new trees, planted on the high point of the existing berm to provide shade
7. Emergency access boat ramp.
8. Upper viewing perches on the embankment link to Scribner with Fish Ladder Park, provide small lounging pockets and expand spectator areas.
9. Approximately 800 lineal feet shared use trail.
10. Angling and wading access steps link the river trail to the bank.
11. Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.

Wealthy St. Access (Concept Design):
Wealthy St. Access is situated at the southern end of the downtown river corridor and a vital connector for residents within the Roosevelt Park and Black Hills Neighborhoods. The eastern edge is a City-owned parking lot with minimal use. The western edge is a small City-owned parking lot that is also minimally used, with dilapidated stairs that provide access about halfway down to the river. The stairs were originally installed for City workers to access an outfall that is now abandoned. The envisioned improvements will provide equitable river access in an area that currently consists of 15-foot tall concrete flood walls and a neglected river edge with some trees. Please note only one of the river edges is anticipated to be improved in this project, but both potential improvements are shown in the figure in Appendix D. At this time, it is unknown which side of the river the project would occur on. Envisioned improvements include the following:

1. Approximately 250 lineal feet of elevated boardwalk/ramps providing access from the existing parking lot to the river
2. Reconfiguration of the existing parking lot with improved drop-off location
3. Site amenities including pedestrian-scale lighting, benches, litter, and interpretive signage
4. Vegetated rip rap

201 Market Ave. (Permitting, HPZ-0BP4-6TQCH):
The existing river's edge on the east side of the Grand River between Fulton Street and Wealthy Street is approximately 2/3 of a mile. The current parcel contains buildings used to store the City's public works equipment. The river edge condition is a combination of cast in place concrete wall and steel sheet piling. Dependent upon the water level, portions of the river's edge include a sloped bank at the base of the walls. The entire length is populated with a combination of mature large trees and dense scrub-shrub underbrush providing screening of views for the current industrial and commercial uses.

The conceptual designs for the river's edge propose removal of the existing floodwall to provide better access to a more natural shoreline while adding freeboard to the flood control system in order to reach the 3 feet above the 100-year base flood elevation. Flood control will be maintained by utilizing a variety of design features rising to the flood control level with gentler slopes, naturally terraced dolomitic limestone and native plantings combined with walking running and biking trails paralleling the river and joining the properties along the Grand River. The proposed trail will be connected to river access points and public right of ways using

universal design guidelines, creating universal access for all to enjoy the Grand River. This development will coincide with changes in the adjacent parcels in the industrial use to commercial use, public green space, and potentially residential use.

Canal Park (Construction, WRP040025 V.1):
Project proposes to remove and replace approximately 3,810 LF of sidewalk and pathways in Canal Park. The new sidewalk and pathways will be 14-foot wide shared-use trail and raised to meet FEMA's NFIP accreditation requirements. A river terrace area and seat wall is proposed along river's edge. In addition, an event pavilion and plaza are also proposed. A river overlook decks is proposed to provide safe and unobstructed view of the river. A barrier-free floating kayak launch is also proposed. Proposed work activities have been designed to minimize impacts below the OHWM to the greatest extent possible. Furthermore, design meets the 100-year BFE plus required freeboard. Design to the 100-year flood plus required freeboard will provide sufficient flood protection within park area and protect infrastructure and park amenities. The barrier-free floatable kayak launch is the only proposed work past water's edge.

6th St. Park (Concept Design):
This park currently consists of a north/south linear trail, a restroom, fish cleaning station, small pavilion, public parking lot, and a concrete floodwall that spans the entire length of the park from I-196 to 6th Street with only one (1) point of access (which is not universally accessible) to the river located at the 6th Street Dam. Due to the concrete floodwall, there is minimal to no biodiversity along the river's edge. Additionally, there are several storm sewers that discharge into the river through the existing concrete floodwall. The southern half of the park consists of an electrical substation and remnant surface parking lots. The City acquired the parking lot parcels through a Michigan Natural Resources Trust Fund acquisition grant and has been temporarily activating the site. Permanent improvements will not proceed for several years as this is one of the anticipated staging and access sites for the Corps Project. This site will provide an opportunity to transform how the City and its citizens engage with its most valuable natural resource in one of its most prominent downtown locations. Envisioned improvements include the following:

1. 1,800 lineal feet of new shared use trail.
2. Increase the flood protection system to 100-year base flood elevation plus 3 feet.
3. Removal of approximately 740 lineal feet of concrete floodwall allowing access into and out of the river as well as creating a naturalized edge and additional flood storage.
4. River landing providing a safe and accessible public river access space.
5. A large universally accessible walk for river access.
6. Daylighted stormwater outfall and stormwater marsh provide resilient, natural stormwater treatment and re-establish a healthy river edge.
7. Stepped seating terraces at the river edge to provide an expanded, resilient rapids viewing area.
8. A shaded seating edge expands park access, even during high water events.
9. An event pavilion to accommodate concessions, restrooms, and services to support recreation.
10. An event lawn sized for markets, concerts, and a number of other uses.
11. Stormwater terraces treat onsite runoff and provide ecological interest and support habitat restoration.
12. A flexible mid-level terrace can host seasonal events and recreation.

13. A skate park in the area near I-196.
14. Non-motorized watercraft takeout point

Riverside Park (Master Plan only):
Riverside Park is Grand Rapid's largest and most prominent park for active and passive recreation users. The 182-acre park with approximately 2,000 lineal feet of river frontage lies almost entirely within the 100-year flood limit with a few exceptions along Monroe Avenue. The river edge is primarily naturalized with the exception of some armored locations and 3 public boat launch facilities. The park also has an interior lagoon with two heavily vegetated islands. Numerous smaller improvements have been made within the park over the last 20 years, but the last major investments were implemented in the late 1990's. Due to the park's popularity, use, and location within a highly fluctuating floodplain, most of the built assets are nearing the end of their functional life cycle. Roads, bridges, trails, and other structures are in need of repair, replacement. or removal. Additionally, over 100 acres of the park consists of maintained turf. This practice, along with the surface runoff from interior roads and parking, and siltation from seasonal flooding have contributed to poor water quality within the park's lagoon. The park is also situated at the downstream end of several large storm outfall pipes. These pipes collect stormwater from an approximately 1,800-acre watershed to the east and discharge directly into the Grand River. The City's master plan contains a broad list of ambitious and exciting changes for the park that focus on the following community priorities:

1. Remove, replace, and expand non-motorized trails network within the park
2. Daylight existing stormwater low-flow and route through new bio-swales, rain gardens, constructed wetlands to collect, cleanse and infiltrate water prior to reaching the lagoon and/or Grand River.
3. Reduce road and parking impervious surfaces
4. Increase native wetland, wet meadow, and upland plantings, especially along areas receiving surface runoff.
5. Renovate existing restrooms and maintenance facility.
6. Provide multi-purpose community waterfront center with restrooms, concessions, large event area, accessible watercraft launch, and river amphitheater.
7. Improve existing active recreation programs including sport fields, cross country course and disc golf.
8. Improve accessibility to the lagoon and river's edge as well as increase edge resiliency through use of bio-engineering techniques.
9. New dog park dedicated as off-leash area
10. Improve all 3 existing boat launches
11. Renovate existing play areas and incorporate nature-based play elements

Ah-Nab-Awen Park - South (Active Design)
Ah-Nab-Awen Park is on the west side of the Grand River between Pearl and Bridge Streets and a vital outdoor event space, trail connector, and cultural site for guests and residents in the heart of downtown. The proposed design for the south end of the park between Gillett Bridge and Pearl Street includes removal of the representative burial mounds, aging restroom and improvements to sidewalks that are not ADA compliant, and cultural interpretation. Special

attention was also given to transform the “Fake Mounds”, as they are referred to by the Grand River Band of Ottawa Indians who helped shape the proposed improvements from an under-utilized and misrepresented historical area to a space for healing, celebration, and a welcoming environment for both tribal members and the general public.

Impacts on the Public's right to Navigate, Fish, and Fowl on the Grand River

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
Removal of the four low-head dams is anticipated to make the Grand River in this reach more accessible, and therefore, improve the public's right to navigate, fish, and fowl.

Corps Project including RFA#2 (Concept Design):
Due to the proposed portage route around the AHS structure that currently does not exist, this project is expected to have a significant positive impact on the public's right to navigate, fish, and fowl on the Grand River. The site improvements related to RFA #2 will also improve access to and from the river, also positively impacting the public's right to navigate, fish, and fowl on the Grand River.

During construction of the project, it may be necessary to temporarily restrict or prohibit use of a portion of the river for public safety.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project is expected to have a positive impact on the public's right to navigate, fish, and fowl on the Grand River by enhancing the riverfront to provide a gathering space for the public along the river's edge. The stairs down to the river in this area will be removed, but two access points to the river are nearby along the Devos Place Convention Center and across Pearl St. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
The East River Edge sidewalk improvements will have a positive impact on the Public's right to navigate, fish, and fowl on the Grand River by rehabilitating and improving access along the river. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project. This public walkway is currently closed due to a public safety hazard and will not reopen until this project occurs. Severe erosion has substantially undercut the sidewalk creating a public safety hazard.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The Grand Rapids Public Museum is reimagining their riverfront and are proposing to remove the large riprap and scrub-shrub vegetation and install a concrete sidewalk with foundation along a portion of their property. This change is expected to have a positive impact on the Public's right to navigate, fish, and fowl as it is creating two access points with universal access design principles to the river's edge that do not currently exist. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
The walkway will provide better access along the river's edge. No adverse impacts are anticipated on the Public's right to fish and fowl the Grand River from this project either.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This site is anticipated to have a positive impact on the Public's right to navigate, fish, and fowl on the Grand River. By removing approximately 150 lineal feet of concrete floodwall to allow access into and out of the river and adding a naturalized river edge with universal design concepts, access to the river will improve allowing anyone to fish or fowl on the Grand River. With improved access, this will positively impact the public's river to navigate the river. There are no anticipated improvements that would adversely affect the public's right to navigate, fish, or fowl on the Grand River.

Fish Ladder Park – RFA #5 (Master Plan only):
This project is anticipated to have positive impacts on the public's right to fish, fowl, and navigate the Grand River. One of the main goals of this project is to provide universal access to the riverfront for all people to enjoy. The proposed improvements of adding more access and associated support facilities (i.e., changing rooms, restrooms, fish cleaning stations) are all added to support the public's use of the river. No adverse impacts are anticipated on the Public's right to fish, fowl, and navigate the Grand River from this project.

Wealthy St. Access (Concept Design):
This project is anticipated to have positive impacts on the public's right to fish, fowl, and navigate the Grand River. This project would add access to a site where minimal facilities currently exist to improve the public's right to fish, fowl, and navigate the Grand River. There are no anticipated adverse impacts on the public's right to fish, fowl, and navigate the Grand River.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
One of the main goals of this potential project is to provide universal access to the riverfront for all people to enjoy. The proposed amenities, including the river edge and bridges, will be designed to add access to aid in the Public's abilities to fish, fowl, and navigate the river. Therefore, this project would have a positive impact on the Public's right to fish, fowl, and navigate the Grand River.

Canal Park (Construction, WRP040025 V.1):
One of the main goals of this potential project is to provide universal access to the riverfront for all people to enjoy. With the removal of the concrete retaining wall, and the addition of a large universally accessible walk, this will positively impact the public's right to fish, fowl, and navigate the Grand River. There are no anticipated adverse impacts to the public's right to fish, fowl, and navigate the Grand Rapids associated with this project.

6th St. Park (Concept Design):
One of the main goals of this potential project is to provide universal access to the riverfront for all people to enjoy. The current river access is limited in its ability to provide sufficient access to all people. With the removal of the concrete retaining wall, and the addition of a large universally accessible walk and stepped terrace seating, this will positively impact the public's right to fish, fowl, and navigate the Grand River by creating more universally accessible space at the edge of the Grand River. There are no anticipated adverse impacts to the public's right to fish, fowl, and navigate the Grand Rapids associated with this project.

Riverside Park (Master Plan only):
Riverside Park currently offers a wide variety of options for people to access the Grand River. With this project, the options would be to further enhance those to provide universal access and boating access or to renew the current assets. Therefore, positive impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated. No adverse impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated.

Ah-Nab-Awen Park - South (Active Design)
Ah-Nab-Awen Park currently offers for people to access the Grand River. With this project, the options would be to further enhance those to provide universally accessible walks to the existing main path leading down to the river. Therefore, positive impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated. No adverse impacts for the public's right to fish, fowl, and navigate the Grand River are anticipated.

Impacts on the Bed Mobility, Downstream Turbidity, and Sediment Transport

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
This project is not anticipated to have any adverse permanent impacts on bed mobility, downstream turbidity, and sediment transport. Temporary increases in downstream turbidity may occur during construction, but proper best management practices will be utilized to minimize impacts.

Corps Project including RFA#2 (Concept Design):
The Corps Project, as being analyzed in this document, is not expected to have adverse impacts on bed mobility, turbidity, or sediment transport. The hydraulic gradient over the dam would be distributed over the proposed AHS and several hydraulic features, each designed with a 2x factor of safety against mobility. In this way, the hydraulic features and AHS would function to maintain grade control throughout the reach. Additionally, modeling and design of features would verify that any increases in the scour potential over existing riverbed would not exceed threshold mobility for existing substrate. Similar to the Lower Reach Project, care will be taken through design and modeling to verify that ongoing accumulation of fine sediment within the project reach is avoided and minimized.

Temporary turbidity during construction would be managed with industry standards and assumed to be performed in a similar fashion to means and methods proposed in the Lower Reach Project.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
The Lyon Edge project is not expected to have any impacts to bed mobility, sediment transport, or downstream turbidity as all project work is occurring above the ordinary high water mark (OHWM) or behind the floodwall.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
The East River Edge sidewalk improvements is anticipated to have a positive impact to bed mobility, downstream turbidity, and sediment transport. Since 1990, the project area has experienced lateral erosion of 1.7 to 2.8 feet of material along the 439-foot length of river edge that has been transported downstream. This demonstrates the project area has eroding and transporting to downstream areas in the past and may be continuing to this day. The project will stabilize the river edge using slabbed pieces of dolomitic limestone and vegetative plugs, resulting in reduced downstream turbidity and substrate mobility. Temporary turbidity during construction would be managed utilizing appropriate best management practices.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The Grand Rapids Public Museum Riverfront Improvements is expected to have no net adverse impact on the bed mobility, downstream turbidity, or sediment transport. Minimal work would be conducted within the flowing channel and any temporary turbidity during construction would be managed with appropriate best management practices.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project is not expected to adversely impact bed mobility, downstream turbidity, and sediment transport as the work is above the OHWM.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This site is anticipated to have no adverse impact on the bed mobility, downstream turbidity, and sediment transport. There is no in-river work planned with this project. The intent of the design is to soften some of the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport.

Some temporary impacts to turbidity may occur during construction, but appropriate best management practices will be taken and/or installed during construction.

Fish Ladder Park – RFA #5 (Master Plan only):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport as the proposed work is not significantly changing the cross-section at this park and the material will be designed to be stable. There may be temporary adverse impacts during construction, but these will be managed by appropriate best management practices.

Wealthy St. Access (Concept Design):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport as any change in the cross-section or any protrusions into the flow that increase shear stresses will be minimal. There may be a slight positive impact on these aspects as an increase in native vegetation may help reduce turbidity in the river. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport. The intent of the design is to soften the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport. There may be a marginal positive impact in downstream turbidity for higher flow events given the additional space in the floodplain. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

Canal Park (Construction, WRP040025 V.1):
There are no anticipated adverse impacts on bed mobility, downstream turbidity, and sediment transport as the intent of the design is to soften the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport. There may be a slight positive impact on these aspects as an increase in native vegetation may help reduce turbidity in the river. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

6th St. Park (Concept Design):
There is no anticipated adverse impact on bed mobility, downstream turbidity, and sediment transport. The intent of the design is to soften the concrete edges through the use of naturalized material. It is anticipated that softening of the river edge and providing more flood storage will not adversely impact the bed mobility, downstream turbidity, and sediment transport. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

Riverside Park (Master Plan only):
With the intent of project to improve the stormwater management, water quality of the stormwater, and the lagoons in the park, work below the OHWM is expected, but it would likely be within the park itself, not on the river edge. Given that the intent of the system is to improve water quality, it is anticipated there will be no adverse impacts to the Grand River related to bed mobility, downstream turbidity, and sediment transport. There may be temporary negative impacts during construction, but these will be managed by appropriate best management practices.

Ah-Nab-Awen Park - South (Active Design)
This project is not expected to adversely impact bed mobility, downstream turbidity, and sediment transport as the work is above the OHWM.

Impacts on Wildlife and Habitat, including Threatened and Endangered Species

Threatened and Endangered Mussel impact was calculated using an estimated polygon of work area compared to extents of the Grand River at 890 cfs. This 890 cfs line is the low water level (7Q10) used to assess changes in the wetted area available for aquatic organisms under low flow conditions as detailed in the Revised Biological Assessment. Where the areas overlapped was assumed to be possible area of mussel impact for the sake of this exercise.

The density of the mussel habitat in the Grand River in the City of Grand Rapids varies based on reach. Based on quantitative samples, in 2013, 2015, and 2016, an average mussel density has been assumed for the following reaches. Impacts to mussels have been estimated based on these densities.

Reach	*Mussel Density (unionids/m^2)*
Proposed AHS to 6th St. bridge	*3.0*
6th St. bridge to 6th St. dam	*1.7*
6th St dam to Fulton St.	*0.3*
Fulton St. to Plaster Creek	*0.1*

It is important to note that these are approximate estimations, based on 30% preliminary design for the in-channel improvements, and include conservative assumptions for construction means and methods which have yet to be determined.

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
This project is pursuing a Biological Opinion from the United States Fish and Wildlife Service due to the presence of the federally endangered snuffbox mussel. No impacts to non-aquatic species are anticipated. All impacts to mussels will be avoided and minimized. The Biological Assessment currently under review by United States Fish and Wildlife Service includes mussel relocation ahead of the project to occur in summer 2024.

Within the direct impact area (45,445 m2) of the project, there are estimated to be 123 E. Triquetra, 1,800 Michigan TES, and 11,711 other unionid species. Within the indirect impact area (82,155 m2) of the project, there are estimated to be 222 E. Triquetra, 3,253 Michigan TES, and 21,171 other unionid species. Upstream of the project, the indirect impacts are estimated at 104 E. Triquetra, 1,521 Michigan TES, and 9,901 other unionid species. Downstream of the project, there are estimated to be no E. Triquetra, 8,325 Michigan TES, and 28,250 other unionid species.

Mussels will be relocated from the direct impact areas. Loss of mussels will also be mitigated through the establishment of a mussel mitigation fund.

Within the direct impact area of the project, two Threatened species have been observed; lake sturgeon *(Acipenser fulvescens)* and river redhorse (*Moxostoma carinatum).* There are no impacts expected to either species. *A. fulvescens* have been observed at the 6th Street Dam during spring ascending discharge and when water temperatures reach 10-11°C (55°F). *A.*

fulvescens migrate downstream and out of the Project area prior to July when construction activities would begin. During summer and fall surveys in the Project area no juvenile *A. fulvescens* have been observed. *M. Carinatum* has been observed in the lower Project area during late May and early June during their spawning window. However, from July through September, *M. Carinatum* adults are only found in low abundance. Over a four-year fish study from Bridge Street down to Rush Creek (GVMC 2023) a total of 4,557 fish were captured. Twenty were adult *M. Carinatum* with only four observed in the Project area. Adult *M. Carinatum* are capable of moving away from any impacts caused by construction.

Corps Project including RFA#2 (Concept Design):
The Corps Project is expected to have a positive impact on wildlife and habitat. Aquatic wildlife would have a more diverse range of habitat types which are more representative of a naturally functioning river. Added habitat types would include pools, riffles, runs, and glides, all of which are not as prevalent under existing conditions. The macroinvertebrate community is categorized as poor in the Lower Grand River because "stable habitat necessary for a diverse macroinvertebrate community" is lacking and riffle habitat has not formed. The macroinvertebrate community is anticipated to benefit and respond with a higher species richness and diversity after construction. The addition of coarse substrate riffle habitat is expected to provide an important habitat type for aquatic macroinvertebrates and produce benefits to the habitat of the reach as a whole.

While there will be temporary impacts associated with the proposed removal of 6th Street Dam and construction of the proposed AHS and hydraulic features, the project is expected to provide access to approximately 80 acres of aquatic habitat for non-jumping fish species, including Lake Sturgeon spawning habitat currently blocked by the 6th Street Dam. The project, with the 16 acres of permanent streambed change as analyzed in this document, is also expected to create 240% more preferred hydrophysical habitat for mussels than existing conditions. There may be temporary impacts on the aquatic wildlife, but the project team will continue to consult with the United State Fish and Wildlife Service (USFWS) and Michigan Department of Natural Resources (MDNR) on ways to avoid, minimize, and mitigate any potential impacts.

Construction access to the proposed AHS site will be most likely through the Water Dept. Storage Yard and access to 6th Street Dam most likely through Fish Ladder Park and 6th Street Park. For this reason, these river edge improvements would likely be constructed following the in-river work for the Corps Project. Since all projects are still in concept design phase and any timeline for construction at the time of this submittal is unknown, the mussels impact from projects were shown separately to provide a conservative estimate.

The species discussed below could experience some potential impacts from the Corps project. These impacts can likely be further mitigated during the design/development process and using best management practices during construction.

Unionids (Mussels):
Construction of the AHS will affect approximately 18,500 m^2 of riverbed. Unionid density in this area is approximately 3.0 unionids/m^2. Approximately 150 *E. triquetra*, 5,300 Michigan TES species, and 51,000 other unionids could be affected by construction of the AHS. However, approximately 80% of those unionids could be translocated before construction: 120 *E. triquetra*,

4,200 Michigan TES species, and 41,000 other unionids. Unionids that would not be translocated include approximately 30 *E. triquetra*, 1,100 Michigan TES species, and 10,200 other unionids.

The area between the 6th Street Bridge and the 6th Street Dam would also be directly impacted during construction, approximately 42,000 m^2. Unionid density in this area averaged 1.7 unionids/m^2, A total of approximately 200 *E. triquetra*, 6,800 Michigan TES species, and 66,000 other unionids could occur in this area. Collecting and translocating unionids from this area would be limited to those within work isolation areas due to the dangerous diving conditions this close to the 6th Street dam. For the purposes of this assessment, unionids were assumed to be collected from one third of the area, as some of the area may require work in wet and some of the area may be covered with isolation measures before unionids can be collected. An estimated 80% of the unionids in one third of the area could be translocated under isolated conditions; 50 *E. triquetra*, 1,800 Michigan TES species, and 17,600 other unionids. Unionids that would not be translocated and affected by the Upstream Project above the dam include 144 *E. triquetra*, 5,000 Michigan TES species, and 48,400 other unionids.

Most of the area between the 6th Street Dam and the Lower Reach project will also be directly impacted by construction below the dam; 107,400 m^2. Freshwater mussels occur at a low density (0.3/m^2) between the 6th Street Dam and the Lower Reach project. Approximately 290 *E. triquetra*, 4,300 Michigan TES species, and 27,700 other unionid species may reside in this direct impact area. Diving conditions below the dam are also dangerous due to the high current velocities. Conservatively, unionids could be collected from within work isolation areas, approximately one third of the area. Approximately 80% of the unionids within the cofferdams would be translocated; 80 *E. triquetra*, 1,150 Michigan TES species, and 7,400 other unionids. Unionids that would not be translocated and assumed to be directly impacted by the Upstream Project below the 6th Street Dam include 215 *E. triquetra*, 3,150 Michigan TES species, and 20,300 other unionids.

The total number of unionids affected after translocation in all 3 areas is approximately 400 *E. triquetra*, 9,200 Michigan TES species, and 79,000 other unionids.

Hydraulic changes to flow depths and velocities would occur between the AHS and channel reconfiguration areas (indirect affect areas). The indirect affects area is approximately 232,000 m^2, with a mussel density of 1.7/m^2. Approximately 400,000 mussels may be indirectly affected, including 1,100 *E. triquetra* and 37,000 other Michigan TES species.

Measures that could be used to mitigate impacts include translocating mussels from the AHS construction area to a suitable recipient site. Collection and translocation of unionids directly affected by the project may be limited to slower flowing areas near the banks and within cofferdams.

The loss of mussels could also be mitigated by the improvement in habitat conditions within the Corps Project area. The area above the 6th Street Dam is now a slow flowing pool. An increased velocity with the removal of the 6th Street Dam should improve habitat conditions for unionid mussels and their host fish. A preliminary Preferred Hydraulic Habitat (PHH) model was developed based on hydraulic conditions within the highest density areas within the sampled area between the AHS and the 6th Street Dam. The model included an index of substrate stability (shear stress/critical shear stress) ≤1.2 under high flow conditions (stable substrate under high

flow), velocity under low flow conditions between 0.15 m/sec and 0.036 m/sec (low enough velocity to allow juvenile settlement but some flow during low flow conditions), and areas with ≤10% bed slope. Bedrock areas and areas that would not be inundated under 7Q10 (low flow conditions) were excluded from the model. Under existing conditions, approximately 32,700 m^2 of PHH occurs above the 6th Street Dam and 2,800 m^2 of PHH occurs between the 6th Street Dam and Dam 2. This should increase to approximately 86,000 m^2 of PHH or a 240% increase after the project is completed.

Myotis septentrionalis (Northern Long-eared Bat)

Northern long-eared bats could be affected if they used any of the trees in the area for roosting if roost trees were removed as part of construction activities. However, few *M. septentrionalis* appear to spend the summer in the southern portion of Michigan. Additionally, the Project is within an urban setting, not likely to harbor this species of bat. A few trees would likely need to be removed from construction/staging areas for the proposed AHS on the east bank but none of these trees appear to be suitable roost trees. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats. Northern long-eared bats are unlikely to be affected by this Project.

Myotis sodalis (Indiana bat)

Although summering *M. sodalis* occur throughout the southern portion of Michigan, including Kent County, it is not likely to be affected by the Project. Impacts to bats would primarily include removal of roost trees as part of construction activities. A few trees would likely need to be removed from construction/staging areas for the AHS (Upstream Reach) on the east bank. This area is already heavily urbanized and trees that are to be removed are unlikely to be roost trees. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. Indiana bats are unlikely to be affected by this Project.

Lycaeides melissa samuelis (Karner blue butterfly)

This species primarily occurs in oak savannas and pine barrens with sandy soil. It is dependent upon wild lupine (*Lupinus perennis*), as larvae feed exclusively on this plant species. Although *L. m. samuelis* is known to occur in Kent County, no suitable habitat exists in the Project Area. This species would not be affected by the Project.

Acipenser fulvescens (Lake Sturgeon) - Threatened

A small *A. fulvescens* population is known to occur in the mainstem of the lower Grand River and the mouth of the Grand River, but within the project area**,** it has not been found upstream of the 6th Street Dam (Figure 3-8, Hanshue and Harrington, 2011). The 6th Street Dam is a barrier to spawning grounds of several Lake Michigan fish species, including *A. fulvescens* (Hanshue and Harrington, 2011). As a result, *A. fulvescens* populations are restricted to the Grand River downstream of this structure. Annual spawning numbers of *A. fulvescens* are believed to be between 66 and 130 fish of primarily older adults (Hanshue and Harrington, 2011). Juvenile Lake Sturgeon have not been documented in the project area. Allowing Lake Sturgeon upstream of the 6th Street Dam and diversifying habitat in the Downstream Reach would improve conditions for A. fulvescens in the Grand River.

Moxostoma carinatum (river redhorse) – Threatened

Adults spawn each year, at temperatures between 18˚C and 24˚C (Mongeau et al., 1992; Jenkins and Burkhead, 1993), which occurs between mid-May through July in the Grand River.

Moxostoma carinatum occurs throughout the entire lower segment of the Grand River, from downstream of the Maple River near Lyons to Grand Haven near the mouth of Lake Michigan (Hanshue and Harrington, 2011). Small numbers of River Redhorse have been found in the project area during summer electrofishing surveys (Holtgren, personal communication). River Redhorse are known to occupy areas with deep runs, swift currents, and larger substrates during Winter and Spring months and then shift to lower velocities and finer substrates during Summer and Fall months. The diversity of habitat, with coarser substrate and a wider variability of localized flow velocities, will increase and subsequently provide a habitat mosaic with improved conditions for River Redhorse.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):

This project is not anticipated to have any impacts on wildlife and habitat. All project work is occurring above the ordinary high water mark (OHWM) or behind the floodwall. No work or construction access will occur within the Grand River and a debris net will be installed under work area to prevent debris from adversely impacting aquatic wildlife, including aquatic macroinvertebrate habitat, fish passage, or fish habitat. USFWS Consistency letter dated May 4, 2022 indicates “no effect” for federally protected Snuffbox Mussel *(Epioblasma triquetra).*

Review of Michigan Natural Features Inventory (MNFI) notes the following state protected aquatic wildlife exist within 1.5 miles of the project area: Snuff box *(Epioblasma triquetra),* Purple wartyback *(Cyclonaias)*, River redhorse *(Moxostoma carinatum)*, Slippershell *(Alasmidonta viridis)*, Black sandshell *(Ligumia recta)*, Fawnsfoot *(Truncilla donaciformis)*. Proposed work activities will not impact these species as no work is proposed within the Grand River.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):

The East River Edge sidewalk improvement project is expected to have a positive impact on wildlife. The project is proposed to install slabs of dolomitic limestone and native vegetative plugs along the river edge to reduce streambank erosion and create streamside habitat foraging, resting, and breeding areas. The project will reduce streambank erosion which will also benefit the aquatic wildlife downstream of the project area. Proposed work extends 2.75 feet waterward of the OHWM and will be conducted entirely from upland area using a turbidity curtain.

Review of Michigan Natural Features Inventory (MNFI) notes the following state protected aquatic wildlife exist within 1.5 miles of the project area: Snuff box *(Epioblasma triquetra),* Purple wartyback *(Cyclonaias)*, River redhorse *(Moxostoma carinatum)*, Slippershell *(Alasmidonta viridis)*, Black sandshell *(Ligumia recta)*, Fawnsfoot *(Truncilla donaciformis)*. It is anticipated that work activities will likely not impact these species as their presence was not identified in the 2020 mussel survey conducted by EcoAnalysts. USFWS Consistency letter dated April 8, 2021 indicates “no effect” for federally protected Snuffbox Mussel.

USFWS has also indicated the 2020 mussel survey conducted by EcoAnalysts would be acceptable for this project and was submitted with the permit application. EcoAnalysts confirmed that common mussels were found in the project area (email correspondence attached). Early

coordination with MDNR Biologist notes 2 state protected mussels (Snuffbox and Black sandshell) species may be in the project reach. As requested by EGLE, further coordination with MDNR and the City to address potential impacts to protected aquatic species has been requested, has not occurred, and will be handled during permit review process.

This project is not anticipated to have an adverse impact on fish passage. The dolomitic limestone and native vegetative plugs will provide a stable natural river edge which will have a positive impact on macroinvertebrates and fish habitat due to reduced sediment load from erosion. Streamside vegetation will provide safe harbor areas and cooler water temperatures for aquatic species, including macroinvertebrates and larval and juvenile fish species. Furthermore, the proposed work is not installing structures that would typically interfere with fish passage (e.g., weir, dam, etc.)

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The Grand Rapids Public Museum riverfront project is expected to have no adverse impacts on wildlife. The current large riprap offers little habitat value. Replacing the existing riprap with either natural field stone or dolomitic limestone would not change that habitat value, and the disturbance on the stream bottom is 0.01 acre.

Native plantings along channel banks will work to improve streamside foraging, resting, and breeding areas for terrestrial wildlife. Work will be conducted from upland areas and steel sheeting cofferdam will be used to protect existing undergrade structures during the construction process, so no tracking in the river is currently proposed. Work is anticipated to extend approximately 0.5-1.0 feet past the water's edge but would not extend into the limits of the 890 cfs line. Therefore, this project would result in no impacts to mussel habitat areas. The dolomitic limestone and native vegetative plugs will provide a stable natural river edge that will have a positive impact on macroinvertebrates and fish habitat due to reduced sediment load from erosion. Streamside vegetation will provide resting areas and refugia, and cooler water temperatures which will benefit aquatic species. Furthermore, proposed work is not installing structures that would significantly modify conditions that would interfere with fish passage (e.g., weir, dam, etc.)

USFWS Consistency letter dated November 16, 2021 (attached) indicates "no effect" for federally protected Snuffbox Mussel). Review of Michigan Natural Features Inventory (MNFI) (attached) notes the following state protected aquatic wildlife exist within 1.5 miles of the project area: Snuff box *(Epioblasma triquetra),* Purple wartyback *(Cyclonaias)*, River redhorse *(Moxostoma carinatum)*, Slippershell *(Alasmidonta viridis)*, Black sandshell *(Ligumia recta)*, Fawnsfoot *(Truncilla donaciformis)*. Impacts from proposed work activities will be negligible given work extends minimally (1 foot) into the water.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
Inquiry to MNFI (attached) notes 3 state Threatened Species (Purple Wartyback, Slippershell and River Red Horse), and 2 state Endangered Species (Black Sand Shell and Peregrine Falcon), may exist within 1 mile of the project area. No adverse impact to Peregrine Falcon or River Red Horse is expected to occur as a result of proposed activities. Peregrine Falcon preferred habitat (inland or coastal cliffs, open woodlands near water, and potentially high city buildings) generally does not exist in the project area. River Red Horse habitat is associated

with long deep runs (1-10 feet) in rivers, and proposed work activities will not extend into these areas of the Grand River. Mussels and/or their habitat will not be impacted as proposed activities do not impact the channel bed.

Evaluation of federally protected species was conducted using USFWS IPaC determination key for the following species: Whooping Crane, Snuffbox Mussel, Karner Blue and Monarch Butterfly, Eastern Massasauga, and Indiana, Northern Long Eared and Tricolored bats. Based on absence of suitable habitat, urbanized area, and existing site conditions, it was determined no impacts to these species would occur as a result of proposed work activities. There is reasonable assumption no impact to mussels will occur as all work will occur from upland area and no activities will impact the riverbed.

Furthermore, all work activities will occur outside the 890 CFS line and not impact mussels or their habitat. Mussel studies for the Grand River note the 890 CFS is the breakpoint line for where mussels live and thrive, therefore no adverse impact to either federal or state protected mussels is anticipated to occur.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This site is currently a parking lot and storage buildings with a concrete floodwall along the river edge. No threatened and endangered species would be anticipated in the upland portion of this project. Threatened and endangered mussels could possibly be in the river near this area.

There is an assumed possible 0.03 acre of permanent streambed impact for the emergency access boat ramp. This would reduce the potential habitat for mussels in the river. A temporary streambed impact of 0.06 acres (243 m^2) was assumed to be needed for construction, including the 0.03 acre area mentioned above. The anticipated population of mussel in this area, assuming a mussel density of 1.7/m^2, would be approximately 420 mussels in this area. Assuming approximately 80% of the unionids would be translocated; the estimated take for this project is 85 mussels based on the current concept design. Measures that would be used to mitigate impacts include translocating mussels from the construction area to a suitable recipient site.

Fish Ladder Park – RFA #5 (Master Plan only):
This site is currently a park along the river edge. No threatened and endangered species would be anticipated in the upland portion of this project. Threatened and endangered mussels could possibly be in the river near this area.

This park may be one access point for the Corps project. Any river edge work included in this plan may be in conjunction with that project. This project is estimated to have up to 0.45 acre (1820 m^2) in areas of the river that could be occupied by mussels. Total permanent streambed impact area is estimated to be 0.08 acres. Assuming the higher 1.7/m^2 density of mussels upstream of 6th St. dam (rather than 0.3/m^2 downstream of the dam) in order to be conservative, the streambed impacts could include approximately 3,100 mussels. Therefore, assuming 80% of the mussels can be translocated, the take is assumed to be 620 mussels. The total impact to the mussels may be duplicated since both the Corps Project and the Fish Ladder Park project may account for the same riverbed area in the impact assessment.

There are some trees in this park, which could potentially be bat habitat, although it is unlikely as the area is already heavily urbanized. As a precaution, trees should be removed from

construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. No threatened and endangered species would be anticipated in the upland portion of this project.

Wealthy St. Access (Concept Design):
The parcels along the river edge are currently underutilized parking areas with minimal facilities to the river. There are some trees in the area, but any potential impacts to threatened or endangered bats would be avoided or minimized. No threatened and endangered species would be anticipated in the upland portion of this project.

Threatened and endangered mussels could possibly be in the river near this area. A mussel survey has not been completed for this area. Within the 0.30 acre (1215 m^2) of temporary streambed impact and no permanent streambed impact area, the anticipated population of mussels, using mussel density of 0.1/m^2, there would be approximately 120 mussels in this area. Approximately 80% of the unionids within the cofferdams would be translocated; therefore, take estimates for mussels associated with his project have been calculated to be approximately 25 mussels.

Measures that would be used to mitigate impacts include translocating mussels from the construction area to a suitable recipient site.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
The June 6, 2023 inquiry to MNFI for the Canal Park and Ah-Nab-Awen projects was determined appropriate to use for this project, given the project site is within close proximity to the two other sites and has similar work activities being proposed. MNFI notes 3 state Threatened Species (Purple Wartyback, Slippershell and River Red Horse), and 2 state Endangered Species (Black Sand Shell and Peregrine Falcon), may exist within 1 mile of the project area. No adverse impact to Peregrine Falcon is expected to occur as a result of proposed activities. Peregrine Falcon preferred habitat (inland or coastal cliffs, open woodlands near water, and potentially high city buildings) generally does not exist in the project area. River Red Horse habitat is associated with long deep runs (1-10 feet) in rivers, and proposed work activities will not extend into these areas of the Grand River. Lastly, protected mussels and/or their habitat will not be impacted as proposed activities do not impact the channel bed, and work will be conducted from upland area.

Evaluation of federally protected species was conducted using USFWS IPaC determination key for the following species: Whooping Crane, Snuffbox Mussel, Karner Blue and Monarch Butterfly, Eastern Massasauga (EMR), and Indiana, Northern Long Eared (NLB) and Tricolored bats. USFWS Consistency letter dated November 20, 2023 notes no effect for all species except EMR and NLB, which have a not likely to adversely affect (NLAA) designation. Based on absence of suitable habitat, urbanized area, existing site conditions, and construction methodology, it was determined no adverse impacts to these species would occur as a result of proposed work activities.

Furthermore, all work activities will occur outside the 890 CFS line and not impact mussels or their habitat. Mussel studies for the Grand River Revitalization project (HNV-A018-7X9N3) note the 890 CFS is the breakpoint line for where mussels live and thrive, therefore no adverse impact to either federal or state protected mussels is anticipated to occur. Tree removals will occur

during the migrating season (October to March 30) to ensure no adverse impact to federally protected bats.

Fishbeck has determined there is reasonable certainty of no take for Snuffbox or Northern Long Eared bat for the following reasons:

- All work will occur from upland area and no equipment will enter the water.
- All work will occur outside the 890 CFS lines, which is breakpoint line for where mussels live and thrive.
- Turbidity curtain will be used in areas where work occurs below the OHWM to prevent off-site siltation to the greatest extent possible. Curtains will be installed from upland area or by wading out into the river.
- Silt fence or coir logs will be used to prevent off-site siltation in work areas above the OHWM.
- All SESC measures will be inspected and maintained daily throughout construction and any deficiencies observed will be repaired prior to commencement of daily activities.
- No work will impact the river bed.
- Tree removals will occur during the migratory season.

Canal Park (Construction, WRP040025 V.1):
Inquiry to MNFI (attached) notes 3 state Threatened Species (Purple Wartyback, Slippershell and River Red Horse), and 2 state Endangered Species (Black Sand Shell and Peregrine Falcon), may exist within 1 mile of the project area. No adverse impact to Peregrine Falcon or River Red Horse is expected to occur as a result of proposed activities. Peregrine Falcon preferred habitat (inland or coastal cliffs, open woodlands near water, and potentially high city buildings) generally does not exist in the project area. River Red Horse habitat is associated with long deep runs (1-10 feet) in rivers, and proposed work activities will not extend into these areas of the Grand River. Mussels and/or their habitat will not be impacted as proposed activities do not impact the channel bed.

Evaluation of federally protected species was conducted using USFWS IPaC determination key for the following species: Whooping Crane, Snuffbox Mussel, Karner Blue and Monarch Butterfly, Eastern Massasauga, and Indiana, Northern Long Eared and Tricolored bats. Based on absence of suitable habitat, urbanized area, and existing site conditions, it was determined no impacts to these species would occur as a result of proposed work activities. There is reasonable assumption no impact to mussels will occur as all work will occur from upland area and no activities will impact the riverbed.

Furthermore, all work activities will occur outside the 890 CFS line and not impact mussels or their habitat. Mussel studies for the Grand River note the 890 CFS is the breakpoint line for where mussels live and thrive, therefore no adverse impact to either federal or state protected mussels is anticipated to occur.

6th St. Park (Concept Design):
This project is anticipated to not adversely impact wildlife and habitat. This park may be one of the access points for the Corps project. Any river edge work included in this plan may be in conjunction with that project. This project is estimated to have up to 1 acre (4046 m^2) in

streambed impacts, which would include approximately 7,000 mussels assuming a 1.7/m^2 density, but the mussels could be translocated. Assuming 80% of the mussels would be translocated, the take is estimated to be 1,400 mussels. The total impact to the mussels in this assessment may be duplicated since the Corps project include the same riverbed area in the impact assessment.

Since the park as it exists today is a dilapidated parking lot, and the proposed improvements will include increased vegetation, it is anticipated to have positive impacts on wildlife and habitat.

There are some trees in this park, which could potentially be bat habitat, although it is unlikely as the area is already heavily urbanized. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. No threatened and endangered species would be anticipated in the upland portion of this project.

Riverside Park (Master Plan only):
This park provides a variety of habitat for wildlife, including some common aquatic wildlife. Envisioned work will be assumed to improve water quality of the lagoons and stormwater runoff and increase wetlands, wet meadows, and upland plantings. For the purpose of this assessment, it was assumed there would be 1.0 acres (4046 m^2) of temporary riverbed impact area that impacted mussels, including 0.5 acres of permanent streambed impact. Assuming a 3.0/m^2 density, this project would impact approximately 12,200 mussels. The mussels would be translocated. Assuming 80% of the mussels would be translocated, the take is estimated to be 2,440 mussels.

Habitat assessments for the northern long-eared bat, Indiana bat, and the karner blue butterfly may be necessary at the time design starts. As a precaution, trees should be removed from construction/staging areas in winter months to avoid effects on roosting bats or evaluated for bat habitat prior to removal. No threatened and endangered species would be anticipated in the upland portion of this project.

Given the current wide variety and habitat, and the goal of adding other natural features, it is anticipated that any impacts to wildlife will be temporary from construction, and the long term impacts is anticipated to be positive. No permanent adverse impacts are anticipated.

Ah-Nab-Awen Park - South (Active Design)
There are no impacts on wildlife and habitat, including threatened and endangered species.

Impacts on Wetlands

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
The Lower Reach Project has been designed to avoid and minimize impacts to wetlands. Temporary impacts have been minimized to 0.01 acres, which would be protected in the field during this impact. Permanent impacts have been minimized to 0.01 acres, which would be replanted following completion of the project.

Corps Project including RFA#2 (Concept Design):
The Corps project may have a direct impact on 0.21 acres of wetlands, as determined from the 2014 Golder Wetland Delineation, which identified a total of 3.09 acres of wetlands along the Grand River from approximately Ann St. to Fulton St. This area of wetland impact includes the area of the elevated boardwalk included in RFA #2, the Water Department Storage Yard. More recent delineation data from the 2019 Fishbeck report was also referenced but does not extend upstream of 6th Street Dam. Wetland impact associated with the Corps project could potentially be reduced based on updated wetlands delineation, further discussion on construction methodology, and/or further design development from the 30% design state.

The changes in water levels relative to existing conditions are expected to have indirect impacts to existing wetlands and other riparian areas within the project reach. Water levels in areas downstream of 6th Street Dam would increase, while water levels in areas between the dam and the AHS would decrease. These changes in water levels would alter the frequency of inundation of existing wetlands and are anticipated to result in some changes to long-term wetland boundaries. Much of the vegetation within the delineated wetlands are well-established non-emergent species; these portions of wetlands would continue to be periodically inundated and remain vegetated similar to existing conditions. Since non-emergent species of wetland vegetation do not rely as much on specific water levels in the river, much of the existing vegetation is expected to survive and/or adjust to the new water level. Specific estimation of indirect impacts to wetlands resulting from the proposed changes to water levels are unable to be approximated at this time. There appears to be some emergent wetland vegetation within the 1.7 acre delineated wetland on the east bank directly upstream of Leonard Street. These emergent species of vegetation are anticipated to be impacted by lower water levels; however, the new inundation patterns of post-project conditions would likely establish new, and potentially expanded areas of emergent wetlands.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
There are no anticipated wetlands impacts for the Lyon Edge Project. All work is upland above the OHWM.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
There are no anticipated wetland impacts for the East River Edge sidewalk improvement project. There are no wetlands in this project area.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
There are no anticipated wetland impacts from the Grand Rapids Public Museum Riverfront project. There are no wetlands in this project area.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
No wetlands are anticipated to be impacted by this project.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
There are no known adverse impacts to wetlands in this project. This area was not included in any of the project wetland delineations, and the State's online wetland mapper shows no wetland in this area. River for All conceptual plans for the Coldbrook Decommissioned Water Pumping Station Site imagines a stormwater outfall water quality treatment area, which could be beneficial to wetlands.

Fish Ladder Park – RFA #5 (Master Plan only):
River for All plans for the Fish Ladder Park redevelopment could result in temporary disturbance of portions of the 0.25 acres of wetland along the RDB between the 6th Street Dam and I-196 as identified in 2014 Golder wetland delineation report. Permanent impacts are not anticipated based on this delineation. The wetlands delineations would be updated prior to any future design, and any impacts would be avoided, minimized, or mitigated to the extent possible.

Wealthy St. Access (Concept Design):
We are not currently aware of any detailed wetland delineation on this site, so the State of Michigan's online wetland mapper was utilized. From this mapper, it appears a forested wetland up to approximately 0.15 acres is on the eastern river edge site. A wetland delineation would have to be performed on this concept prior to future design. Any impacts to the wetland would be avoided, minimized, or mitigated.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
A wetlands delineation was performed in July 2023. The wetland in the project area consisted of ten segments with an approximate total area of 0.95-acre. De minimus impacts to wetlands area, totaling 0.09 acres, will result from the proposed work. This project will result in improved ecological resources along the river's edge due to the naturalization of the shoreline. Proposed native vegetation will improve water quality and facilitate streamside aquatic habitat and foraging areas do not currently exist.

Canal Park (Construction, WRP040025 V.1):
There are no anticipated wetlands impacts for the Canal Park Project. There are no wetlands in this project area.

6th St. Park (Concept Design): From the 2014 Golder Wetland Delineation, there was 0.05 acres of wetland just north of 6th St. dam. These wetlands may be temporarily impacted by construction, but proper best management practices to protect, avoid, or minimize the impacts would be utilized. River for All conceptual plans for portions of this site along the left descending bank just north of the I-196 westbound bridge include the creation of two small marsh-type wetland features, which would lead to a beneficial impact.

Riverside Park (Master Plan only):
A wetland delineation has not yet been performed for this site. Based on the State's online wetland mapper, there could be 50-60 acres of wetland in the park, including the area of the lagoons. The goals of the project include to improve the lagoons, wetlands, wet meadows, and upland plantings. To achieve this goal, it may be necessary to impact wetlands in the park, but

these adverse impacts are assumed to be temporary, and permanent impacts would be positive. No permanent adverse impacts to the wetlands are anticipated. A wetland delineation will be performed prior to finalizing design. Temporary impacts due to construction may occur, but proper best management practices may be installed.

Ah-Nab-Awen Park - South (Active Design)
There are no anticipated wetlands impacts for this project. There are no wetlands in this project area.

Impacts on Stream Function

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):

Hydrology:
The project would not impact the hydrology of the river.

Hydraulics:
The proposed removal the four low-head dams and installation of the proposed substrate enhancements would replace a very uniformly flowing and hydraulically disconnected reach with a more dynamic and diverse hydraulic environment that more-closely emulates a natural river. The stream gradient distributed at the dams would be spread-out over the project reach, both over the proposed grade control structures and over the existing channel bed. Average flow velocities throughout the reach would generally increase as energy dissipation is spread out. More diversity in flow depths and velocities, as well as substrate, would result from the project and riffles, glides, pools, and runs would exist that do not under existing conditions.

Geomorphology:
The geomorphology of the reach may see positive change. The woody debris that collects on the low-head dams would collect in more natural ways on proposed substrate enhancements or native channel bed. Sediment would transport through the reach similar to existing conditions; localized transient sand deposition areas would be changed by the project but is still anticipated to flush from the reach during annual high flow events, similar to existing conditions. The post project conditions seek to encourage a dynamic equilibrium between hydraulics and substrate while maintaining stability and grade control within the reach.

Physicochemical:
Water temperatures are not anticipated to see notable change; however, dissolved oxygen levels may see slight improvements, resulting from increased hydraulic and substrate diversity.

Biological:
The biological health of the river is anticipated to gradually improve as a result of the project. Increased diversity in hydraulics and substrates provide areas of improved habitat for macro-invertebrates, benthic fish species, and mussels. The substrate enhancements and naturalized hydraulic function of the reach is also anticipated to have beneficial impacts to aquatic habitat diversity for resident fish communities.

Corps Project including RFA#2 (Concept Design):

Similar to the Lower Reach Project, the Corps project proposes significant changes to the existing stream function of the Grand River through the project reach. The proposed removal of 6th Street Dam and installation of the proposed in-river features seeks to replace a very uniformly flowing and hydraulically disconnected reach with a more dynamic and diverse hydraulic environment that more-closely emulates a natural river The stream gradient distributed at the dam would be spread-out over the project reach, both over the proposed features and over the existing channel bed. Average flow velocities throughout the reach would generally increase. Water levels would increase, when compared to existing conditions, downstream of the dam and decrease between the dam and the proposed AHS, establishing a more-gradual hydraulic gradient throughout the reach. More diversity in flow depths and velocities, as well as substrate,

would result from the project and riffles, glides, pools, and runs would exist that do not under existing conditions.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
This project is not anticipated to have discernable impacts to the stream function of the Grand River

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project is not anticipated to have discernable adverse impacts to the stream function of the Grand River.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Fish Ladder Park – RFA #5 (Master Plan only):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Wealthy St. Access (Concept Design):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Canal Park (Construction, WRP040025 V.1):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

6th St. Park (Concept Design):
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Riverside Park (Master Plan only):
If the lagoons are improved and wetlands are improved or added, there could be a positive impact on the stream function of the Grand River. None of the other improvements to this project would have discernable impacts to the stream function of the Grand River.

Ah-Nab-Awen Park - South (Active Design)
This project is not anticipated to have discernable impacts to the stream function of the Grand River.

Impacts on Modeled Flood Risk

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
This project has been hydraulically modelled and designed to maintain the City's freeboard deficient certification from FEMA. Localized increases in modeled flood stages occur within the project reach; however, the hydraulic evaluation of the project indicates that no harmful interference would result from the project. A CLOMR will be submitted to FEMA to fully address modeled increases in 100-yr flood levels.

Corps Project including RFA#2 (Concept Design):
The Corps Project has been added to the cumulative impacts model for the Lower Reach Project as requested by EGLE. The model calculates a no-rise condition during the 100-yr flood based on the 30% design of the proposed improvements. Localized increases in flood stages are modeled to occur at some locations within the project reach; however, all increases would be contained within the flood protections system and would not result in harmful interference.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
Per the request from EGLE prior to Correction Request #3, all ancillary bank projects have been added to the HEC-RAS model for the Lower Reach Project; this includes the addition of the Lyon Edge Project. Model results indicate that no increases in modeled flood levels would occur from adding this project to the HEC-RAS model for the Project.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
Per the request from EGLE prior to Correction Request #3, all ancillary bank projects have been added to the HEC-RAS model for the Lower Reach Project; this includes the addition of the East River Edge Project. Model results indicate that no increases in modeled flood levels would occur from adding this project to the HEC-RAS model for the Project.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
Per the request from EGLE prior to Correction Request #3, all ancillary bank projects have been added to the HEC-RAS model for the Lower Reach Project; this includes the addition of the Grand Rapids Public Museum Riverfront Improvements Project. Model results indicate that no increases in modeled flood levels would occur from adding this project to the HEC-RAS model for the Project.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
This project has a net fill of 100 CY in the floodplain with no fill proposed to be under the OHWM. No changes to the modelled flood risk are anticipated.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut within the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

Fish Ladder Park – RFA #5 (Master Plan only):

This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut below the OHWM and in the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

Wealthy St. Access (Concept Design):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Portions of this project may be designed to be within a conveyance shadow of the Wealthy St. bridge abutment and would be designed to have no impact on the base flood elevation. No adverse impacts to modelled flood risk are anticipated.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
A hydraulic model for this project was created in HEC-RAS version 4.1. The project result in a slight decrease in Energy Grade Line or Hydraulic Grade Line throughout the project reach. Therefore, it is concluded the proposed project does not result in harmful interference.

Canal Park (Construction, WRP040025 V.1):
Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut below the OHWM and in the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

6th St. Park (Concept Design):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. Based on the current estimate of earthwork quantities shown in Appendix B, this project would have a net cut below the OHWM and in the floodplain; therefore, no adverse impacts to modeled flood risk are anticipated.

Riverside Park (Master Plan only):
This project has not progressed design far enough to have developed a hydraulic model to incorporate into the cumulative impacts HEC-RAS model for the Lower Reach Project. The task of the design team is to build the project without causing an increase in the modeled flood levels.

Ah-Nab-Awen Park - South (Active Design)
This project has a dredge of 56 CY and fill of 128 CY which results in a net fill of 72 CY in the floodplain with no fill proposed to be under the OHWM. No changes to the modelled flood risk are anticipated.

Temporary Construction Impacts

Lower Reach Project (Permitting, HQ2-Y2FM-WS9TA):
This project team has evaluated construction means and methods to avoid and minimize construction impact to the environment. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee from the nearshore area. However, it is anticipated species will return when construction is complete. Temporary turbidity during construction would be managed with industry standards best management practices including turbidity curtains.

Corps Project including RFA#2 (Concept Design):
Similar to the discussion of construction means and methods for the Lower Reach Project, temporary impacts during construction for this project would also evaluate alternative means and methods for construction to minimize and avoid impacts to aquatic resources. A discussion of temporary construction impacts to aquatic wildlife and threatened and endangered species for the Corps project has been included in the earlier section on Impacts to Wildlife and Habitat. Assumed construction impact was included in the assessments of the mussels. Temporary construction impacts to fish passage are minimal and would be similar to that of the Lower Reach project. It is worth noting that because the 6th St dam is currently a barrier to many species of fish in the Grand River, temporary adverse impacts to fish passage (relative to existing conditions) would be minimal. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee from the nearshore area. However, it is anticipated species will return when construction is complete. Temporary turbidity during construction would be managed with industry standards and assumed to be performed in a similar fashion to means and methods proposed in the Lower Reach Project.

Lyon Edge Project (Construction, HP8-8RNS-2WDK2):
There are no construction impacts to the riverbed, shoreline or other water features as no work is proposed within the river and floodwall exists throughout entire project area. All work will occur from upland areas and no equipment will enter the river. Approximately 200 lineal feet of temporary construction debris net will be stretched under the work platform to ensure no construction debris enters the river. It is not anticipated that shade from the debris net will adversely impact aquatic resources. Proposed work activities will permanently reduce cover over bottom land by 367 square feet. It is anticipated that aquatic biota and insects will not be adversely impacted by temporary construction netting or increased sunlight. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee from the nearshore area. However, it is anticipated species will return when construction is complete.

East River Edge Project (Campau) (Construction, HP8-PWB2-465KA):
All construction activities will occur from upland area and no heavy equipment will enter the water. A turbidity curtain will be placed sufficient to cover the entire project area during construction. Construction activities will permanently impact 360 lineal feet of shoreline. Approximately 288 square feet of riverbed will be impacted. Riverbed impacts will extend no greater than 2.75 lineal feet into water from edge of shoreline. Disturbance from construction equipment (noise, equipment, traffic, vibration) may temporarily cause aquatic wildlife to flee

from the nearshore area. However, it is anticipated species will return when construction is complete.

Grand Rapids Public Museum Riverfront Improvements (Construction, HPD-8EMK-1EGF2):
The majority of construction activities will occur from upland areas and no heavy equipment will enter the water. 500 lineal feet of temporary sheet piling will be installed approximately +/-1 foot east of water's edge at 3500 CFS. Approximately 500 square feet of riverbed will be impacted. Temporary sheeting is necessary to protect existing channel bank and undergrade structures during the construction process. Impacts to the riverbed, aquatic wildlife and organisms during construction will be negligible. Disturbances from construction equipment (noise, equipment, traffic, vibration, etc.) may temporarily cause aquatic wildlife to flee from the nearshore area, however, it is anticipated species will return when construction is complete.

Leonard St. to Ann St. Trail (Construction, WRP040128 v. 1):
Temporary construction impacts are anticipated to be minimal. All work will occur upland and will not be performed during high flow events. Disturbances from construction equipment (noise, equipment, traffic, vibration, etc.) may temporarily cause wildlife to flee from the area, however, it is anticipated species will return when construction is complete.

Coldbrook Water Pump Stations – RFA #3 (Master Plan only):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

Fish Ladder Park – RFA #5 (Master Plan only):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

Wealthy St. Access (Concept Design):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed temporary impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

201 Market Ave. (Permitting HPZ-0BP4-6TQCH):
Most of the construction of this project will take place in upland areas. Some work below the OHWM is needed in order to construct the base of the retaining wall or sea wall as well as to remove existing debris and plant vegetation. Prior to any work occurring, appropriate best management practices such as a turbidity curtain would be installed to limit any potential turbidity that arose from the project. The project will also schedule the work under the OHWM during periods of typical low flows on the Grand River.

Canal Park (Construction, WRP040025 V.1):
The construction is assumed to take place from the river edge and no work will occur from the riverbed. Appropriate best management practices such as turbidity curtain would be installed to limit any potential turbidity that arose from the project.

6th St. Park (Concept Design):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

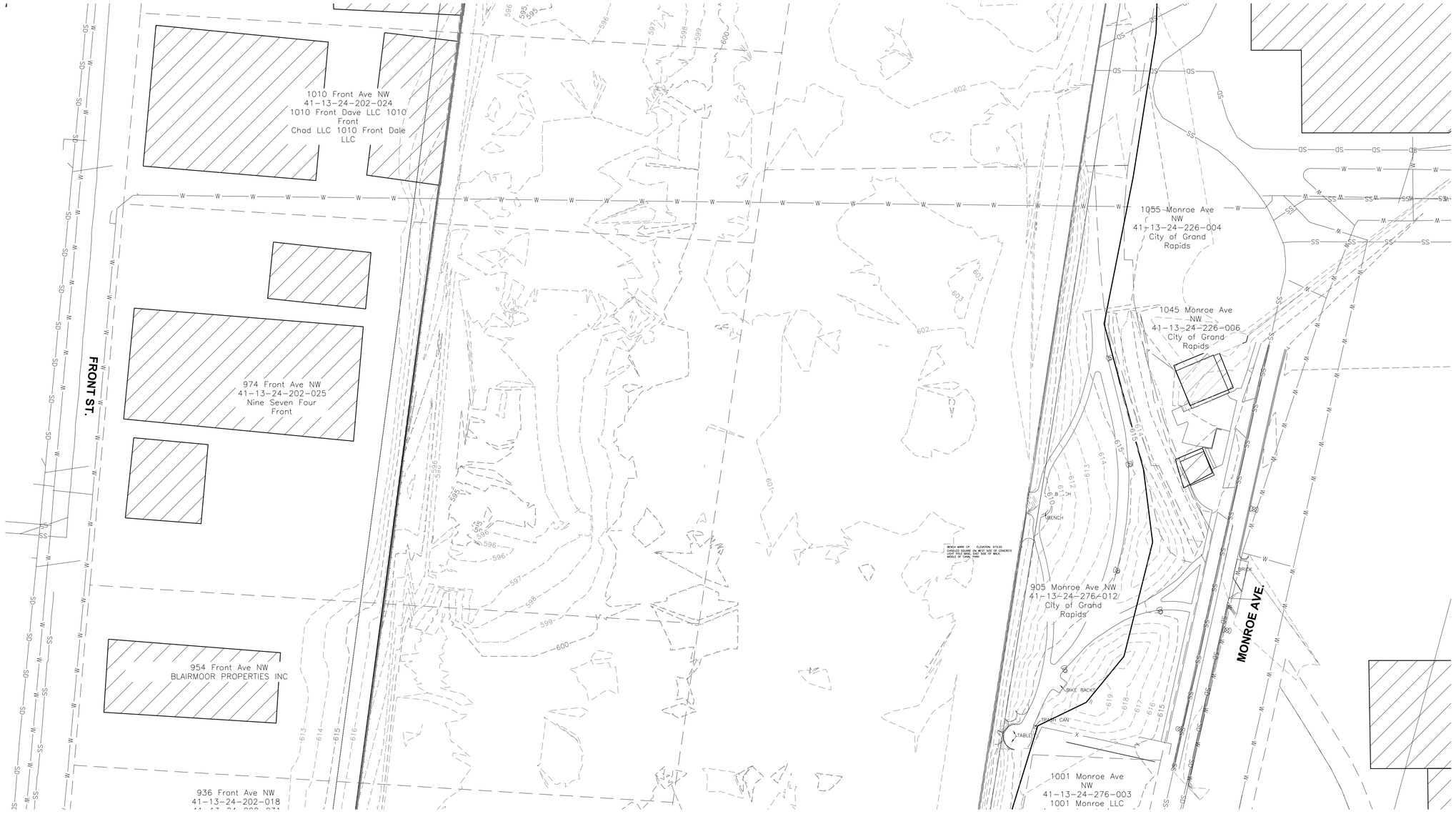
The assumptions are discussed in the sections on impact to wildlife and habitat and turbidity above. The assumed impacts would be minimized using best management practices. There are no other anticipated constructions impacts at this time.

Riverside Park (Master Plan only):
Since this project is only at conceptual design stage, the project design still needs significant development prior to developing a construction plan. For the sake of this cumulative impact assessment, several assumptions will be made to satisfy EGLE's request. However, these assumptions will be refined as the project develops.

Any work along the river edge would take place from land. Appropriate best management practices such as turbidity curtain would be installed to limit any potential turbidity that arose from the project.

Ah-Nab-Awen Park - South (Active Design)
There are no construction impacts to the riverbed, shoreline or other water features as no work is proposed within the river or below the OHWM. All work will occur from upland areas and will not be any closer than 80' from the river's edge. Between the proposed work and river includes existing lawn and landscape beds. A silt fence barrier will be placed and maintained throughout the duration of construction to prevent any silt from entering the river.

APPENDIX D
Drawings



N

50 0 50 100

SCALE: 1" = 50'

LEGEND

- EX. WATER MAIN
- EX. SANITARY SEWER
- EX. STORM SEWER
- EX. OVERHEAD ELECTRICAL
- EX. PROPERTY LINE
- EX. BUILDING
- EX. MAJOR CONTOUR
- EX. MINOR CONTOUR

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Detroit District

Mark	Description	Date	Appr.

File Name: C-001 Existing Site Plan.dwg
Plot Scale: 1:1
Plot Date: October 26, 2020
PROJECT NO. 60616728

Zero Accidents
Zero Tolerance

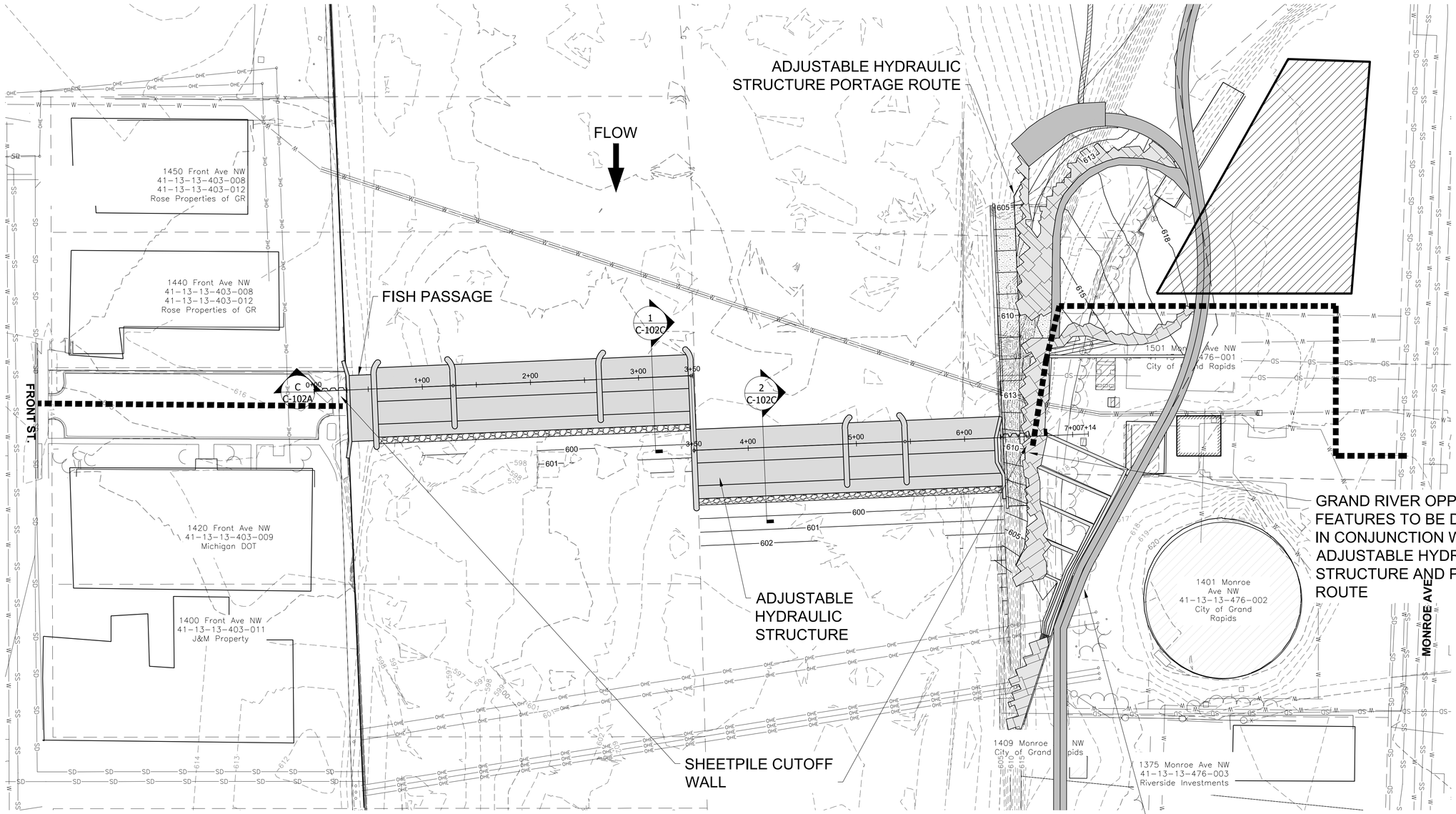
DESIGN BY: J. MCDERMOTT
DRAWN BY: C. WARREN
REVIEWED BY: T. NAPERALA

AECOM
3950 SPARKS DRIVE SE
GRAND RAPIDS, MI 49505
ph.(616) 574-8500

GRAND RAPIDS WHITEWATER EIS
ALTERNATIVE 2
EXISTING SITE PLAN
LOCATION C

SHEET
C-001C

C:\Civil 3D Projects\GRWW\20-SHEETS\Alt-2\C-001 Existing Site Plan.dwg October 26, 2020 - 4:20pm chris.warren



LEGEND

ACCESS ROUTE

STAGING/ MATERIAL STORAGE AREA

NOT FOR CONSTRUCTION

N

50 0 50 100

SCALE: 1" = 50'

US Army Corps of Engineers
Detroit District

Mark	Description	Date	Appr.

File Name: C-100 Detailed Site Plan.dwg
Plot Scale: 1:1
Plot Date: October 26, 2020
PROJECT NO. 60616728

Zero Accidents
Zero Tolerance

DESIGN BY: J. MCDERMOTT
DRAWN BY: C. WARREN
REVIEWED BY: T. NAPERALA

AECOM
3950 SPARKS DRIVE SE
GRAND RAPIDS, MI 49105
ph (616) 574-8500

GRAND RAPIDS
WHITEWATER EIS
ALTERNATIVE 2
DETAILED SITE PLAN
LOCATION C

SHEET
C-100C

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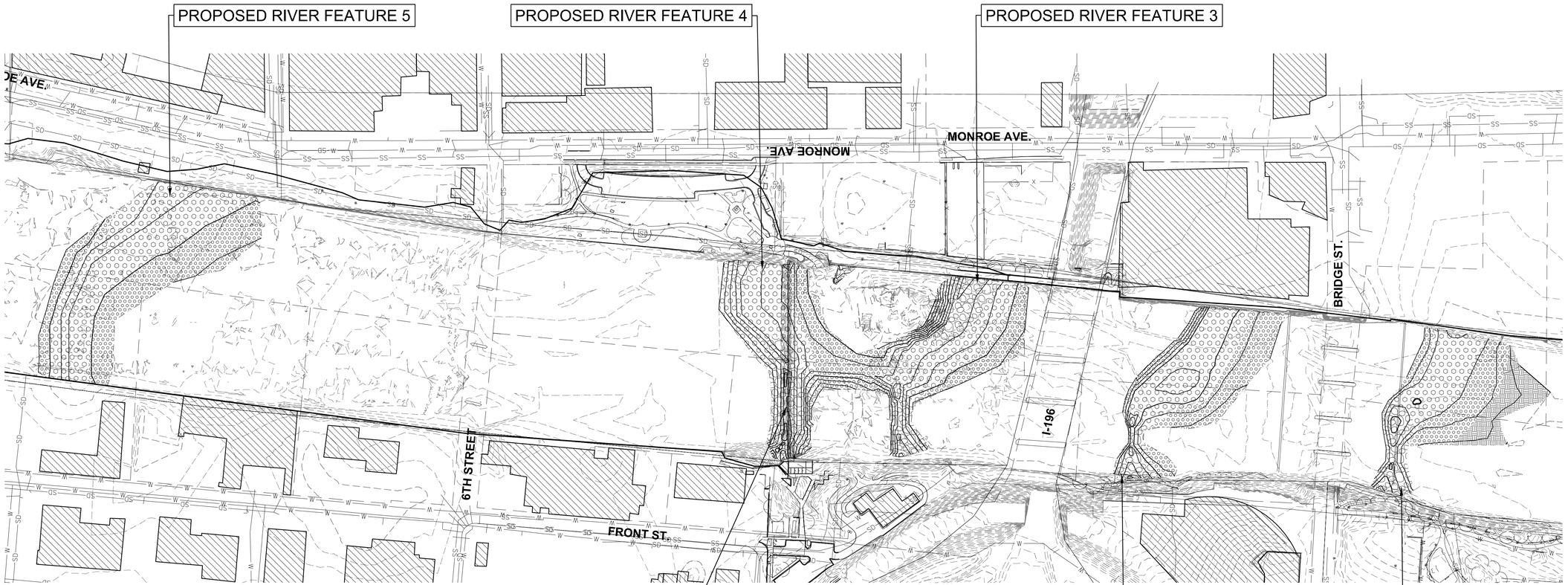

N

100 0 100 200

SCALE: 1" = 100'

LEGEND

- ALLUVIUM COARSE (6 INCH D50)
- ALLUVIUM V COARSE (12 INCH D50)
- BOULDER (36 INCH - 48 INCH)
- ALLUVIUM NATIVE

NOTE: SEE SHEET C-200 FOR TYPICAL RIVER FEATURE DETAILS

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Detroit District

Mark	Description	Date	Appr.

File Name: C-101 River Features.dwg
Plot Scale: 1:1
Plot Date: October 26, 2020

PROJECT NO. 60616728

Zero Accidents
Zero Tolerance

DESIGN BY: J. MCDERMOTT
DRAWN BY: C. WARREN
REVIEWED BY: T. NAPIERALA

AECOM
3950 SPARKS DRIVE SE
GRAND RAPIDS, MI 48105
ph (616) 574-8500

GRAND RAPIDS WHITEWATER EIS
ALTERNATIVE 2
RIVER FEATURE PLACEMENT
ALTERNATIVE 2.2

SHEET
C-101C

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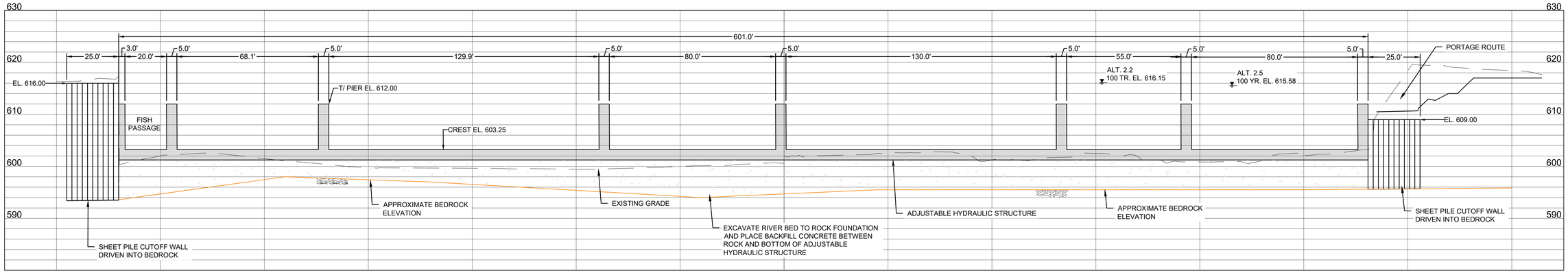
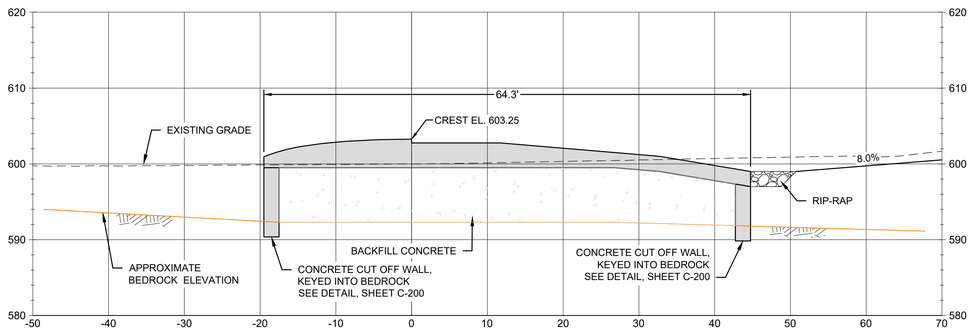
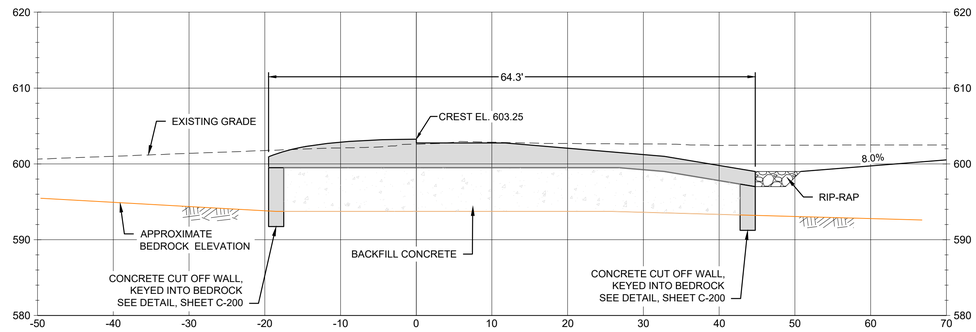


C | **A.H.S. PROFILE**
C-100C



1 | **A.H.S. SECTION**
C-100C



2 | **A.H.S. SECTION**
C-100C

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VERT. SCALE: 1" = 10'

25 0 25 50
HORZ. SCALE: 1" = 25'

10 0 10 20
VERT. SCALE: 1" = 10'

10 0 10 20
HORZ. SCALE: 1" = 10'

US Army Corps of Engineers
Detroit District

Mark	Description	Date	Appr.

File Name: C-102 Profile Viewing
Plot Scale: 1:1
Plot Date: October 26, 2020
PROJECT NO. 60616728
Zero Accidents
Zero Tolerance

DESIGN BY: J. MCDERMOTT
DRAWN BY: C. WARREN
REVIEWED BY: T. NAPERALA

AECOM
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GRAND RAPIDS, MI 49546
ph (616) 574-8500

GRAND RAPIDS WHITEWATER EIS
ALTERNATIVE 2
PROFILE AND SECTION VIEWS
LOCATION C

SHEET
C-102C

C:\Civil 3D Projects\GRWW\20-SHEETS\Alt-2\C-102 Profile Views.dwg October 26, 2020 - 4:21pm chris.warren

CANTILEVERED TRAIL CONNECTION

ELEVATED CANOPY TRAIL

MID LEVEL TERRACE

RIVER TERRACES

LOW TRAIL CONNECTION

STEPPED RIVER ACCESS

WATER QUALITY TREATMENT

OVERLOOK

STORM WATER MARSH

STEPPED SEATING TERRACES

MID LEVEL TERRACE

BOATING/TUBING TAKEOUT



FIXED CREST DAM AT LOCATION C
SEE SHEET C-100C

NOT FOR CONSTRUCTION

300 0 300 600
SCALE: 1" = 300'

US Army Corps of Engineers
Detroit District

Mark	Description	Date	Appr.

File Name: C-103 River For Mcdwg
Plot Scale: 1:1
Plot Date: October 26, 2020
PROJECT NO. 60616728
Zero Accidents Zero Tolerance

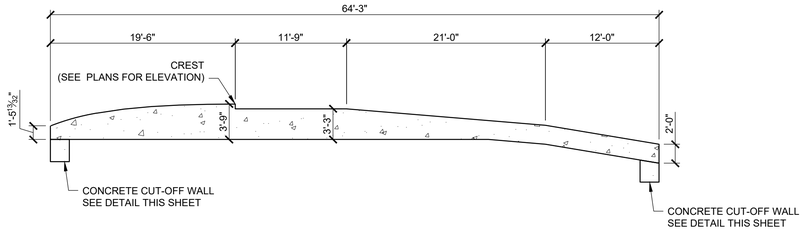
DESIGN BY: J. MCDERMOTT
DRAWN BY: C. WARREN
REVIEWED BY: T. NAPERALA

AECOM
3950 SPARKS DRIVE SE
GRAND RAPIDS, MI 49546
ph (616) 574-8500

GRAND RAPIDS WHITEWATER EIS
ALTERNATIVE 2
GRAND RIVER OPPORTUNITY SITES ALTERNATIVES 2.2 & 2.5

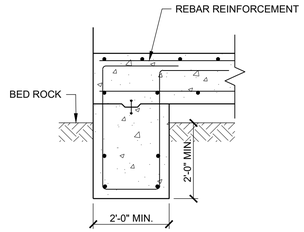
SHEET
C-103C

C:\Civil 3D Projects\GRWW\20-SHEETS\Alt-2\C-103 River For All.dwg October 26, 2020 - 4:21pm chris.warren



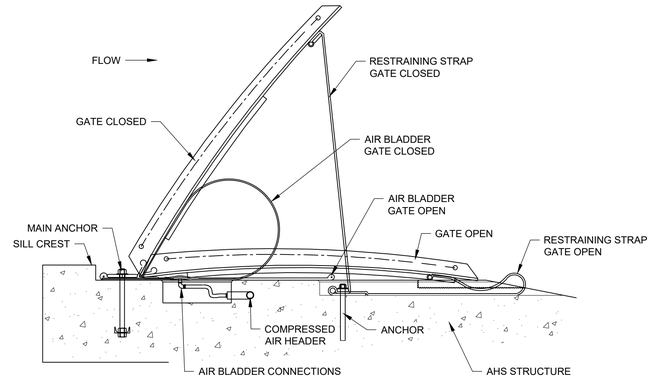
TYPICAL ADJUSTABLE HYDRAULIC STRUCTURE SECTION

N.T.S.



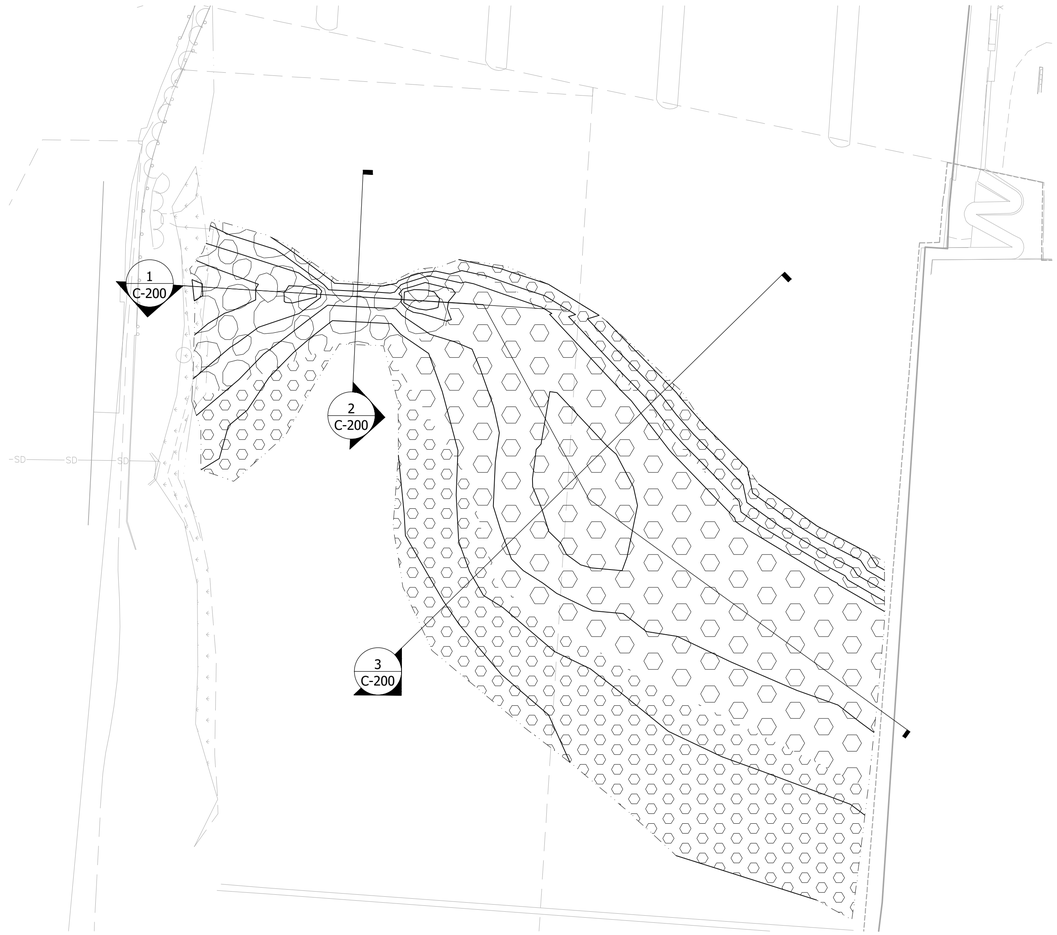
TYPICAL CONCRETE CUT-OFF WALL

N.T.S.



TYPICAL GATE DETAIL

N.T.S.



TYPICAL RIVER FEATURE

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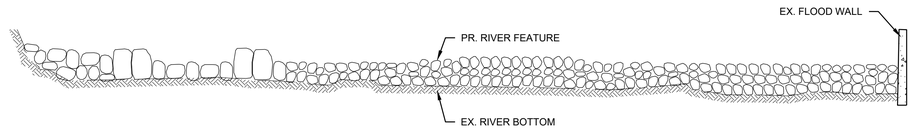
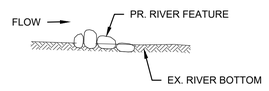
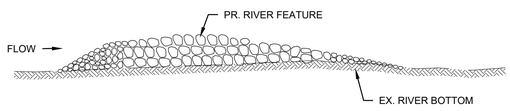
SCALE: 1" = 50'



1 | **RIVER FEATURE SECTION** — C-200 — N.T.S.



2 | **RIVER FEATURE SECTION** — C-200 — N.T.S.



3 | **RIVER FEATURE SECTION** — C-200 — N.T.S.

NOTES:
1. PROPOSED RIVER FEATURE 2 SHOWN, SECTIONS TYPICAL FOR ALL FEATURES.
2. VERTICAL SCALE EXAGGERATED FOR CLARITY.

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Detroit District

Mark	Description	Date	Appr.

File Name: C-200 Typical Details.dwg
Plot Scale: 1:1
Plot Date: October 26, 2020
PROJECT NO. 60616728

Zero Accidents
Zero Tolerance

DESIGN BY: J. MCDERMOTT
DRAWN BY: C. WARREN
REVIEWED BY: T. NAPIERALA

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GRAND RAPIDS, MI 48105
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GRAND RAPIDS
WHITEWATER EIS
ALTERNATIVE 2
TYPICAL DETAILS

SHEET
C-200

C:\Civil 3D Projects\GRWW\20-SHEETS\Alt-2\C-200 Typical Details.dwg October 26, 2020 - 4:22pm chris.warren

OPPORTUNITY SITE #2

DECOMMISSIONED WATER DEPARTMENT STORAGE YARD SITE

SCHEMATIC DESIGN PLAN

This site will be decommissioned as a storage yard for the City of Grand Rapids Water Department and is re-envisioned as a riverfront park. When the rapids are restored and an adjustable hydraulic structure is added, boat passage and river access will dramatically transform this site into a regional activity hub. Design plans call for:

1. **An elevated canopy trail** to connect pedestrians to the forested canopy and protect habitat areas.
2. **Protected ceremonial fire rings** for Anishinaabe and Great River Bands of Ottawa Indian use.
2b. **Public-use outdoor fire pits** Activate the plaza in the winter
3. **A winter lodge** for year-round educational and cultural events.
4. **A repurposed water storage tank** provides a unique space for large events and daily use.
5. **A log-jam inspired nature playground** ensures this park will provide on-land destination recreation for users of all ages.
6. **A dedicated drop-off area** can accommodate large group access and circulating river traffic.
7. **The mid-level terrace** provides a flexible, multi-use lawn area closer to the water.
8. **River terraces** provide additional access to the water's edge for anglers, tubers, and waders.
9. **Small gathering overlooks** allow friends, family and fans to watch boaters from the river's edge.

Integrated Grand River restoration improvements:

10. Adjustable hydraulic structure (AHS)
11. AHS maintenance and control building
12. Boat passage



N
NOT TO SCALE

PRECEDENT IMAGERY - DESIGN & PROGRAM INTENT



1 *Elevated canopy trail*



2b *Public-use outdoor fire pits*



4 *Repurposed water tank*



5 *Log jam inspired nature playground*



8 *River terraces*



9 *Small gathering overlook*



Conceptual rendering of Decommissioned Water Department Storage Yard Site

RIVER FOR ALL
GRAND RIVER CORRIDOR
IMPLEMENTATION PLAN AND RIVER DESIGN GUIDELINES

FINAL DESIGN RECOMMENDATIONS

OPPORTUNITY SITE #3

COLDBROOK DECOMMISSIONED WATER PUMPING STATION SITE

SCHEMATIC DESIGN PLAN

This site is unique because Coldbrook Creek historically outfalled to the Grand River at this location, but was buried in a pipe as part of industrial development. This is an opportunity to divert a portion of the creek into a low-flow channel and open up the outfall for natural, visible stormwater treatment. Following the Grand River restoration, this site will be a critical hub for river access.

(1) **The mid-block crossing and low-trail connection** links this site to the larger River Trail network.

(2) **Stepped river access** connects to the trail and can potentially be used for commercial boat launches and fishing access.

(3) **Existing overlook** to remain.

(4a) **Diversion and surfacing of a portion of Coldbrook Creek** demonstrates the channel's historic alignment.

(4b) **Water quality treatment area at the outfall** treats stormwater before it enters the Grand River.

(5) **A reinforced earth/green wall** softens the corridor.

(6) **A sculptural play area** connects learning and play.

(7) **A repurposed water department building** is planned for public use, and may include relocation of the Parks and Recreation offices, recreation fitness classes, and river-centric event spaces.

(8) **Flexible plaza spaces** adjacent to the building provide areas for outdoor learning and events. Cultural activities, such as canoe building with the Anishinaabe and programmed outdoor recreation activities should be pursued here.

(9) **Mixed use redevelopment** is anticipated at the corner of Leonard Street and North Monroe Avenue with plazas oriented towards the river.

(10) **A large multipurpose lawn** provides flexible space with an option for future bus drop off and trailers transporting tubers and kayakers to the site.

(11) **ADA and small parking lot** is located onsite.

(12) **An emergency boat-access ramp**, placed in coordination with the ongoing Grand River restoration planning.

(13) **Proposed overlook** complements existing design.



NOT TO SCALE

PRECEDENT IMAGERY - DESIGN & PROGRAM INTENT



(1) *Mid-block crossing and low-water trail connection*



(3) *Existing overlook*



(4a) *Diversion and surfacing of a portion of Coldbrook Creek*



(5) *Reinforced earth / green wall*



(6) *Sculptural play area*



Conceptual rendering of Coldbrook Decommissioned Water Pump Station Site

RIVER FOR ALL
GRAND RIVER CORRIDOR

IMPLEMENTATION PLAN AND RIVER DESIGN GUIDELINES

FINAL DESIGN RECOMMENDATIONS

FISH LADDER PARK

SCHEMATIC DESIGN PLAN

Fish Ladder Park has been identified as an important community gathering spot and the structure is an iconic piece of functional art. Following removal of the 6th Street Dam, the Fish Ladder structure will be modified to continue to provide fish passage, and the surrounding park will become a the primary destination for whitewater competition spectators, as well as a hub for boaters and fishing access.

1. **An upper-falls trail deck** is located in the existing tree canopy north of the Fish Ladder.
2. **The existing fish ladder structure** will remain for rapids viewing and fish observation.
3. **The existing pump station** is operated by City Environmental Services and will remain onsite.
4. **A small changing room, restroom, and fish cleaning station** provide services for river users and screen the pump station maintenance court.
5. **A flexible plaza and adjacent parking area** can accommodate small seasonal farmers' markets or other events.
6. **A series of picnic groves** are located near the parking lot to provide shaded seating.
7. **A sloped event lawn next to new trees** that are planted on the high point of the existing berm to provide shade.
8. **An overlook deck** screens an existing outfall.
9. **River seating terraces** allow viewing and lounging at the water's edge.
10. **Emergency boat ramp** provides river access.
11. **Upper viewing perches** on the embankment link Scribner Avenue to Fish Ladder Park, provide small lounging pockets, and expand spectator areas.
12. **A high-water trail connection** and stepped walkway creates a critical year-round trail connection for the west bank of the Grand River.
13. **Angling and wading access steps** link the River Trail to the bank below the rapids.

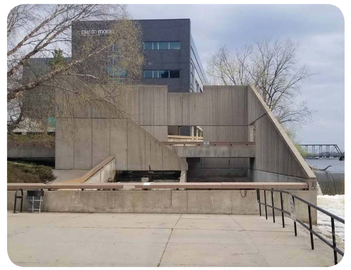


NOT TO SCALE

PRECEDENT IMAGERY - DESIGN & PROGRAM INTENT



1 *Upper falls trail deck in tree canopy*



2 *Existing fish ladder (to remain)*



7 *Sloped event lawn next to new trees*



8 *Overlook deck*



9 *River's edge seating terrace*



13 *Angling and wading access steps*



Conceptual rendering of Fish Ladder Park

RIVER FOR ALL
GRAND RIVER CORRIDOR
IMPLEMENTATION PLAN AND RIVER DESIGN GUIDELINES

FINAL DESIGN RECOMMENDATIONS



River Access Feasability Study - Wealthy Street West Option

July 2018

VIRIDIS Design Group + FTCH



River Access Feasability Study - Wealthy Street East Option

July 2018

VIRIDIS Design Group + FTCH

BRIDGE PIER LINE

FLOODWAY LINE

ABUT WALL

WEALTHY

STAIRS DOWN FROM SIDEWALK

RET. WALL BF SIDEWALK

+611.5

ELEVATED BWALK RAMP @ 8.33%

EDGE OF WATER @ 587.5

STONE SEAT STEPS

RIVER

SPAND

+605

PICK-UP/DROP OFF

River Access Feasability Study - Wealthy Street East Option 2

July 2018

VIRIDIS Design Group + FTCH



6TH STREET & CANAL PARK MASTER PLAN

City of Grand Rapids, Michigan

PRELIMINARY CONCEPT STUDY 1.25.22

Parks and Recreation CITY OF GRAND RAPIDS · DOWNTOWN GRAND RAPIDS INC · VIRIDIS Design Group

0' 50' 100' 150'

PRIORITY PARK CASE STUDY:
REGIONAL PARK + RIVER VALLEY

Riverside Park



EXISTING

- A RESTROOM & MAINTENANCE BUILDING
- B BOAT LAUNCH
- C SOCCER FIELD
- D LITTLE LEAGUE COMPLEX
- E RESTROOM & SHELTER
- F DISC GOLF
- G LAGOON
- H PARKING
- I LARGE GROUP SHELTER
- J PUMP STATION
- K PEDESTRIAN BRIDGE

PROPOSED

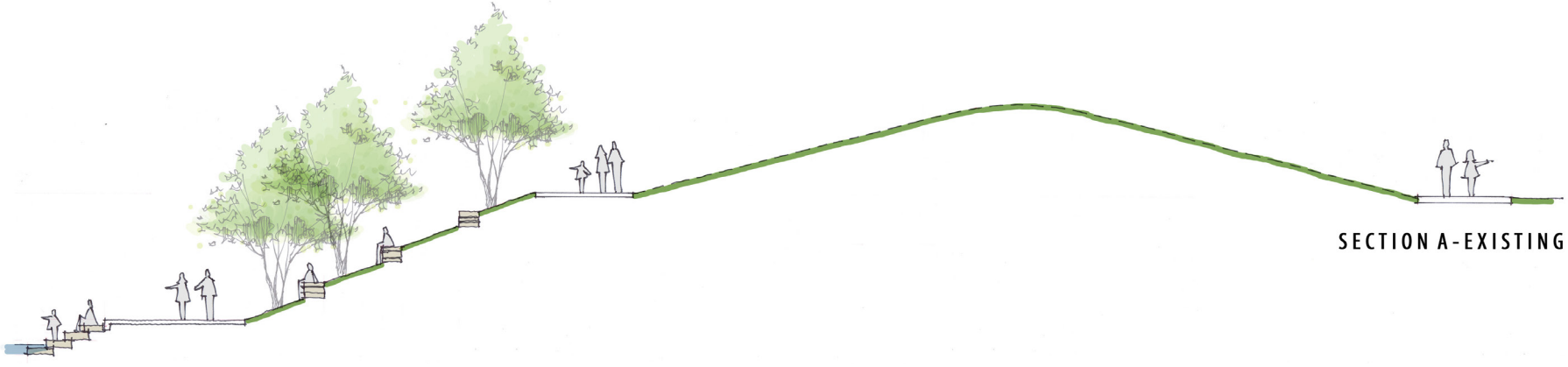
- A RENOVATED RESTROOM & NEW MAINTENANCE BUILDING
- B IMPROVED BOAT LAUNCH AND RECONFIGURED PARKING
- C FENCED OFF-LEASH AREA - 5 ACRES, ADJACENT PARKING
- D NON-MOTORIZED BOAT LAUNCH, BARRIER FREE
- E RENOVATED RESTROOMS & SHELTER
- F IMPROVED LARGE EVENT AREA
- G NEW NATURE-BASED PLAY AREA
- H STORMWATER DAYLIGHTING
- I ISLAND NATURE PRESERVE - NO BOAT ACCESS
- J NEW RESTROOM & SHELTER (2022 IMPROVEMENTS)
- K BOATING CENTER RENTAL & LARGE EVENT SHELTER
  - NON-MOTORIZED
  - FLOATING DOCKS
  - TERRACED OVERLOOK
  - 7,000 SF, +/-, 300 CAPACITY (4,500 SF)
  - RESTROOMS & CONCESSIONS
- L PARKING IMPROVEMENTS
- M RIVER AMPHITHEATER
- N ADDITIONAL CROSSWALKS
- O GENERAL NOTE:
  - REMOVE INVASIVE & SCRUB SHRUB AROUND LAGOON EDGES.
  - PHASE IN WETLAND EDGE/WET MEADOW FILTER STRIP WITHIN 2FT OF SUMMER LOW WATER
- P GENERAL NOTE:
  - SELECTIVELY CLEAR OVERGROWN TREES & BRUSH ALONG TRAIL TO ALLOW GREATER VISIBILITY TO WATER
- Q SEPARATE, FENCED SMALL DOG AREA

- IMPROVED SHARED-USE TRAIL, 12' WIDE
- NEW SHARED-USE TRAIL, 8' WIDE
- STORMWATER DAYLIGHTING
- DISC GOLF
- 100-YEAR FLOODPLAIN LINE
- FLOODWAY LINE
- GRASS TURF
- UPLAND PRAIRIE RESTORATION
- RIVER ACCESS SEATING AREA
- WET MEADOW & WETLAND/OPEN WATER
- EVENT AREA DELINEATION

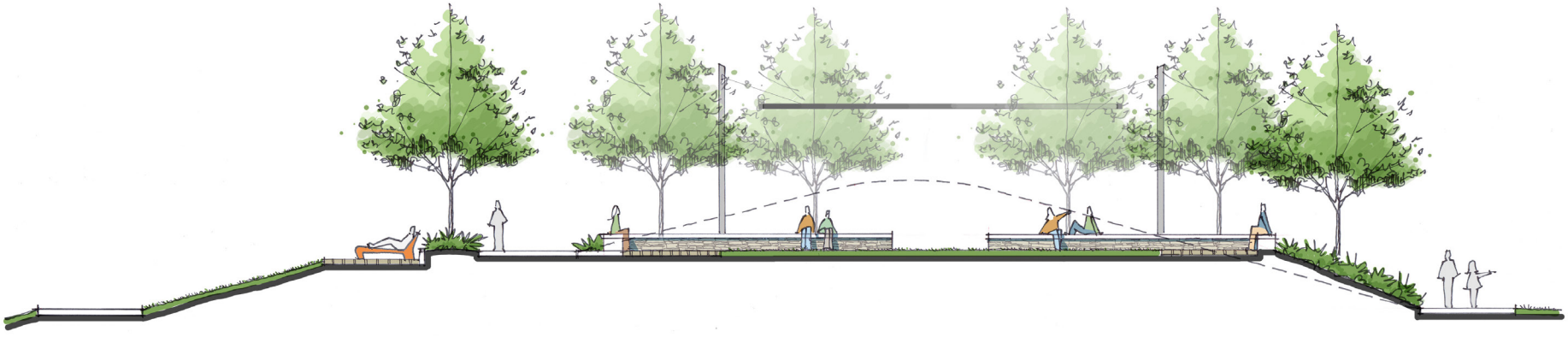

CIRCLE PLAZA WITH MOVABLE PUBLIC SEATING AND UNIT PAVERS
EXISTING STREET LIGHTING BUILDING TO REMAIN
RESTROOM WITH MENS, WOMENS, AND FAMILY UNITS
EXISTING PLUM GROVE SCULPTURE AND TREE
EXISTING CONCRETE PAVILION REMOVED. UTILIZE SPACE FOR BIKE PARKING AND SUPPORT FACILITIES
SPIRIT OF SOLIDARITY FOUNTAIN TO REMAIN
SCULPTURE
PROTECT BRICK PAVERS
+607
+609
+611
+612.4
+613
SECTION A
SECTION B
NATIVE PLANTING LANDSCAPE BEDS, TYP.
PARK GATEWAY SIGN AND LANDSCAPE TREATMENT
DANCE CIRCLE PLAZA WITH MEDICINE WHEEL INLAY, SEATWALL AND UNIT PAVERS
CIRCLE PLAZA WITH MOVABLE PUBLIC SEATING AND UNIT PAVERS
ANISHINAABE ART
SUSPENDED LIGHT CIRCLE, TYP.
VIEWING TERRACE
NEW SHADE TREE, TYP.
EX. SHADE TREE, TYP.
EX. BRIDGE ABUTMENT WALL
EXISTING SIDEWALKS, LIGHTING,LANDSCAPE, AND WALLS TO REMAIN
EX. RIVER WALK
EX. RIVER WALK
PEARL STREET
EX. STONE SEAT STEP RIVER ACCESS TO REMAIN
GRAND RIVER (OWASHTANONG)
FILL EX. RIP RAP VOIDS WITH TOPSOIL AND NATIVE PLUGS
GILLETT BRIDGE



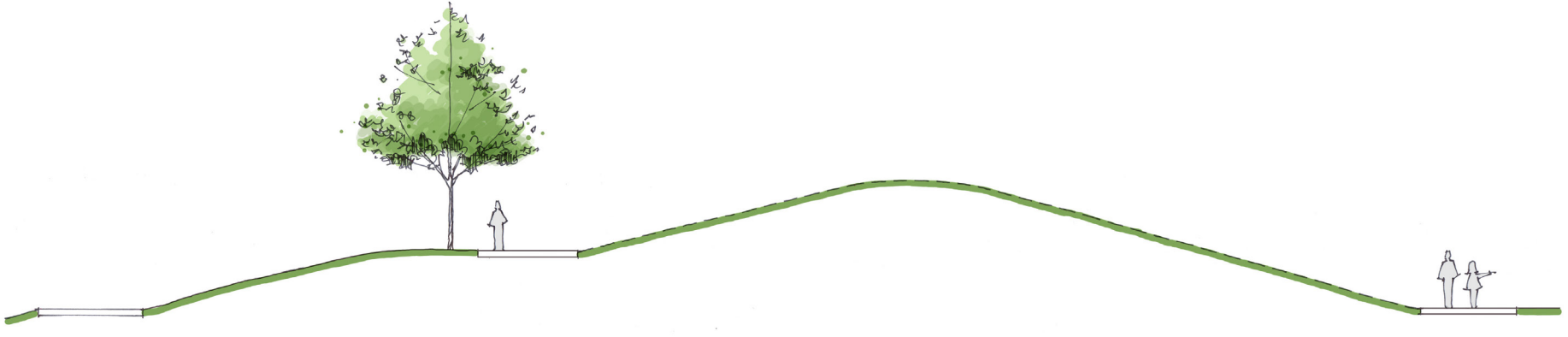
SECTION A-PROPOSED



SECTION A-EXISTING



SECTION B-PROPOSED



SECTION B-EXISTING

APPENDIX E

Other Supporting Information

Preliminary Geotechnical Engineering Study; July 2015

Materials Testing Consultants, INC.

Corporate Office
693 Plymouth NE • Grand Rapids, MI 49505 • (616) 456.5469 • FAX (616) 456.5784

Southeast Michigan
253 Dino Drive, Suite B • Ann Arbor, MI 48103 • (800) 968.8378 • (734) 619.6868

MATERIALS Engineers, Independent TESTING Laboratories, Geotechnical & Environmental CONSULTANTS — Since 1968

July 20, 2015
Project No. 141579

RiverRestoration
P.O. Box 248
Carbondale, Colorado 81623

Attention: Mr. Jason Carey, P.E.

Reference: Report of Preliminary Geotechnical Engineering Study
Grand River Rapids Restoration
Grand Rapids, Michigan

Dear Mr. Carey:

MATERIALS TESTING CONSULTANTS, INC. has completed a preliminary geotechnical engineering study related to the proposed modifications to the Grand River based on our understanding of the project as indicated in the *Grand River Rapids Restoration Preferred Alternative Plan Set* dated April 5, 2015. Results of the study are presented in the attached report.

We appreciate this opportunity to provide engineering services to you. Please contact our office should have any questions or require further assistance.

Sincerely,

MATERIALS TESTING CONSULTANTS, INC.

Todd D. Munger, P.E.
Senior Project Engineer

Steven M. Elliott, P.E.
President

att: Report

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REPORT OF
PRELIMINARY GEOTECHNICAL STUDY
GRAND RIVER RAPIDS RESTORATION
GRAND RAPIDS, MICHIGAN

Prepared For:

RIVERRESTORATION
Carbondale, Colorado

Prepared By:

MATERIALS TESTING CONSULTANTS, INC.
Grand Rapids, Michigan

July 2015
MTC Project No. 141579

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FIGURE 1 STUDY AREA PLAN

FIGURES 2 - 14 BORING LOCATION PLANS

APPENDIX A: SLOPE STABILITY ANALYSIS RESULTS

APPENDIX B: FLOODWALL STABILITY ANALYSIS RESULTS

APPENDIX C: POWERS MINE DOCUMENTATION

Materials Testing Consultants, INC.

REPORT OF PRELIMINARY GEOTECHNICAL STUDY
GRAND RIVER RAPIDS RESTORATION

1.0 INTRODUCTION

Grand Rapids Whitewater has retained RiverRestoration to provide engineering and restoration planning services associated with the proposed modifications to the Grand River. RiverRestoration has retained Materials Testing Consultants, Inc. (MTC) to perform a preliminary geotechnical study for the proposed river modifications. Descriptions of the study methods and results are provided herein. This work has been performed as described in our proposal dated January 29, 2015.

The scope of this study includes the following:

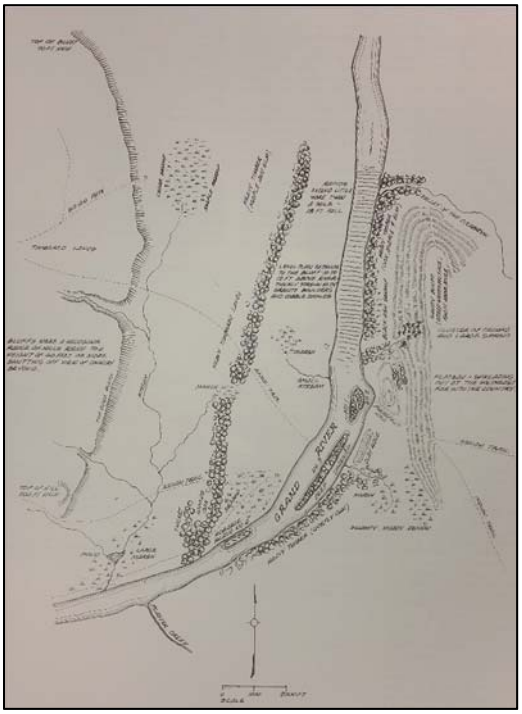
- Task 1 - Information gathering and review of available existing information, including:
    - Research of available boring logs from MDOT and the City of Grand Rapids for bridges that cross the Grand River;
    - Compile prior boring logs compiled from our recent study of the stability of the existing floodwalls and embankments; and
    - Review of documentation available for the existing Powers Gypsum Mine, which was located partially under the Grand River north of Fulton Street near the existing pedestrian bridge.
- Task 2 - Perform preliminary geotechnical analyses for proposed river modification structures, including:
    - Riverside Park Berm
        - Provide recommendations for berm geometry and materials and evaluate berm stability.
    - Adjustable Crest Hydraulic Structure and Fish Passage Structure
        - Evaluate foundation options for support of proposed structures;
        - Provide foundation constructability considerations (bedrock excavation and rock anchors);
        - Evaluate acceptable slope angles for adjacent riverbank; and
        - Evaluate Seepage/piping below proposed fish passage structure and barrier structure.

        - Evaluate report of past geotechnical concerns at MDOT office building on Front Street adjacent to proposed barrier structure and evaluate need for cutoff wall.
    - Floodwall modifications
        - Evaluate stability impact of proposed river modifications to existing floodwall system; and
        - Provide recommendations for naturalized levee.
    - 6th Street Dam and Beautification Dam Removal
        - Provide preliminary geotechnical recommendations for removal.
- Task 3 - Preparation of this report.

Presented herein are descriptions of background information pertaining to the study, the proposed river modifications, the investigation methodology, investigation results, and our preliminary conclusions and engineering recommendations. A study area plan (Figure 1) and boring location plans (Figures 2 through 14) are attached as well as stability analysis results (Appendices A and B) and mine research documentation (Appendix C) to support this report.

1.1 Background Information

The Grand Rapids area was first settled by Europeans near the start of the 19th century by missionaries and fur traders alongside the Ottawa Indians who had developed several villages along the banks of the Grand River. The Northwest Territory survey reached Grand Rapids in 1831, setting the boundaries for Kent County and leading to the incorporation of Grand Rapids as a village in 1838. A map of Grand Rapids prior to incorporation as a village was prepared by E.C. Swanson from survey records made between 1831 and 1837. The map describes rapids within the Grand River extending over one mile in length with a total fall of approximately 18 ft.



Grand Rapids was incorporated as a city in 1850 and continued to develop adjacent to the Grand River as the population grew, utilizing the river for transportation of raw materials and manufactured items, drinking water, sewage disposal and personal transportation. Beginning in the 1830's, canals were constructed along the west and east banks of the river to generate power for mills and factories.



In 1866, the 6th Street Dam (located at the alignment of 4th Street) was constructed to further harness the river's power. The west and east canals have since been backfilled, however, the 6th Street Dam remains as can be seen in the picture at left.

As growth and development continued along the banks of the river, flooding became more and more problematic, prompting the construction of a flood protection system. The Grand River flood protection system was constructed through numerous initiatives dating back to the late 1800's, however, significant momentum towards the completion of the system occurred only after demands from the public following the "Great Flood" of 1904 and subsequent flood events in 1905 and 1907.



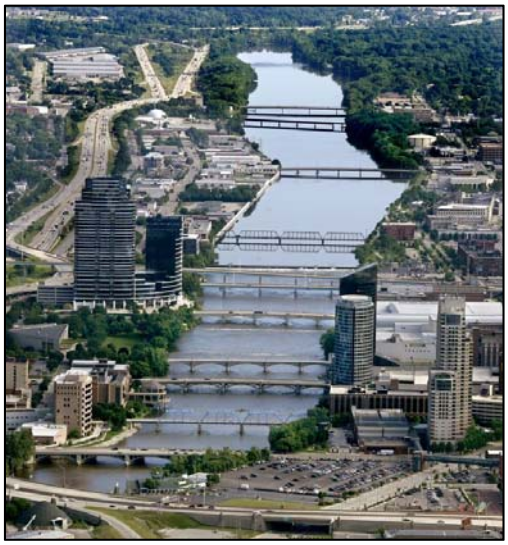
Flooding in the spring of 1904 due to a sudden spring thaw combined with heavy rains resulted in river levels rising to over 5 ft above flood stage (20. 4 ft peak), over $1 million in property damage and flooding which extended as far as John Ball Park. Construction of the original floodwall system was completed in 1911.

Numerous modifications and improvements have been made on both private and public properties since the original construction was completed. Floodwalls include gravity walls, cantilever walls, counterfort walls, hybrid retaining walls containing properties of several wall types in addition to a combination trunk sewer-floodwall. A majority of the floodwalls were constructed using concrete, however, several of the gravity walls utilized stone and mortar construction methods as was popular in the late 1800's and early 1900's. The picture below shows construction of the cobble and mortar gravity floodwall located immediately north of the Pearl Street Bridge in front of the current Amway Grand Plaza Hotel.



Modifications to the river since 1911 were not limited to floodwalls, as is evident from the presence of four beautification dams, located downstream of the 6th Street Dam, constructed in 1927 with the goal of maintaining a constant river level throughout downtown. By 1960, the former west side and east side power canals had been backfilled to create development property and parking space, however, the 6th Street Dam and beautification dams remain.

In 1974, a concrete fish ladder was constructed along the west side of the 6th Street Dam to aid spawning fish intent on swimming upstream of the 6th Street Dam. Modifications to the existing flood protection system are ongoing as a result of continued development adjacent to the river as well as freeboard requirements based on revised FEMA Base Flood Elevations (BFE). The Grand River flowing through modern downtown Grand Rapids is pictured to the right viewed from the south.



1.2 Proposed River Modifications

The current study constitutes an approximately 3.6 mile length of the Grand River from Riverside Park (north extent) to the Fulton Street Bridge (south extent). Modifications and additions to the existing Grand River are proposed in an effort to increase recreational use of the Grand River as well as restore and enhance the river to a more natural condition complete with rapids after the namesake of the City. A summary of proposed modifications is provided below:

- Construction of a new earth berm within Riverside Park
- Construction of an adjustable crest hydraulic structure and fish passage between Leonard Street Bridge and Ann Street Bridge
- Boat ramp construction between 6th Street Bridge and Leonard Street Bridge
- Access ramp construction north of I-196 Bridge
- Removal of the five existing dam structures (6th Street Dam and beautification dams)
- River bottom grading south of the 6th Street Dam
- Construction of miscellaneous proposed river structures

Construction of a new earth berm near Station 2310+00 is proposed within Riverside Park to provide control of flows less than 19,000 cfs for the area. The proposed berm will have an approximate length of 2500 ft with a proposed top of berm elevation at el 611 requiring the placement of approximately 1 to 3 ft of additional fill. The proposed berm will be completely submerged with water levels above the 10-year event. It should be noted that elevations provided within this report are based upon the NAVD88 datum.

Avoiding and minimizing impacts with the removal of the 6th Street Dam necessitates a means to control Grand River water levels during high and low water flow events as well as to control the migration of invasive species upstream. An adjustable crest hydraulic structure and accompanying fish passage will be constructed between Stations 2211+00 and 2217+00 to avoid and minimize impacts.

A new emergency access boat ramp (Station 2187+00) is proposed between the Leonard Street Bridge and the 6th Street Bridge along the east bank of the river. The boat ramp will be approximately 120 ft long and constructed utilizing a 6-inch reinforced concrete slab with 1.5 to 2 ft deep turned-down slab edges.

The 6th Street Dam and accompanying 4 beautification dam structures will be removed as part of construction and various river channel modifications will be performed south of the existing 6th Street Dam including river bottom grading, placement of gravel, cobble and boulder and wave block construction. Proposed river grading will require cuts up to 6 ft deep and fill placement up to 8 ft high creating pools, riffles and rapids through downtown Grand Rapids from the 6th Street Dam to Fulton Street. Wading crossing downstream of the 6th Street Dam and slabstone steps upstream of the dam will provide access to river features.

A new pedestrian access ramp (Station 2153+00) is proposed along the east riverbank between the 6th Street Dam and the I-196 Bridge. The new ramp will require removal of the existing floodwall as well as retaining wall construction to support existing grades north and south of the proposed ramp. Other proposed river structures include pre-cast channel markers and wading crossings. Details for a concrete accessible platform supported by 20-inch concrete piers were also included in the project plans to be constructed at the end of the ramp.

2.0 INVESTIGATION METHODOLOGY

Information gathering and review of available information were included in Task 1 which included relevant boring logs and geotechnical reports completed near the current study area as well as historical drawings for projects completed near the river including flood protection, bridge construction and utility placement projects. A majority of the subsurface information was obtained from company archive files with supplementary information obtained from City of Grand Rapids and Michigan Department of Transportation (MDOT) archives. In total, approximately 650 borings logs from soil borings performed within the City limits adjacent to the Grand River were reviewed dating back to 1921. Location plans of the borings are attached as Figures B-2 through B-14.

Geotechnical reports reviewed as part of this project included a 2012 geotechnical study performed by MTC for Fishbeck, Thompson, Carr & Huber (FTCH) whereby the stability of the existing Grand River flood protection system was evaluated according to Federal Regulation (44CFR65.10). Development of the 2010 FEMA base flood model for the Grand River in Grand Rapids resulted in a general increase in the FEMA Base Flood Elevation within the City limits. As a result of the increase, several areas of existing flood protection no longer met freeboard requirements above the revised 2010 BFE per the reference Federal Regulation which prompted the 2012 study. The information gathered during the 2012 study provided a foundation of data which was both utilized and expanded upon for the current study.

Historical drawings were obtained from Mr. Mark Garvey of the City of Grand Rapids and Mr. Joseph Platte, P.E. of FTCH. Historical drawings provided relevant information pertaining to the design and construction of various structures within the study area including floodwalls and embankments dating back to the early 1900's, vehicular bridges between Ann Street Bridge and Wealthy Street Bridge and utility placement adjacent to and below the Grand River. Subsurface information obtained from boring logs performed for bridge piers and abutments was frequently provided on historic bridge plan sheets including the soil strata type and thickness and depth to bedrock if encountered. The bearing elevations of bridge foundations (bottom of piles, bottom of pier/abutment footings) were frequently provided on the individual bridge boring logs.

Gypsum mining, once a major industry in Grand Rapids, began in 1841 with an open quarry and mill on Plaster Creek near the Grand River. As demand for gypsum products evolved from soil fertilizer to plaster and stucco applications, additional mines were developed within the area including the Powers Mine which operated on the west bank of the Grand River between Fulton Street and Pearl Street. Past projects including the Grand Valley State University Eberhard Center and the Grand Rapids Public Museum constructed near the former underground Powers Mine required research into the mine's location and an understanding of the potential impact of the former mine on the proposed construction. Pertinent available information was obtained from Grand Rapids Public Museum and Public Library archives in addition to various government agencies including the Michigan Department of Natural Resources Geological Survey Division, the United States Bureau of Mining, the DOW Mine Map Repository and the office of Mine Safety and Health Administration. Results of our research are discussed in Section 3.2 with historical documentation related to the Powers Mine included in Appendix C.

3.0 INVESTIGATION RESULTS

3.1 Regional Geology

The *Map of the Surface Formations of the Southern Peninsula of Michigan*, published by the State of Michigan, indicates the site is in an area of glacial outwash. The Grand River valley is known to have been a major channel of glacial water flows. Near-surface soil conditions typically are found to be primarily granular with numerous cobbles and boulders, erratics from a distant geologic source. Several areas along the west and east riverbanks are known to have been low-lying areas prior to development of the area and have been filled with a variety of uncontrolled urban fill materials. Some fill material may have originated from dredging the main channel.

Relatively shallow bedrock is present throughout the study area which includes a limestone and sandstone cap of the Bayport Formation from the north end of the study area to the approximate Lyon Street alignment where the Bayport Formation ends and the underlying weathered shale and gypsum of the Michigan Formation continues south below the overburden soil. The top of the Bayport Limestone is exposed at the riverbed at the site of the fish ladder and 6th Street Dam and floodwall drawings in the vicinity indicate bearing directly on bedrock. In the vicinity of Pearl Street and south where the Bayport Limestone is absent the Michigan Formation Shale is approximately 10 to 30 ft below the alluvial riverbed.

3.2 Subsurface Conditions

During the development of the area during the late 1800's and early 1900's, placement of available miscellaneous material was common to raise low-lying riverbank levels, to create additional property for development as well as flood protection for nearby residences and businesses, defining what is now the current river boundary. A majority of the existing riverbanks are therefore composed of miscellaneous fill material extending to depths up to 20 or 30 ft depth.

The miscellaneous fill material is composed of a highly variable assortment of granular and cohesive soil, boulder and cobble (primarily granite erratics), organic material (topsoil, peat and wood), building debris, cinders, brick and the like. Directly adjacent to and within the river channel, granular glacial outwash and post-glacial alluvium are present below the miscellaneous fill material below which relatively shallow bedrock is present as previously discussed. Native cohesive soil is also encountered adjacent to and within the river channel most often in the form of highly weathered shale above more competent shale. A summary of subsurface conditions described at various bridges crossing the Grand River within the study area is provided below including the approximate depth to bedrock and bedrock type.

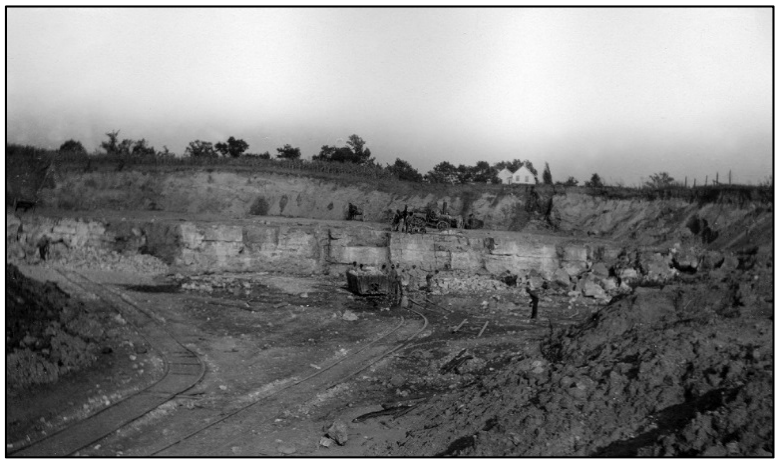
Table 3.2.1 - General Subsurface Conditions Encountered at Bridge Structures

Bridge Structure	Overburden Soil	Bedrock Type	Bedrock Depth (ft)
Ann Street	Granular	Limestone	> 60
Leonard Street	Granular	Limestone	1 to 7
Sixth Street	Granular	Limestone	1 to 2
I-196	Granular	Limestone	2 to 3
Bridge Street	Granular	Limestone	3 to 11
Gillett Bridge	Granular	Shale and Gypsum	20 to 30
Pearl Street	Granular	Gypsum and Shale	26 to 30
Blue Bridge	Granular	Gypsum and Shale	10 to 15
Fulton Street	Granular	Shale with Limestone	26 to 30
Wealthy Street	Granular	Shale	7 to 9

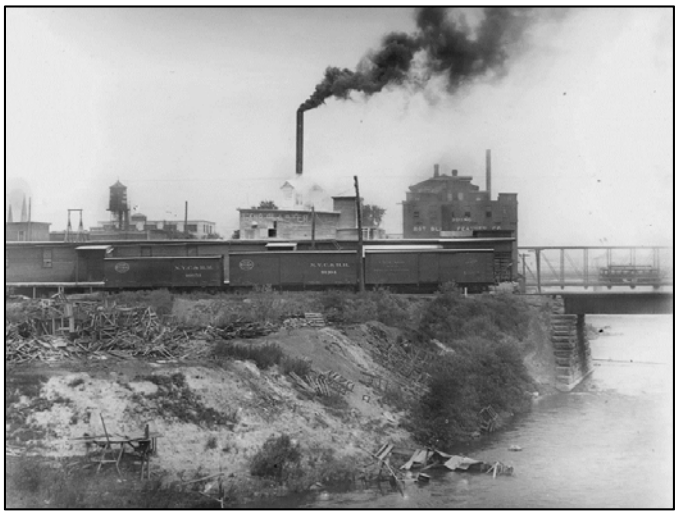
Note: Bedrock depth provided is approximate and is measured from bottom of river.

Historical documents indicating the foundation-type and bedrock depth at the Gillett and Blue Bridges were not found during our research. Bedrock information provided in Table 3.2.1 for the Gillett and Blue Bridges is based on soil borings performed near these structures.

3.3 Mine Research



Gypsum mining formerly located near the study area include the Plaster Creek Quarry, located southwest of the project limits (pictured below) and the Powers Mine located within the south end of the project. The presence of surface beds of gypsum near Plaster Creek allowed for the formation of an open quarry and corresponding mill around the mid-1800's which remained in operation until the early 1900's. Subsequent development of the area has resulted in filling of the former quarry.



Available information concerning the Powers Mine indicates the shaft to the mine began in 1896 by Mr. William T. Powers. Mr. Powers organized the Gypsum Products Manufacturing Company in 1896 prior to construction of the 12 ft by 12 ft mine shaft to mine a 12 ft thick layer of gypsum located approximately 60 ft below the riverbed with a total shaft depth of approximately 85 ft. Approximate mining limits were obtained from *The Gypsum of Michigan and The Plaster Industry*, Volume IX, Part II, 1904. Records indicate that a mill was constructed directly above the mine shaft. Historical photographs and city directories place the mill at the northwest corner of the existing Blue Bridge west abutment (former Grand Rapids & Indiana Railroad Bridge). The picture at right shows the top of the former mill structure directly north of the Blue Bridge on the west bank of the Grand River.

A room-and-pillar style mining operation was utilized consisting of rooms 50 ft square and pillars 20 ft square. The mine was in operation from approximately 1896 to 1911. A fire in 1903 caused a temporary shutdown in the mining. It is not known when the mill was re-opened, however, records indicate that gypsum was mined at least during 1908 to 1911. The roof of the mine contained numerous faults and seams which allowed significant amounts of water to infiltrate the mine necessitating groundwater pumping upwards of 150 gallons per minute to create suitable working conditions.

Records indicate the Gypsum Products Manufacturing Company owned up to approximately 8 acres of property during this time, mostly under the Grand River with 75 percent of the gypsum removed from approximately one acre, mostly below the Grand River's west bank. After the founding of the Company, the land was sold to various entities until in 1910, the extent of the property owned by the Company consisted of a small parcel containing the mill structure and underlying mine shaft. The Company still retained the rights to mine below the entire original parcel.

Following Mr. Powers death in 1910, the mine was succeeded to his son-in-law, Mr. J.W. Spooner, who stated in 1911 that the mine was on too small a scale to be profitable and intended to shut the mining operation down in the coming year. Records indicate that the mine only ran approximately 25 percent of the time between 1896 and 1911. The Company was dissolved in 1914 with property and rights associated with the mining operation sold to the railroad. It not expected that the railroad continued mining at the site following acquisition of the mine property.

Based on the existing site topography and no indication of significant ground subsidence in the area, it is expected that the mine shaft was closed and filled and the underground mine rooms allowed to fill with water. A 1955 letter from a Grand Rapids Public Museum Employee stated that the mine was filled in some time after it was closed. Additional information regarding the closure and possible filling of the mine could not be found. The estimated limits of the mining and mining rights are shown on Figure 3 based on information from a 1907 survey and 1911 tax assessor.

MTC has performed soil borings directly south and north of the Blue Bridge on the west bank of the Grand River for the GVSU Eberhard Center Project and for the Grand Rapids Public Museum Project with no indication of a mine shaft or void within bedrock encountered to depths up to 82 ft below the former ground surface at the boring locations. The boring information obtained by MTC to-date within this area lends further evidence to historical information describing the mines location, footprint and impact below ground. The impact of prior mining activity on the proposed river modifications is discussed in Section 4.6.

3.4 Floodwall and Embankment Stability

A total of 6 cross section locations within non-natural ground segments of the study area were selected to evaluate floodwall and embankment stability with respect to existing conditions as well as conditions associated with the proposed river modifications. Sections were selected where subsurface conditions and floodwall/embankment geometries were well established allowing for an accurate assessment of both existing and proposed stability. Section locations are shown on Figure 1.

Section locations are labeled with a "W" or "E" to designate the west or east riverbank, respectively. Of the 6 section locations, 2 include floodwall protections while 4 include non-natural embankment flood protection. Table 3.4.1 provides a summary of the location and flood protection type at the stability sections.

Table 3.4.1 –Section Summary

Section No.	Address	Flood Protection Type
1W	220 Front Ave SW	Embankment
2W	750 Front Ave NW	Gravity Floodwall
2E	905 Monroe Ave NW	Embankment
3W	1300 Front Ave NW	Gravity / Cantilever Floodwall
3E	1529 Monroe Ave NW	Embankment
4E	60 Ann St NW	Embankment

Stability and seepage requirements for embankments and foundations are provided in the U.S. Army Corps of Engineers (COE) Manual "Design and Construction of Levees" (EM 1110-2-1913), Chapter 6, Section 2 which provides required factors of safety associated with specific loading cases. The loading cases and the corresponding required factors of safety are provided in Table 3.4.2

Table 3.4.2 – Loading Cases and Corresponding Required Factors of Safety

Case	Loading Description	Required Factor of Safety
Case I	Existing Condition	1.3
Case II	Sudden Drawdown	1.0 to 1.2
Case III	Steady State Seepage (BFE)	1.4
Case IV	Earthquake	See Discussion Below

For Case I loading, effective stress parameters are utilized for both granular and cohesive soils while for Case II, III and IV loading, total stress parameters were used for cohesive soil to reflect the shear strength of the soil under short-term loading conditions. Base flood elevations, required for analysis of Case II and Case III loading, were provided by Mr. Joseph Platte, P.E. of FTCH in an email received on April 6, 2015 which are based upon the 2010 FEMA base flood model.

ER 1110-2-1806 is referenced by EM 1110-2-1913 for earthquake design and evaluation. Although no specific factor of safety is provided in the reference regarding earthquake loading, the reference states that the project "team is responsible for establishing the earthquake engineering requirements for the project, planning and executing the seismological and engineering investigations, and evaluating the results." The reference also describes that detailed site explorations, site-specific ground motion studies, and structural analyses are not necessary for projects located in Zones 0 and 1 and that preliminary values of the ground motions obtained from published seismic zone maps may be used to determine if seismic loadings control the design and to set the scope of any proposed site specific studies. The study area is in Zone 0 with a very low risk for seismic activity and, therefore, it is considered that a detailed site exploration and determination of site-specific ground motions will not be necessary and a pseudostatic analysis will be sufficient.

The pseudostatic method is an inertial analysis method originally applied by Terzaghi (1950) where the cyclic nature of the earthquake is ignored and the earthquake loading is applied as an additional static force acting through the centroid of the mass under consideration. The horizontal pseudostatic force (F_h) acts to decrease stability while the vertical pseudostatic force (F_v) typically has less impact on stability and is frequently neglected. The horizontal pseudostatic force acting upon the mass is equal to the product of the total weight of the mass (W) and the horizontal pseudostatic coefficient (k_h) where k_h is equal to the maximum horizontal acceleration (a_{max}) divided by the acceleration due to gravity (g).

Per Kramer (*Geotechnical Earthquake Engineering*, Prentice Hall, 1996), pseudostatic coefficients used in practice generally correspond to acceleration values well below a_{max} because the body of mass is typically not rigid and the peak acceleration occurs only for a very short time period. Kramer references a study performed by Hynes-Griffin and Franklin (1984) which concluded that earth dams with pseudostatic factors of safety greater than 1.0 using $k_h = 0.5a_{max}/g$ should not develop "dangerously large" deformations.

Conservatively, the peak ground acceleration (PGA) can be selected for a_{max} if the maximum horizontal acceleration is unknown. United States Geological Survey (USGS) 2008 Earthquake Hazard Maps of the Central/Eastern United States were used to select a PGA for the study area corresponding to an earthquake with a 10 percent probability of exceedance in 50 years (CEUS

PGA 10%/50 years, 2008). A PGA of 2% g (0.02g) was selected. The PGA associated with 2 percent probability of exceedance in 50 years in the study area is also very near 2% g. The pseudostatic coefficient was then computed as follows:

$$k_h = 0.5 \times \frac{a_{max}}{g} = 0.5 \times \frac{0.02g}{g} = 0.01 .$$

Therefore, significant deformations are not anticipated when using a horizontal pseudostatic coefficient of 0.01 and where static stability safety factors are greater than 1.0.

Computer software SLIDE 6.0 was utilized to perform limit equilibrium slope stability and finite element steady state seepage analyses (where appropriate) at the section locations. The Modified Bishop Method was utilized to compute the factor of safety against slope stability failure for the four loading cases considered. In addition to global stability for section locations with walls, factors of safety associated with sliding and overturning failure were estimated. Floodwalls are generally bearing upon and keyed into bedrock, therefore, bearing considerations were deemed unnecessary.

Steady state seepage analyses were performed for embankment sections to evaluate seepage behind embankments (seepage flow perpendicular to riverbank) as well as the potential for the formation of seepage faces. Due to floodwalls bearing upon bedrock, seepage below floodwalls is not expected to be a concern and was not analyzed. Although some seepage faces were predicted to develop on the landside of the embankments due to seepage flow perpendicular to the riverbank during steady state base flood conditions, the predicted hydraulic gradient was substantially less (15 to 20 percent) compared to the critical hydraulic gradient necessary to initiate piping or heave at the estimated seepage discharge point. Steady state seepage concerns are not expected to be exacerbated by the proposed river modifications.

The Adjustable Crest Hydraulic Structure will create a hydraulic head on the order of 8 ft (el 610 to 602) and a damming effect with river elevations slightly higher (several feet) on the upstream side (el 610) of the hydraulic structure and slightly lower (several feet) on the downstream side (el 602) when compared to existing ordinary high water elevations. The presence of the floodwall on the west bank and the concrete retaining wall on the east back, both possibly founded upon and

keyed into bedrock, are expected to significantly restrict seepage flow perpendicular to river flow. The presence of floodwall approximately 500 ft upstream of the hydraulic structure along the west bank is expected to result in a longshore hydraulic gradient less than the critical hydraulic gradient of retained soil behind the floodwalls, thus, effectively controlling seepage below the west riverbank. A seepage cutoff wall west of the west floodwall to control the hydraulic gradient below the west riverbank is not expected to be necessary. Longshore seepage below the east riverbank will be controlled through design measures associated with the proposed fish passage and slope reconstruction.

Settlement is generally not applicable to our study as the potential and magnitude for future settlement is negligible because settlement associated with construction has already occurred given the age of the flood protection system (100 years ±). Proposed modifications to the system may result in low water elevations several feet below current levels, however, the increase in effective stress from potential lower water elevations is not expected to result in significant amounts of settlement. Some settlement below the proposed Riverside Park berm may occur as result of fill placement, however, additional soil borings will be required to accurately evaluate the magnitude of differential settlement along the berm. Settlement of foundation soils below the berm fill can be accommodated for through the placement of additional fill during construction.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The available information suggests the Grand River originally (prior to City's development in the mid 1800's) dropped 18 ft in elevation in a distance of a little more than one mile. This region of the "Grand Rapids" extended from the approximate current alignment of Leonard Street southward to approximately the current Gillette Bridge. We suspect the Grand River throughout much of the rapids was flowing upon or very near the top of bedrock surface of the Bayport Limestone Formation. It is expected that numerous boulders and cobbles were present in the region of the rapids as glacial outwash flows would have deposited such erratics. Although several feet of variation is noted, the top of bedrock at Leonard Street is approximately el 600 while at Michigan Street it is approximately el 590. Floodwalls, bridges and the 6th Street Dam throughout this area are largely founded on bedrock.

The gravity sections of boulder floodwalls north and south of Pearl Street are believed to have been constructed with primarily granite boulders pulled from the river and are founded at the river bottom with very little embedment or scour protection.

Soil behind the floodwalls and along the Grand River embankments is primarily miscellaneous fill over shallow bedrock throughout the region of former rapids and miscellaneous fill over post-glacial alluvium both north and south of the former rapids.

4.1 Proposed Riverside Park Berm

Additional control of overbanking flows will be provided by the construction of an approximately 2500 ft long earth berm along the east bank of the Grand River in Riverside Park. Existing grades in the area of the proposed berm range from el 608 to 610 with a proposed top of berm elevation at 611. The placement of approximately 1 to 3 ft of engineered fill will, therefore, be required to construct the proposed earth berm.



A picture of Riverside Park viewed from the north where the proposed berm will be constructed is shown at right. Past soil borings performed in the area for the completed Riverside Trail Project encountered several feet of very loose sand fill and soft sandy clay fill with variable amounts of organic material overlying loose to medium dense granular soil. This material is expected to be suitable for as subgrade for berm construction following appropriate site and subgrade preparation.

The limits of the proposed berm area should be prepared initially through clearing and grubbing followed by topsoil stripping. The limits of the proposed construction area, prior to the placement fill material, should be proof-rolled by the contractor. Proof-rolling is defined as the passing of relatively heavy construction equipment over the soil subgrade under observation by the Geotechnical Engineer. The response of the soil, when subjected to the applied load, is subjectively evaluated by our staff with respect to its ability to support the overlying soil or structure. In areas where excessive deflection is observed, special subgrade preparation measures may be recommended to provide an acceptable subgrade condition. These measures may consist of compaction of the subgrade at moisture contents close to the optimum value, undercutting affected areas and replacing with engineered fill, use of a geotextile separation fabric or some combination of these measures.

The berm should be constructed through the placement of low permeability soil consisting of clayey sand (SC), lean clay (CL) or a combination thereof. The soil should be compacted in lifts not exceeding 9 inches in thickness to at least 95 percent of the maximum Standard Proctor dry density (ASTM D 698) with moisture contents during compaction within $\pm$2 percent of the soil's optimum moisture content. Sheepsfoot type compactors with a kneading form of compaction are typically found to be most effective in cohesive soil. The berm will be designed with overflow channels to equalize water pressure as a result of overtopping flows.

For preliminary design purposes, the berm should be constructed with maximum 1V:4H side slopes with a minimum top of berm width of 5 ft. The presence of a pedestrian path on top of the berm may necessitate a wider berm width. Considering the soil conditions encountered in nearby soil borings, excessive settlement associated with 3 ft of soil surcharge is not expected. Additional soil borings (at least 6 borings at 15 ft minimum depth) should be performed as part of final design phase services to evaluate the stability of the proposed earth berm and the seepage potential through the berm considering the design water surface elevations.

4.2 Proposed Adjustable Crest Hydraulic Structure and Fish Passage

The proposed Adjustable Crest Hydraulic Structure (ACHS) and accompanying fish passage will be constructed between Leonard Street and Ann Street, approximately 100 to 150 ft north of the existing Monroe Avenue water storage tank. Per Sheet D.08 of the preliminary project plans, three gate alternatives are under consideration supported by a concrete foundation bearing within the existing river channel. The fish passage will be constructed directly east of the hydraulic gate structure within the existing east bank slope and will consist of a terraced boulder wall on the east side of the passage and concrete walls on the west side of the passage. The passage is expected to be constructed of concrete and will contain five adjustable gates.

The existing west riverbank is supported by a counterfort and cantilever concrete floodwall bearing upon bedrock with a top of wall near el 617 and a bottom of foundation near el 597. The east riverbank contains a concrete retaining wall extending several feet above the ordinary water level with a vegetated soil slope extending from the top of the concrete wall up on an approximately 1V:2H slope to a walking path near el 620. Historical plans of the concrete retaining wall were not available from the City of Grand Rapids or FTCH, however, based on the observed wall geometry, historical building practices and the depth to bedrock, it is possible that the wall in question is founded upon bedrock. A soil boring performed northeast of the proposed structure near the east bank of the river encountered approximately 12 ft of granular fill containing varying amounts of debris and organic material overlying lean clay and peat to approximately 20 to 22 ft where limestone bedrock was encountered near el 598. The river channel bottom near the proposed hydraulic gate and fish passage structures varies from approximately els 600 to 602 and is expected to be composed of granular soil consisting of sand and gravel outwash overlying weathered limestone bedrock.

The proposed ACHS and fish passage are located near an active 46-inch transmission water main. As-built records from 1938 show the water main alignment extending due west from the former Monroe Avenue water treatment plant to the Grand River and crossing the river in a west-northwest direction to near the intersection of Front Avenue and Webster Street as shown on Figure 9. The water main is composed of reinforced concrete pipe with an invert elevation below the river near el 594. It is expected that a trench was excavated within the bedrock base in the river and the water main was placed directly in the trench during installation. Details regarding water main placement below the west floodwall are unknown including alignment, backfill, presence of bulkheads, etc. The approximate alignment of the 46-inch transmission water main, as shown on Figure 9, indicates an intersection between it and the proposed ACHS. The trench in the bedrock presents potential conduits of seepage pathways beneath the proposed structure. If an alternate location is not available, it will be necessary to investigate further the water transmission main and trench as well as potential seepage impacts and strategies to mitigate. The water main alignment has not been surveyed according to FTCH.

If an alternate location of the ACHS immediately north or south of the 46-inch transmission water main is selected, construction will likely require partial-width construction within the river channel and either bypassing of the river flow through placement of a temporary dam to create a controlled working environment for construction. Rock anchors are expected to be required for anchorage of the proposed ACHS with the structure keyed into the underlying limestone bedrock. Rock anchors may also be necessary for anchorage of the fish passage structure depending on the estimated lateral and uplift forces. For preliminary design, an anchor diameter of 4 inches, a minimum bond length of 8 ft into rock and center-to-center spacing of 7.5 ft an allowable uplift capacity of 28 kips may be used. The design loading upon the ACHS foundation as well as the condition and shear strength of the underlying bedrock will need to be understood in conjunction in order to estimate the number and depth of rock anchors required. Final design phase geotechnical services should include the performance of soil borings (at least 4 borings with rock coring to el 580) to evaluate the condition and strength properties of the bedrock.

The west side of the ACHS will connect into the existing floodwall adjacent to MDOT property. As part of Task 1 (information gathering), MDOT was contacted regarding whether or not any performance issues have occurred with the floodwall located on the east side of their property. We were informed by MDOT that no known settlement or movement issues are known. Excessive settlement and seepage below or west of the west floodwall associated with construction of the ACHS are not expected.

Considering the limited amount of design information available with respect to the proposed fish passage structure and based on the information provided, construction of the fish passage structure appears feasible. The presence of uncontrolled fill and organic soil (peat) creates stability concerns requiring probable overexcavation and replacement with engineered fill for proper support. Considering the foundation and slope influence region will likely be overexcavated and replaced with select engineered fill, a slope angle of 1V:3H may be used to satisfy USACE requirements for slope stability. Final design phase services should include the performance of soil borings (at least 5 borings to bedrock at estimated 20 ft depth) at the location of the proposed fish passage to evaluate these geotechnical risks.

The proposed ACHS and fish passage will likely both bear upon and be keyed into limestone bedrock. The seepage/piping associated with structures bearing seated within the bedrock is expected to be negligible.

It should be noted the concrete wall present at the toe of the east riverbank slope is in relatively poor condition based on a walkover survey of the area and observation of the exposed surfaces of the wall. The top and east side of the concrete wall as exposed during our site visit with a majority of the concrete surface experiencing severe cracking and spalling. It is expected this wall will need to be replaced where it is relied upon to support new structures or loads. The replacement wall section may consist of either a concrete gravity wall or a concrete cantilever wall founded upon and keyed into bedrock.

4.3 Impact to Existing Floodwalls and Embankments

A summary of the slope stability analyses performed at the 6 section locations for the four loading cases previously described is provided in Table 4.3.1. The geotechnical parameters considered at each section and the corresponding SLIDE output for each individual analysis are provided in Appendix A.

Table 4.3.1 – Slope Stability Analysis Summary

Section No.	Flood Protection Type	Loading Case	Minimum Global Factor of Safety	
			Existing Conditions	Proposed Conditions
1W	Embankment	Case I	3.42	3.43
		Case II	1.77	2.67
		Case III	3.42	3.95
		Case IV	3.42	3.72
2W	Gravity Floodwall	Case I	2.54	2.32
		Case II	2.03	1.62
		Case III	5.33	4.51
		Case IV	2.48	2.27
2E	Embankment	Case I	2.44	1.81
		Case II	1.90	1.39
		Case III	3.43	2.74
		Case IV	2.25	1.80
3W	Gravity / Cantilever Floodwall	Case I	2.32	2.26
		Case II	1.78	1.56
		Case III	4.98	4.78
		Case IV	2.27	2.21
3E	Embankment	Case I	2.45	2.71
		Case II	1.07	1.03
		Case III	2.49	2.41
		Case IV	2.33	2.57
4E	Embankment	Case I	1.40	1.30
		Case II	3.15	1.66
		Case III	5.91	2.10
		Case IV	3.54	2.15

Sections containing floodwall were evaluated for sliding and overturning stability for Case I (Existing Condition) and Case II (Sudden Drawdown) loading cases. Case III (Steady State Seepage) and Case IV (Earthquake) loading were not considered for floodwall sections due to (1) the hydrostatic pressure acting on the waterside of the floodwall will contribute to stability for Case III loading and (2) the earthquake loading influence is inconsequential as previously discussed considering Case IV loading. A summary of floodwall stability analyses is provided in Table 4.3.2. Floodwall stability calculations are provided in Appendix B.

Table 4.3.2 – Floodwall Stability Analysis Summary

Section No.	Floodwall Type	Loading Case	ΔH (ft) [1]	Overturning FS	Sliding FS	Eccentricity (ft)
2W	Gravity Wall	Case I: Existing OHW = 606.4	0	1.48	1.79	1.19
		Case I: Proposed OLW = 601.8	0	1.97	2.14	2.25
		Case II: Proposed	4.6	1.04	1.46	2.56
3W	Gravity / Cantilever Wall	Case I: Existing OHW = 607.0	0	3.28	2.09	-1.71
		Case I: Proposed OLW = 602.0	0	8.37	2.72	-1.38
		Case II: Proposed	9.0	1.11	1.11	3.00
		Case II: Proposed	11.1	0.77	0.93	6.03

1. Change in water head between landside and waterside
2. Cells highlighted in red indicate the controlling stability case (i.e. overturning vs. sliding)

Table 4.3.2 demonstrates the maximum allowable head differential during Case II loading to maintain a stable floodwall conditions. Although floodwalls within the Grand Rapids flood protection system do not appear to have been designed to resist loading strictly following Case II loading (total base flood retention with complete river drawdown), historically, the walls have withstood pressures resulting from drawdown after flood stage and provide a safety factor of at least 1.0. Although the walls become unstable with greater unbalanced water pressures, it is unrealistic to apply such parameters based on the successful past performance of the floodwalls and embankments.

Although the proposed modifications are expected to both positively and negatively affect the stability of floodwalls and embankments, factors of safety against embankment and foundation failure for both existing and proposed conditions are predicted to meet or exceed USACE requirements per EM 1110-2-1913.

As mentioned previously, steady state seepage through embankment sections and settlement due to proposed modifications is not expected to be a significant concern. Settlement computations were not performed given the duration of time which has passed since the original construction (100 ± years) and because anticipated modifications will not add substantial load to the structures.

The floodwalls at Pearl Street Bridge along the east bank of the river consist of cobble and mortar acting as a gravity mass to resist sliding and overturning forces from earth pressures and surcharge loads from both building loads and live loads. The walls extend approximately 170 ft north and 150 ft south of Pearl Street as shown on Figure 3 (approximately Stations 2129+80 to 2133+00). Sections of these floodwalls have been evaluated in the past as a result of both geotechnical and structural stability concerns and are known to have shallow embedment depths on the order of 1 to 2 ft below the existing river bottom with wall backfill consisting of uncontrolled soil and urban fill. River bottom grading resulting in soil removal and the corresponding removal of stabilizing passive soil resistance must be prevented in these areas. Additional scour protection should be included in the final design to prevent future scour adjacent to and below these structures.

4.4 Dam Removal

Partial-width construction techniques, temporary damming and the controlled lowering and discharge of retained water are expected to be required to remove the existing 6th Street Dam in order to avoid negatively impacting adjacent structures. It is suspected that construction of the beautification dams occurred after construction of the adjacent floodwalls. Considering this as well as the relatively small cross section of the beautification dams, beautification dam removal is not expected to pose a significant stability risk to adjacent structures.

Historical plans from 1926 indicate the 6th Street Dam has an approximate width of 17 ft, a total height on the order of 11 ft and a 2 ft embedment into bedrock with possible steel anchorage on the downstream end of the dam into bedrock. The dam was constructed utilizing a stone fill core with a concrete exterior. Historical plans for the beautification head dams indicate dam widths ranging from 4.3 ft to 5.8 ft with heights above the river bottom ranging from 1.5 ft to 3 ft with an embedment depth of 12 inches below the river bottom.

The 6th Street Dam extends continuously from the west riverbank to the east riverbank. On the west side of the river, the dam extends below the fish ladder which was constructed above the dam as shown in the picture at right (east fish ladder wall looking down at dam extending below ladder wall).





On the east side of the river, the 6th Street Dam intersects a pile-supported concrete floodwall and steel sheet pile floodwall on the east bank above which an overlook observation area is located. A picture of the east end of the dam and the east floodwall is shown at left (viewed from the south). In 2013, flooding of the Grand River resulted in undermining of the east bank floodwall immediately upstream and downstream of the 6th Street Dam necessitating steel sheet pile installation and grout fill placement within void areas below the overlook structure.

We envision two basic options for removal of the 6th Street Dam. One would involve complete removal including impacted structures at the east and west banks of the river. The other would involve leaving sections of the dam adjacent to the shore structures in place. More specifically, we expect the complete removal option would involve removal of the fish ladder structure on the west riverbank as well as the east floodwall structure supporting the previously-described observation area. Allowing the west and east extents of the dam to remain in-place option is expected to be less costly and involve integration with the on-shore structures in the river modification plan.

Removal of the 6th Street Dam will require a detailed demolition plan and schedule with contingency plans in-place should instability of adjacent structures be observed during demolition. The retained water surface should be lowered at a controlled rate no greater than 1 ft per 3 days to maintain stability of floodwalls and embankments. It should be noted we have not been retained to evaluate potential environmental risks associated with removal of the dams, including, but not limited to, sediment transport, localized scour or other issues within the study area.

If complete removal of the 6th Street Dam is selected, a minimum of two soil test borings with rock coring are recommended for design of new floodwall structures.

4.5 Miscellaneous Proposed Structures

Miscellaneous proposed structures associated with the project include the previously-described boat ramp, pedestrian access ramp, pre-cast wave blocks and channel markers, wading crossings and a concrete accessible platform. For on-shore structures, such as boat ramps and access ramps, overexcavation of the miscellaneous fill and replacement with compacted engineered fill is expected to be required. Overexcavation will likely be required to native alluvial deposits, the approximate depth of which should be evaluated through the performance of additional soil borings. For structures within the river, adequate embedment for scour protection and resistance to lateral loads are the primary concerns, recognizing that limestone bedrock is relatively close to the riverbed from approximately the location of the proposed Adjustable Crest Hydraulic Structure southward to approximately Gillette Bridge. Some rock excavation may be necessary to provide sufficient embedment and anchorage may be required.

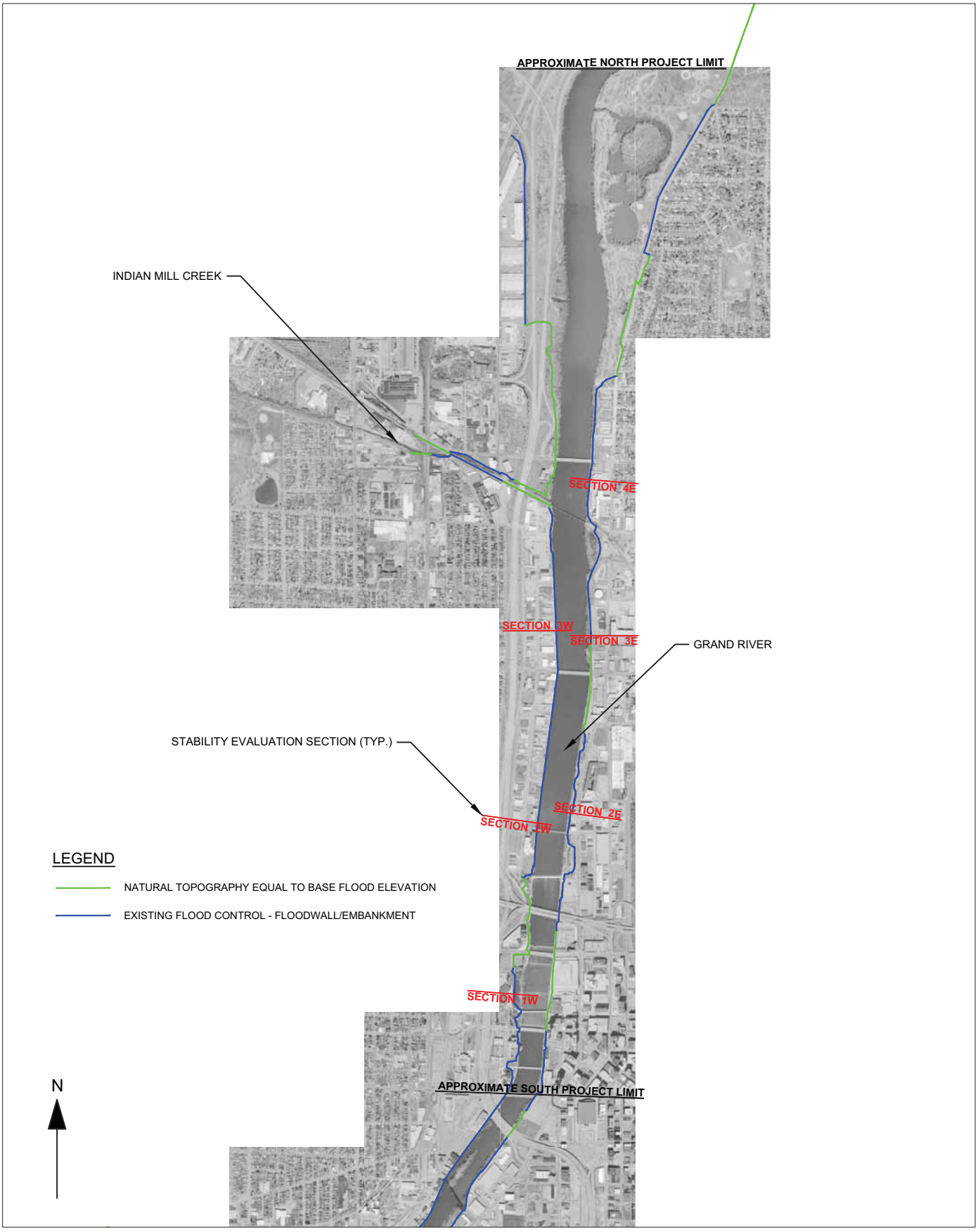
The pedestrian access ramp will require removal of a section of the east floodwall located north of the I-196 Bridge structure. Retaining wall construction will be required north and south of the ramp to support ramp grades ranging from approximately el 600 at the river to el 615 at the east end of the ramp. Retaining wall design will need to consider all applicable surcharge loads which may act upon the walls including the adjacent I-196 Bridge embankment. Final design phase services should include the performance of soil borings (at least 4 borings to bedrock at estimated 20 ft depth) at the location of the proposed pedestrian access ramp.

4.6 Impact of Prior Mining Activity on Proposed River Modifications

There is no significant available evidence of ground subsidence or related settlement in the area of the former Powers Mine due to the prior mining activity in the early 1900's. Proposed river channel modifications in the vicinity of the former Powers Mine include the creation of pools requiring the excavation of approximately 1 to 2 ft. The proposed river modifications are not expected to impact the stability of the Powers Mine including sinkhole opportunities, mine roof collapse or solution activity of gypsum due to changing groundwater gradients in the vicinity of the mine. The former Plaster Creek Quarry is outside of the area of this project.

5.0 CLOSURE

In this report, descriptions of the background information pertaining to the study, the proposed river modification concept, the investigation methodology, investigation results and our preliminary conclusions and engineering recommendations have been provided. This effort does not imply or provide a guarantee or warranty of performance. We remain available to complete the remaining geotechnical investigation and evaluations necessary throughout the completion of this project. It is possible that hidden or latent conditions may be present and, should such conditions become evident, will require re-assessment or further investigation.



NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: STUDY AREA PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
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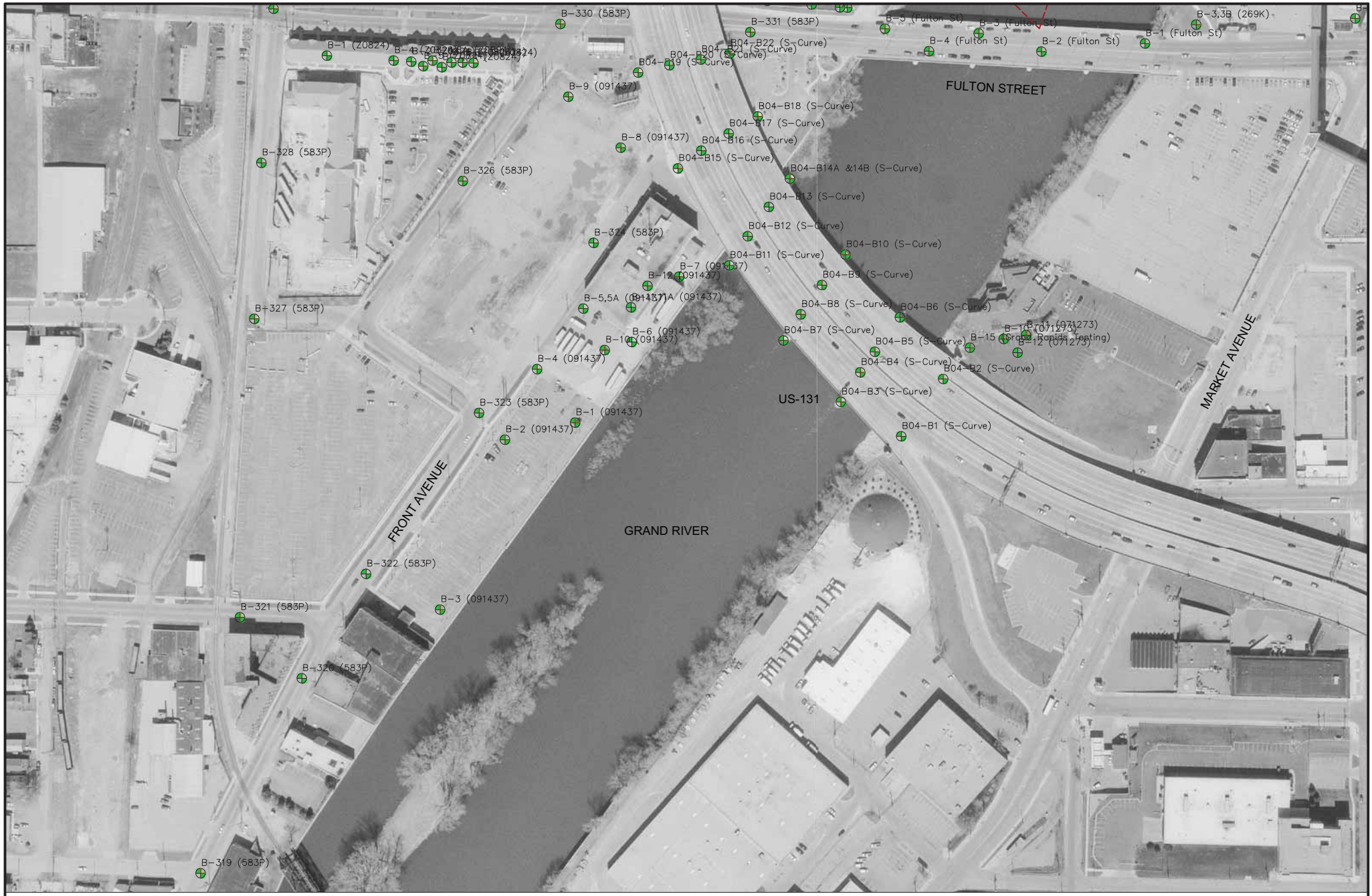
FIG. NO.: 1	DR. BY: TM	REV. BY: SE	



N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
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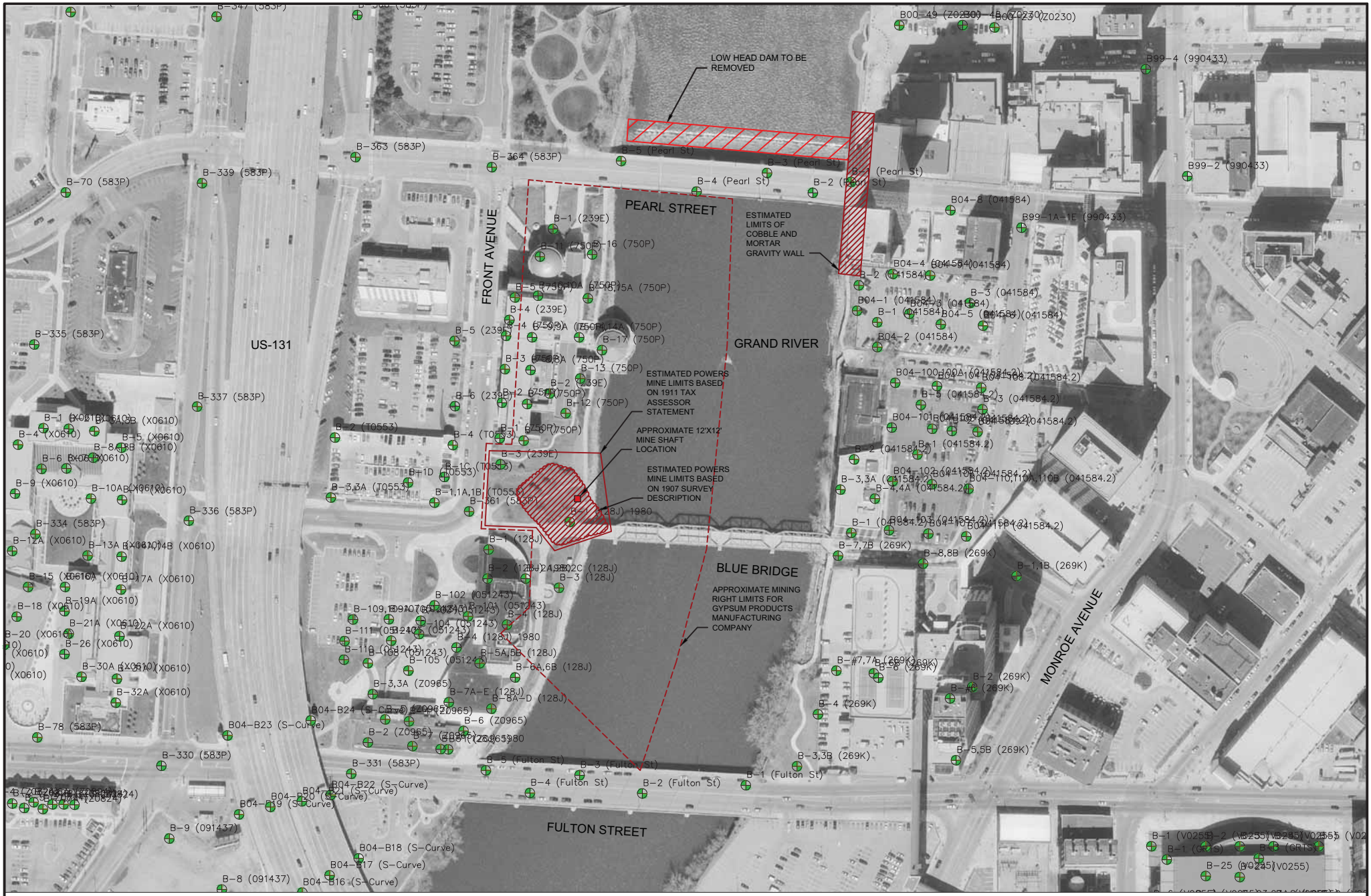
FIG. NO.: 2	DR. BY: TM	REV. BY: SE	



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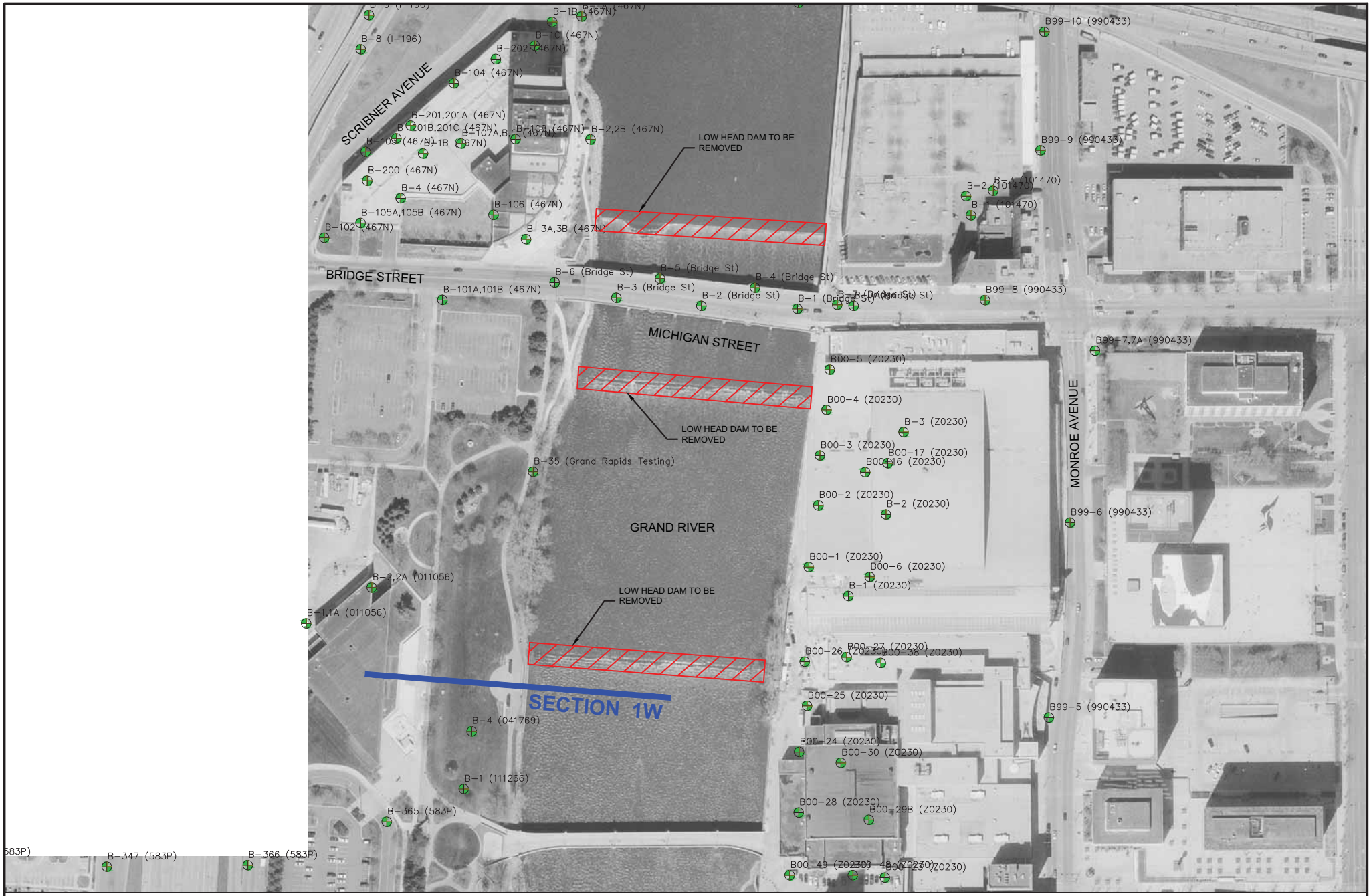
LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 7-16-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 3	DR. BY: TM	REV. BY: SE	



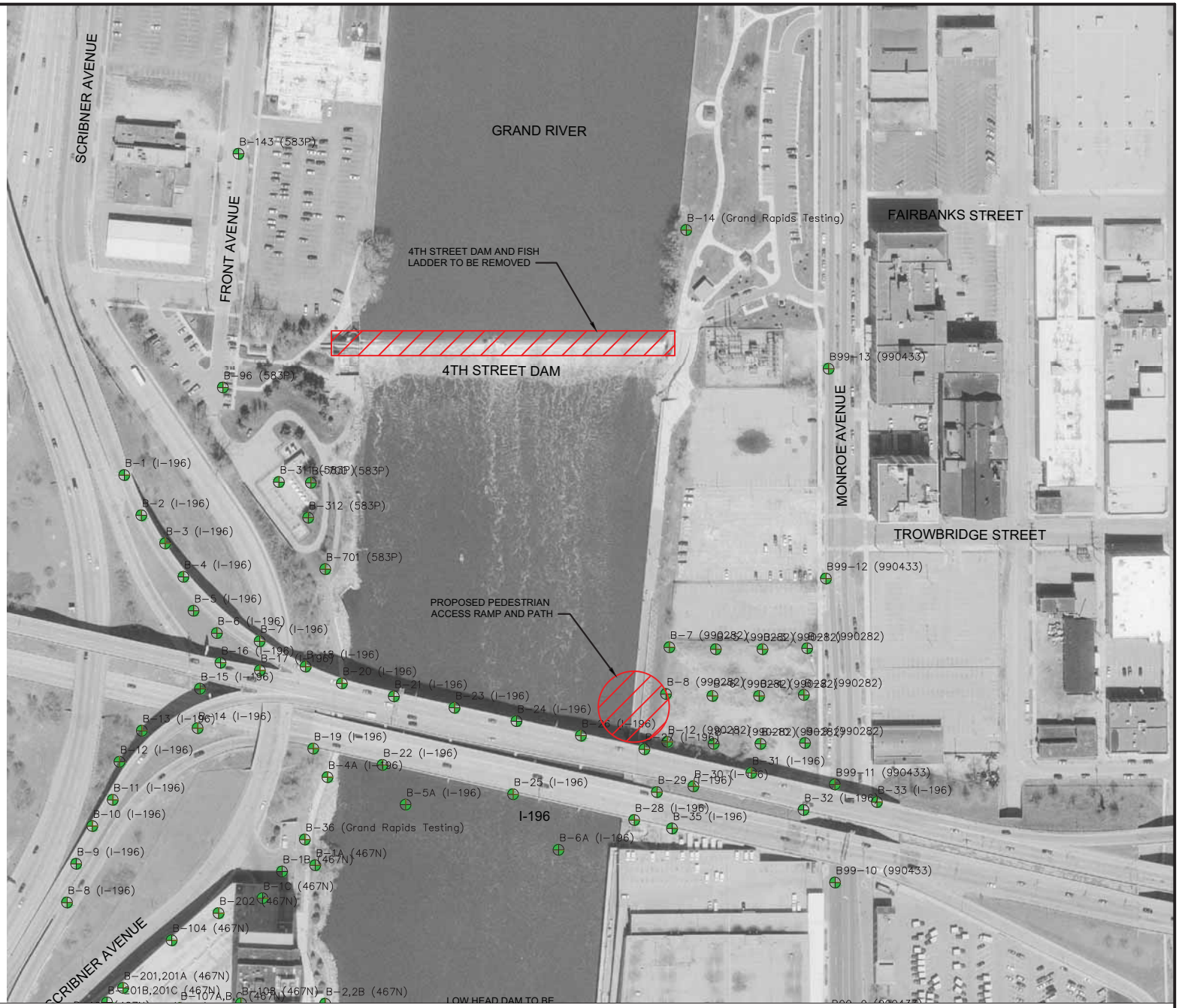
N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 4	DR. BY: TM	REV. BY: SE	



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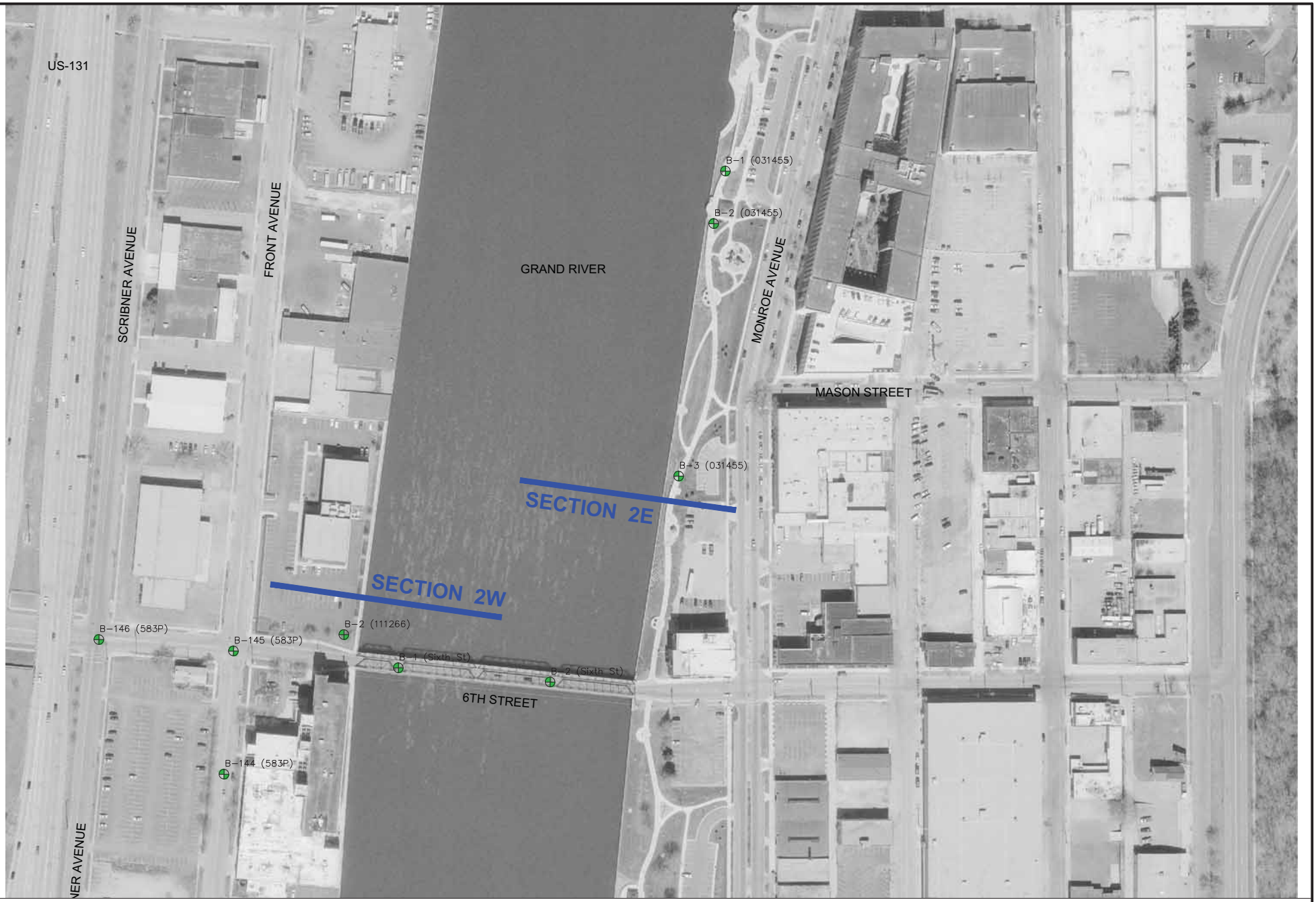
LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 5	DR. BY: TM	REV. BY: SE	



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LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 6	DR. BY: TM	REV. BY: SE	



N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 7	DR. BY: TM	REV. BY: SE	



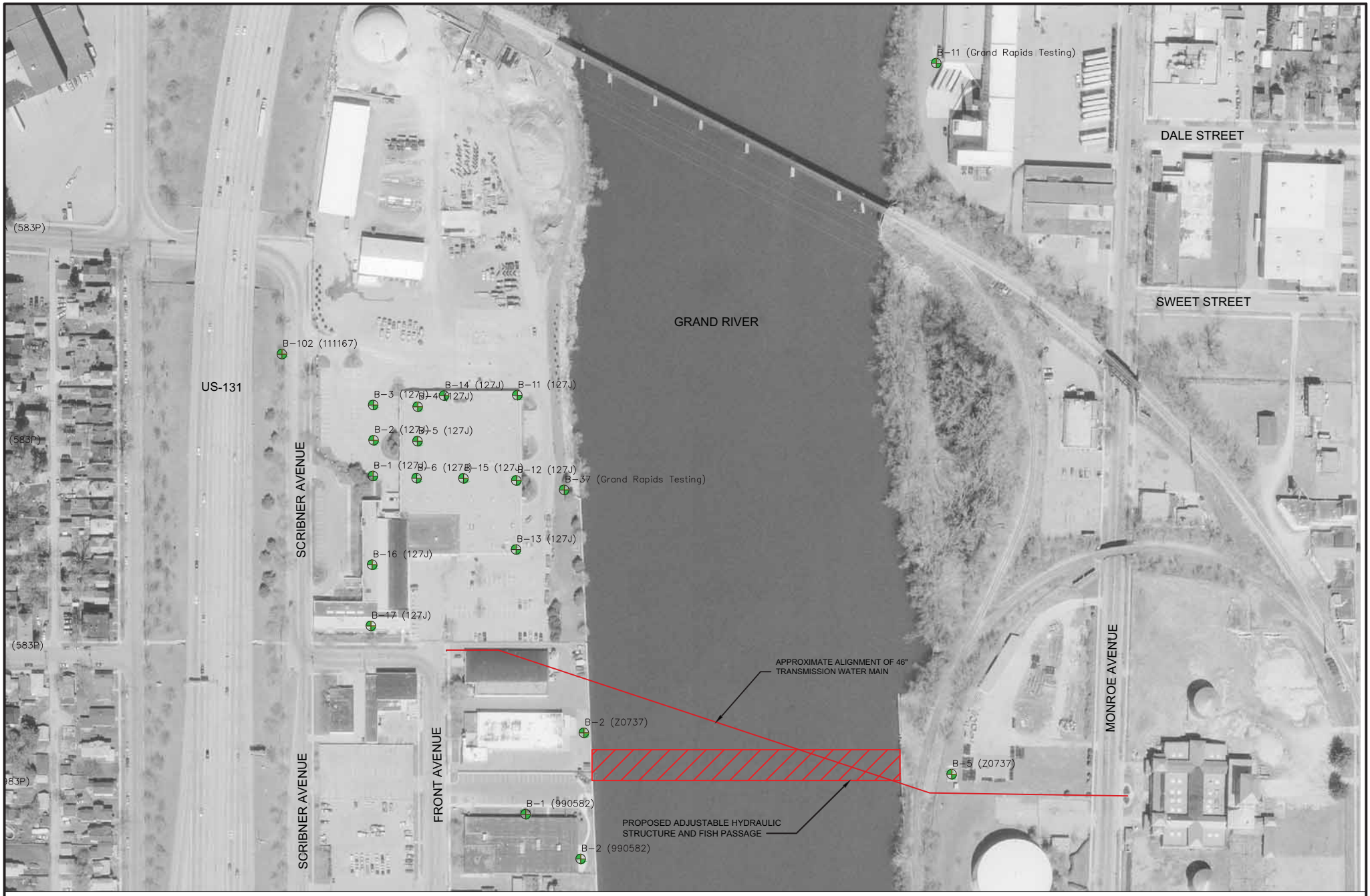
N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 8	DR. BY: TM	REV. BY: SE	



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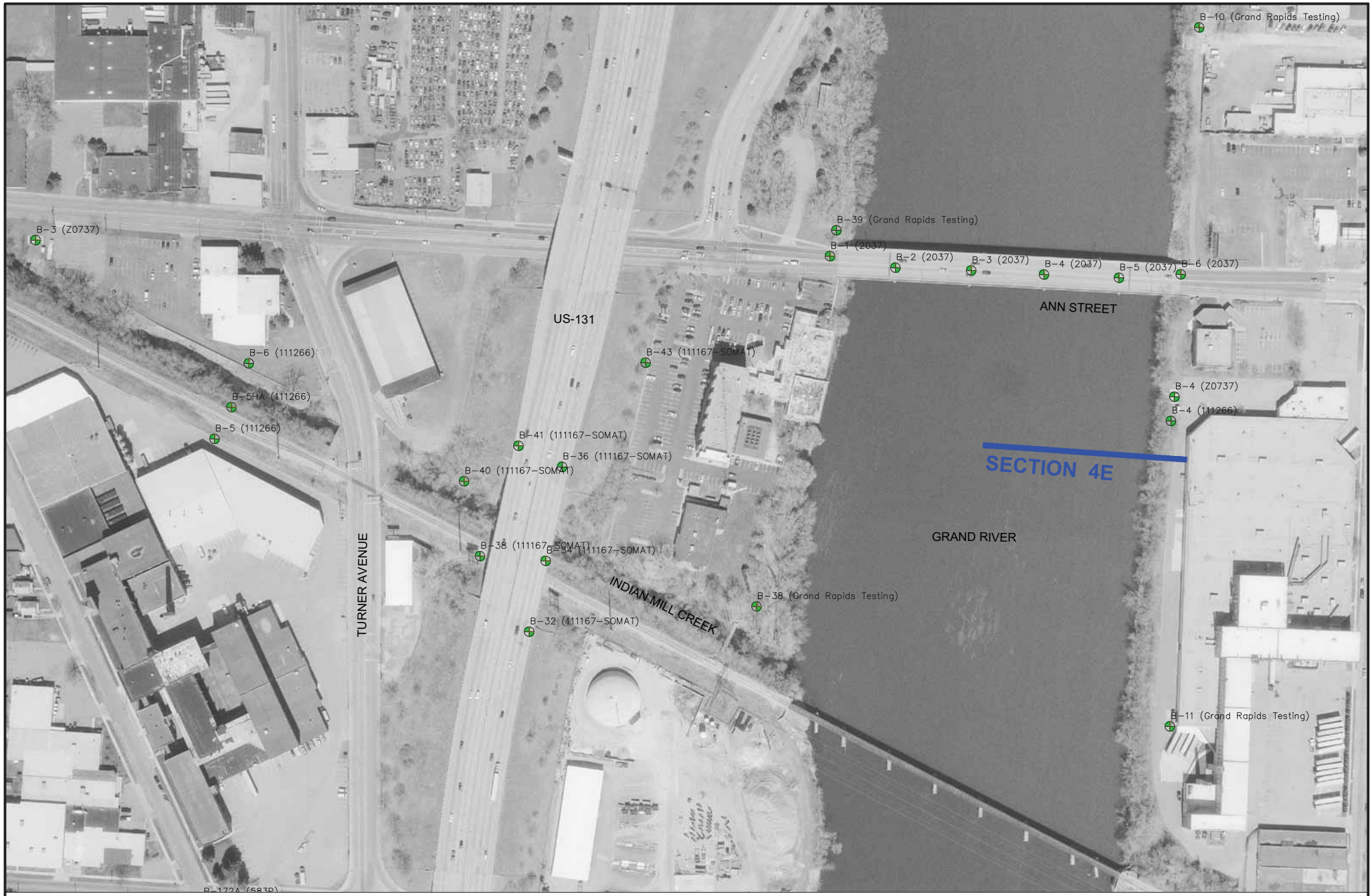
LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 7-16-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 9	DR. BY: TM	REV. BY: SE	



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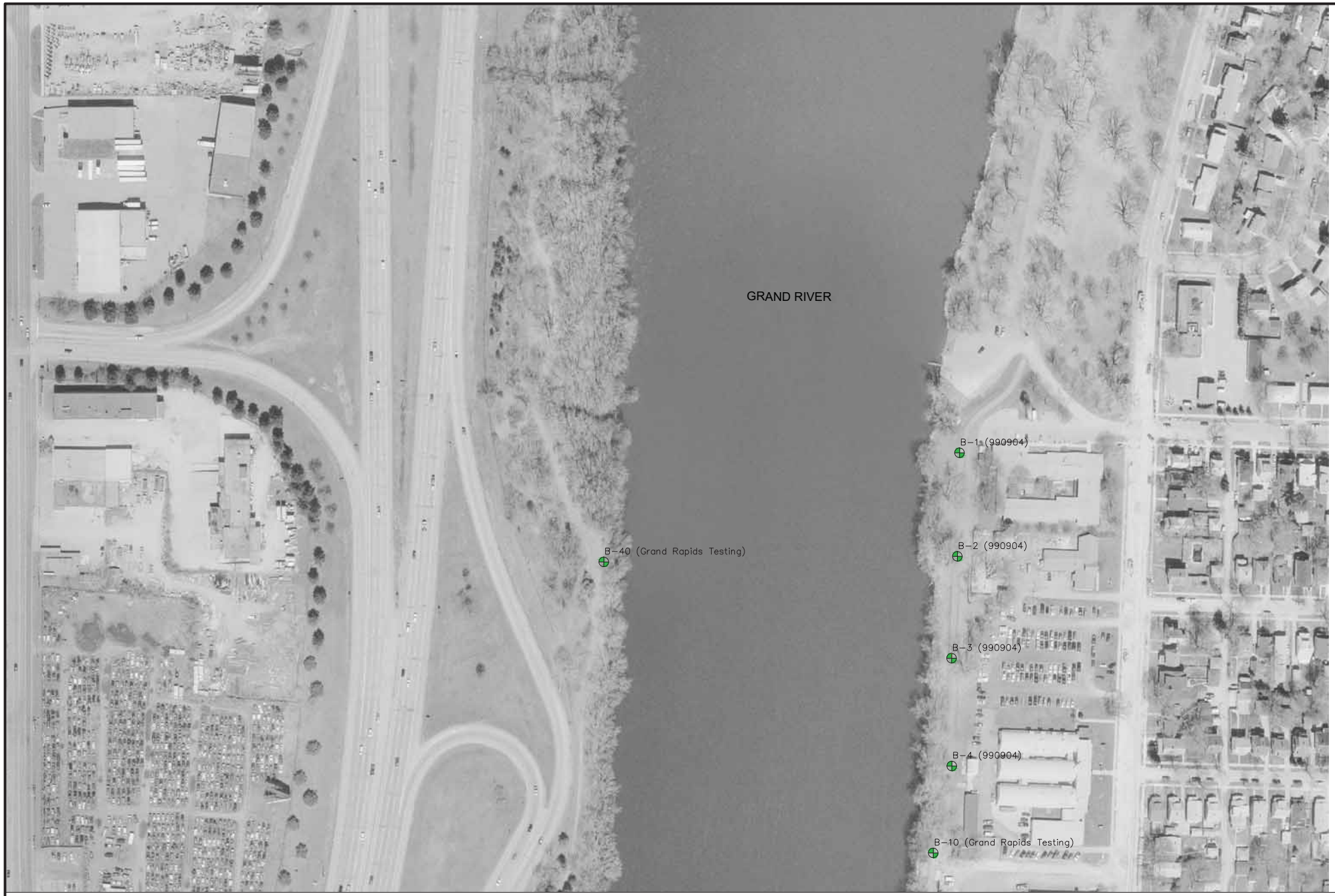
LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 10	DR. BY: TM	REV. BY: SE	



N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 11	DR. BY: TM	REV. BY: SE	



N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 12	DR. BY: TM	REV. BY: SE	



N

LEGEND

= PAST SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 13	DR. BY: TM	REV. BY: SE	



N

LEGEND

= PAST SOIL BORING (TYP)

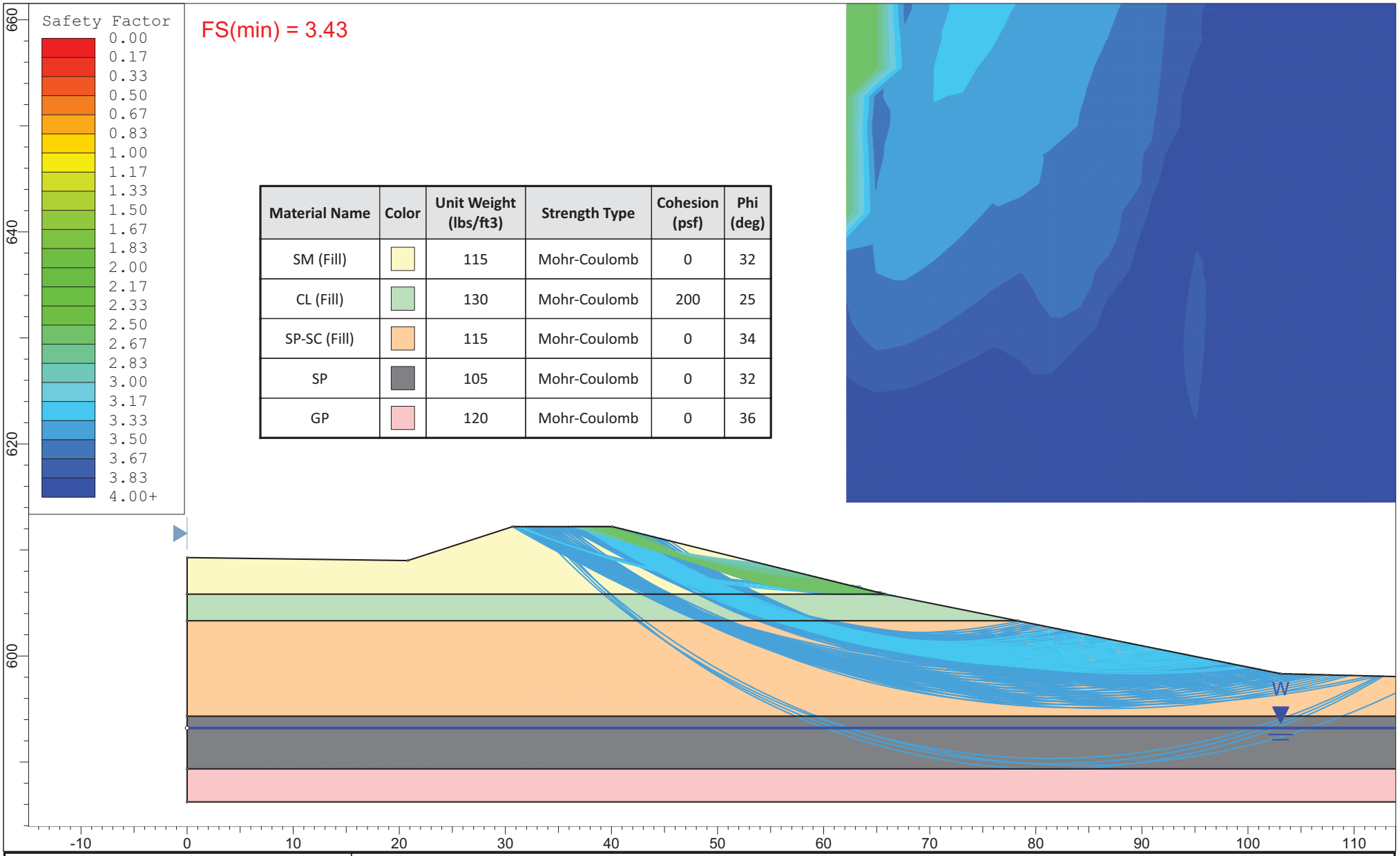
NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: 1" = 250'	DATE: 6-1-2015	PROJECT NO.: 141579	**Materials Testing Consultants, INC.**
FIG. NO.: 14	DR. BY: TM	REV. BY: SE	

APPENDICES

- **Appendix A: Slope Stability Analysis Results**
- **Appendix B: Floodwall Stability Analysis Results**
- **Appendix C: Powers Mine Documentation**

Appendix A: Slope Stability Analysis Results

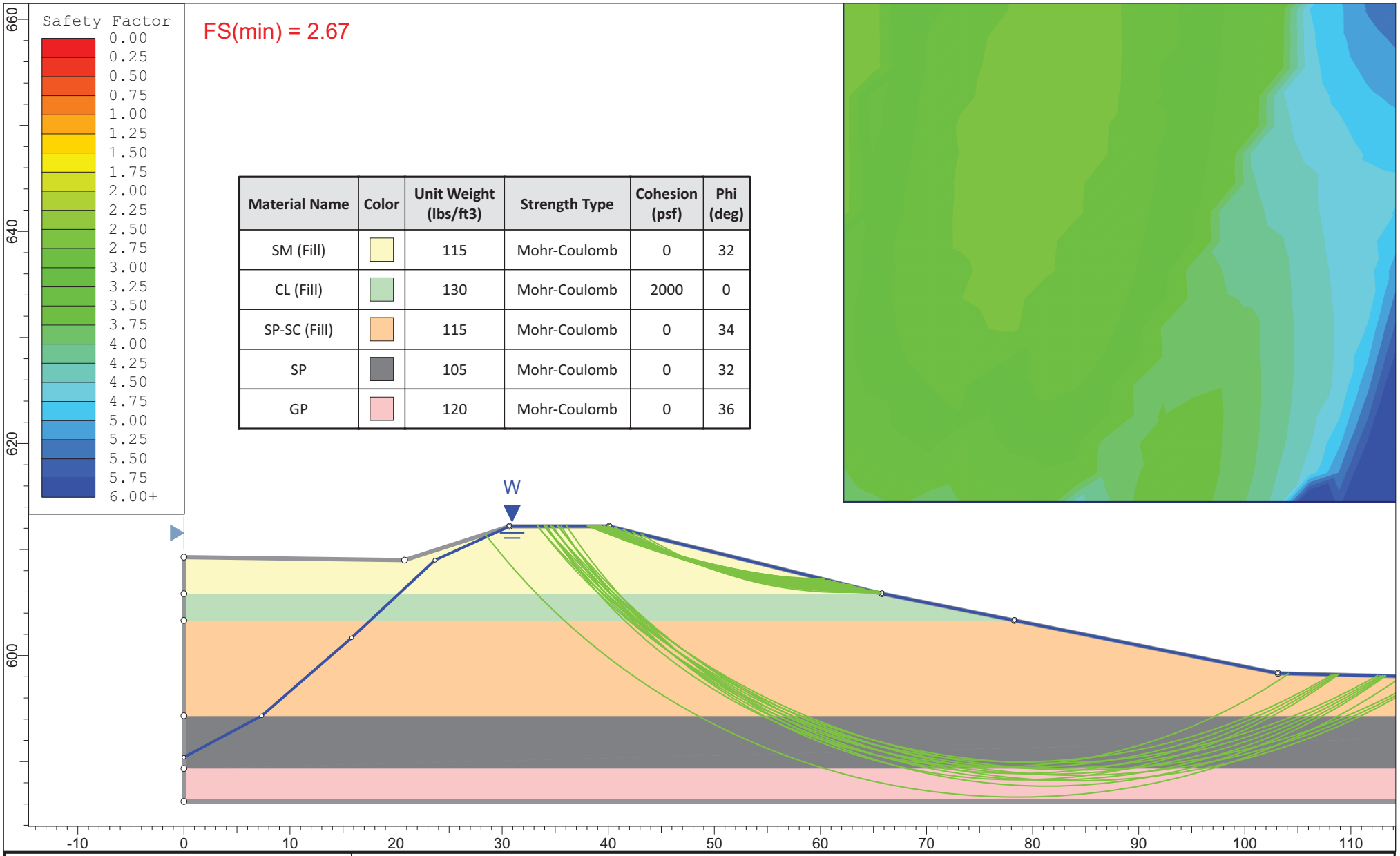


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	200	25
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

rocscience

SLIDEINTERPRET 6.035

Project	Grand River Rapids Restoration
Analysis Description	Section 1W - Proposed - OLW = 593.2
Drawn By	TM
Company	MTC
Date	6-5-2015
File Name	Case 1, Section 1W - Proposed - OLW = 593.2.slim

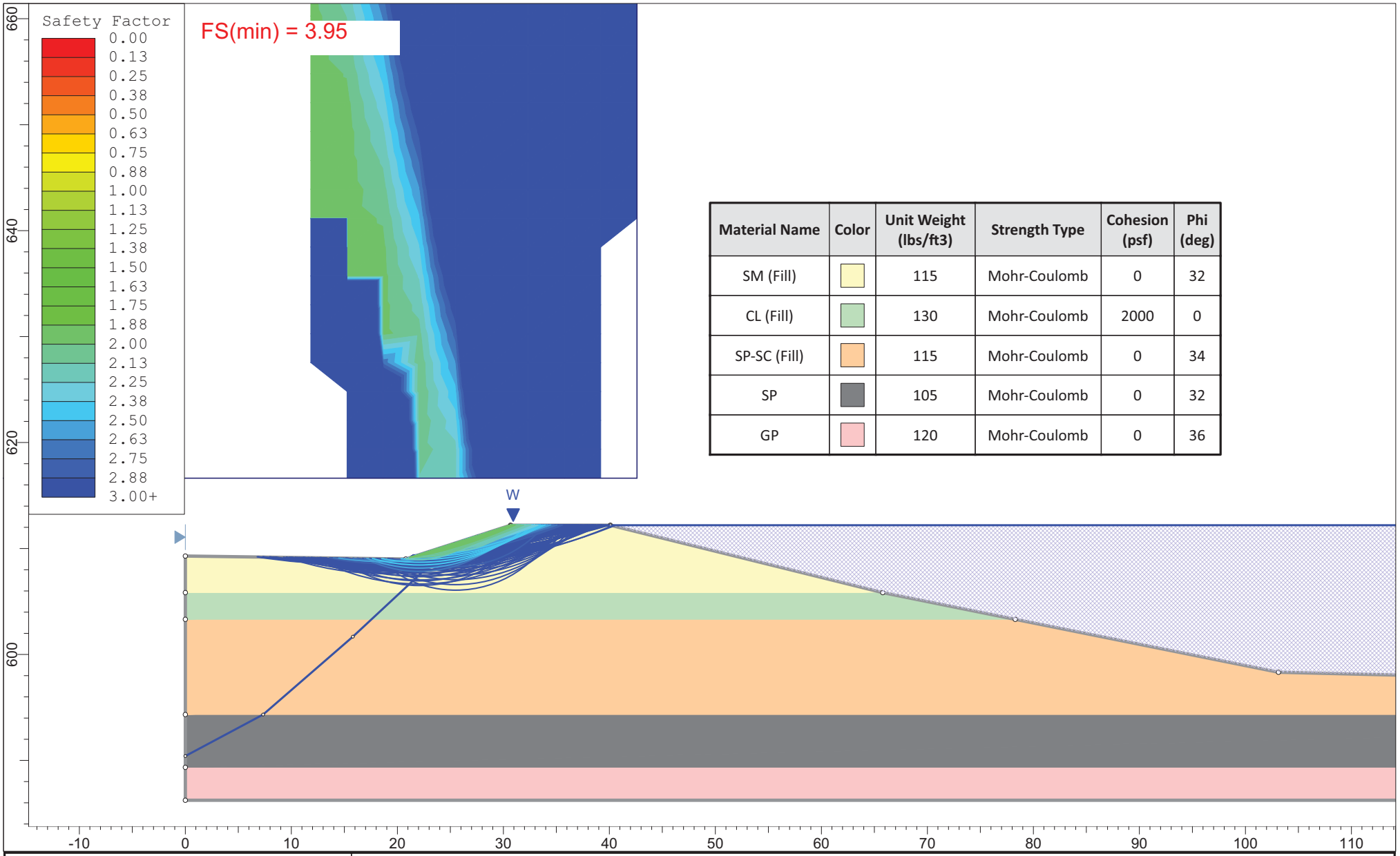


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

rocscience

SLIDEINTERPRET 6.035

Project	Grand River Rapids Restoration		
Analysis Description	Section 1W - Proposed - Drawdown		
Drawn By	TM	*Company*	MTC
Date	6-5-2015	*File Name*	Case 2, Section 1W - Proposed - Drawdown.slim

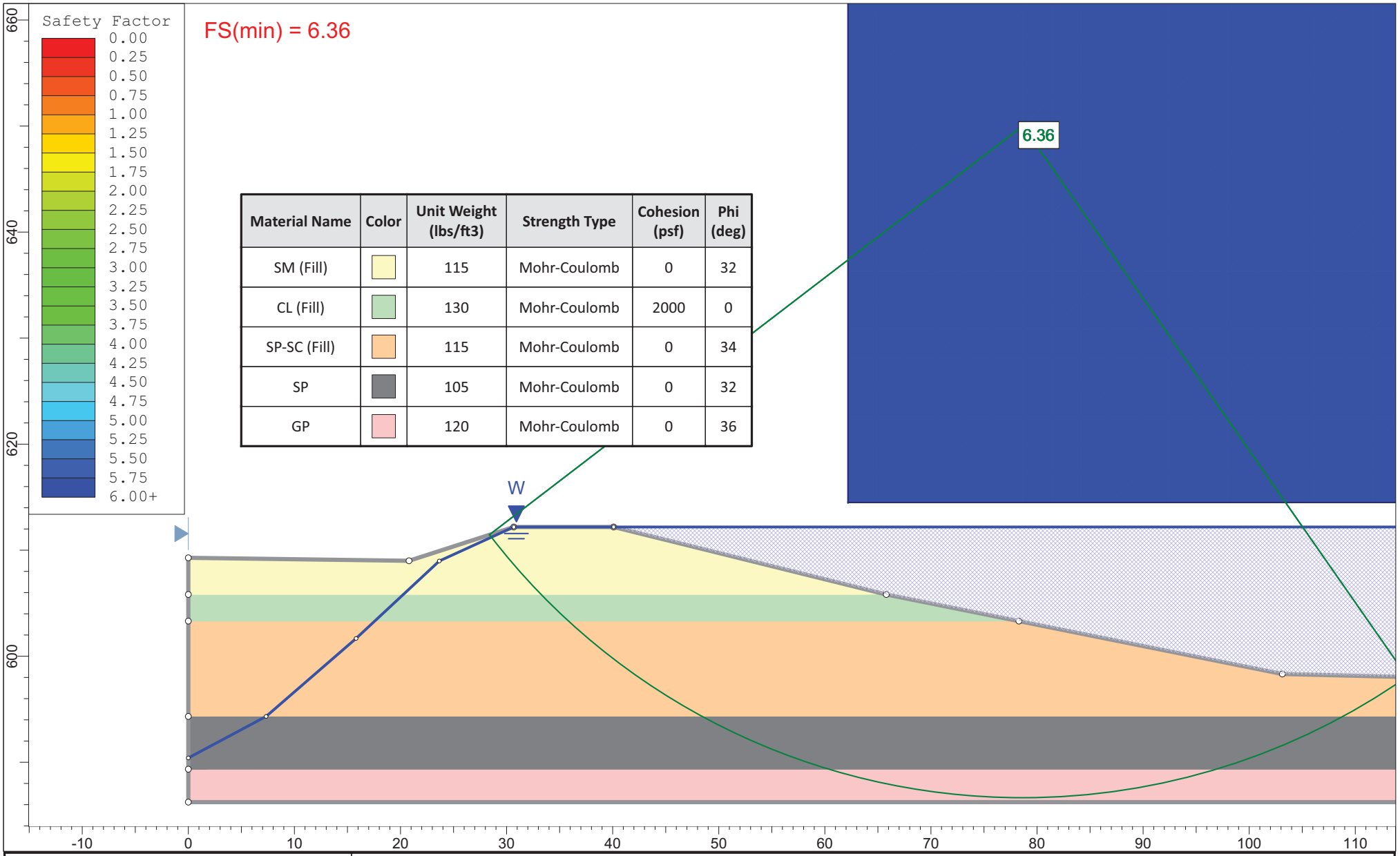


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

rocscience

SLIDEINTERPRET 6.035

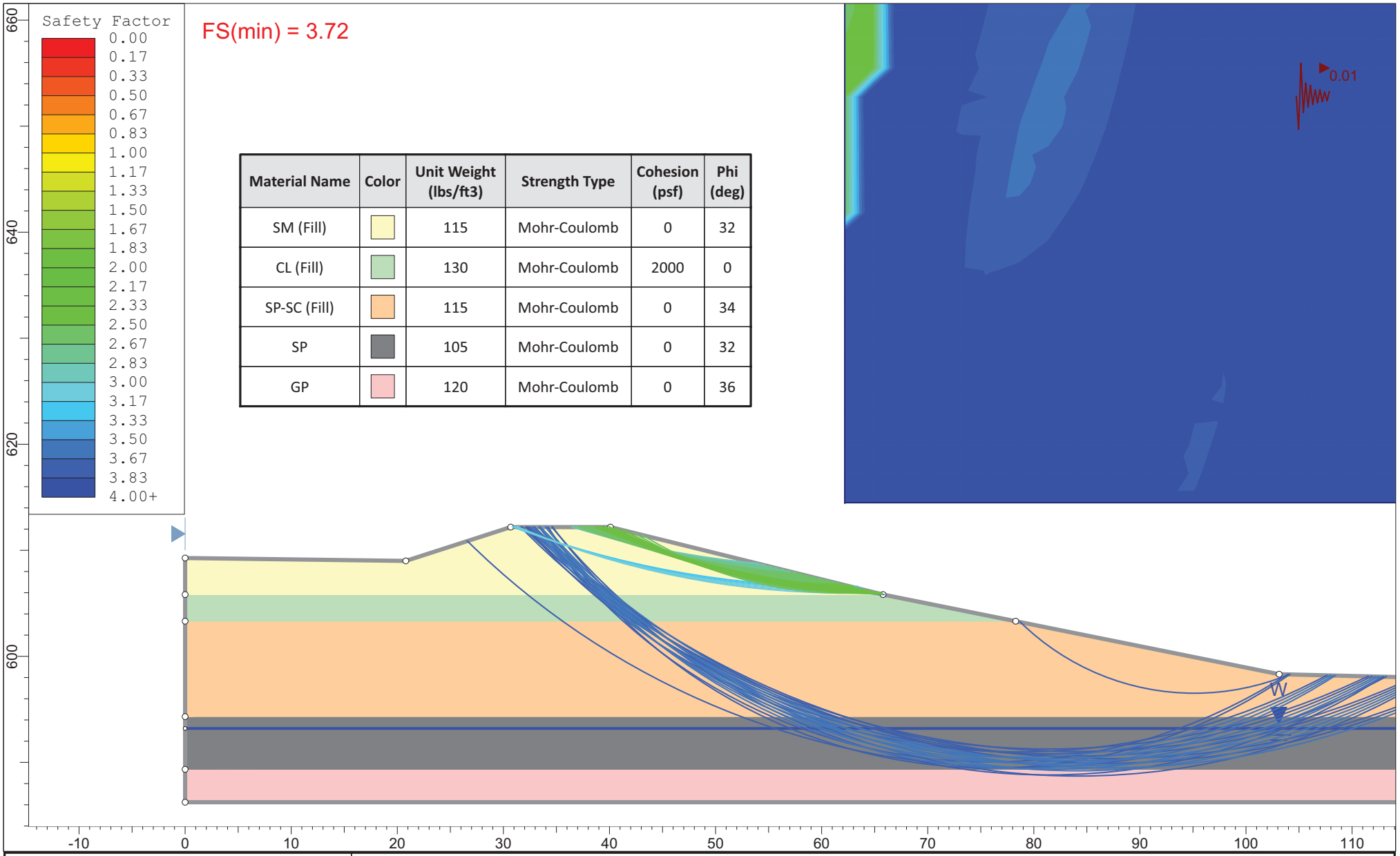
Project	Grand River Rapids Restoration		
Analysis Description	Section 1W - Proposed - Steady State Seepage - Landside		
Drawn By	TM	*Company*	MTC
Date	6-5-2015	*File Name*	Case 3, Section 1W - Proposed - Steady State Seepage - Landside.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 1W - Proposed - Steady State Seepage - Waterside	
	Drawn By	TM	*Company* MTC
	Date	6-5-2015	*File Name* Case 3, Section 1W - Proposed - Steady State Seepage - Waterside.slim

SLIDEINTERPRET 6.035

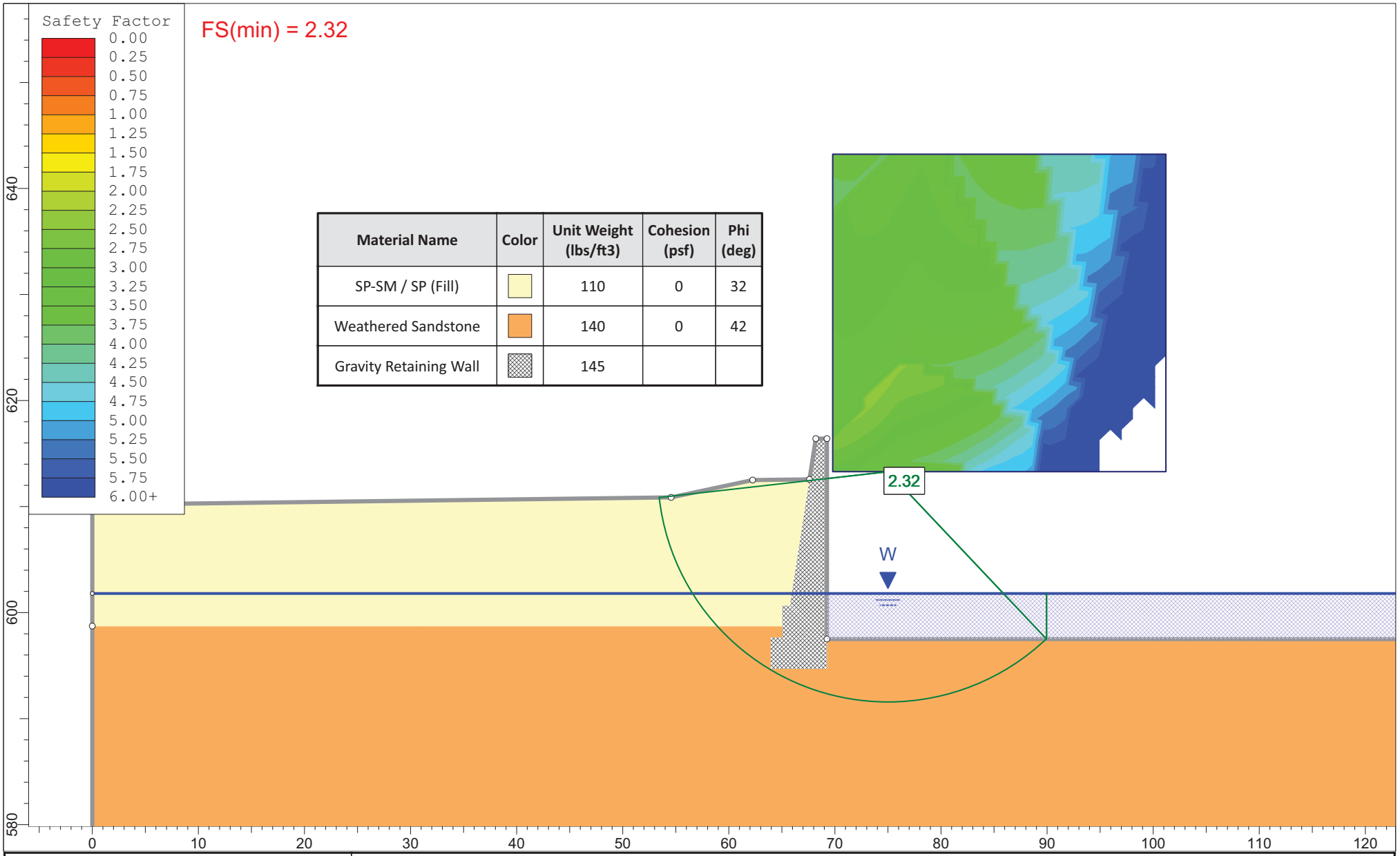


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

rocscience

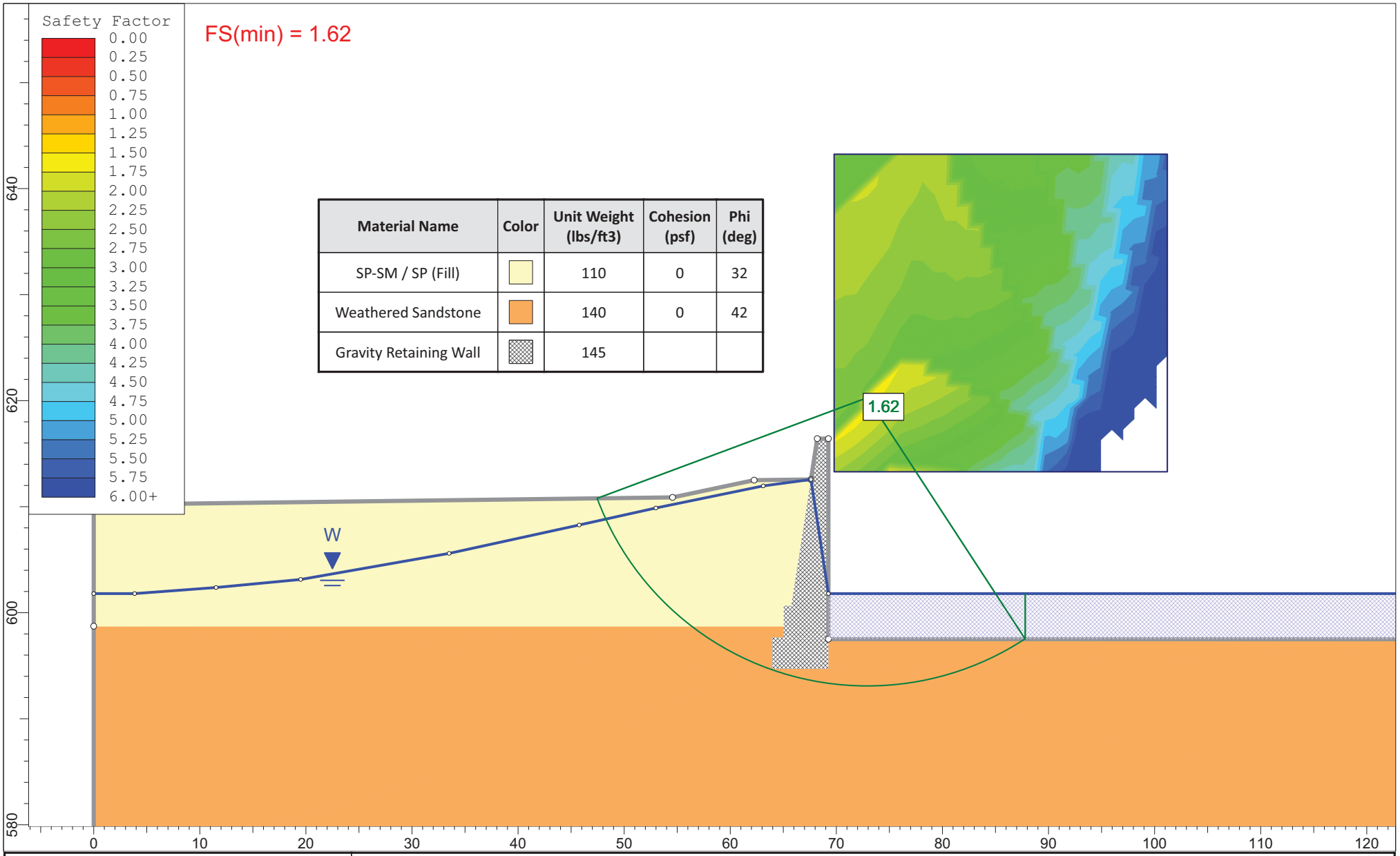
SLIDEINTERPRET 6.035

Project	Grand River Rapids Restoration		
Analysis Description	Section 1W - Proposed - Earthquake		
Drawn By	TM	*Company*	MTC
Date	6-5-2015	*File Name*	Case 4, Section 1W - Proposed - EQ.slim



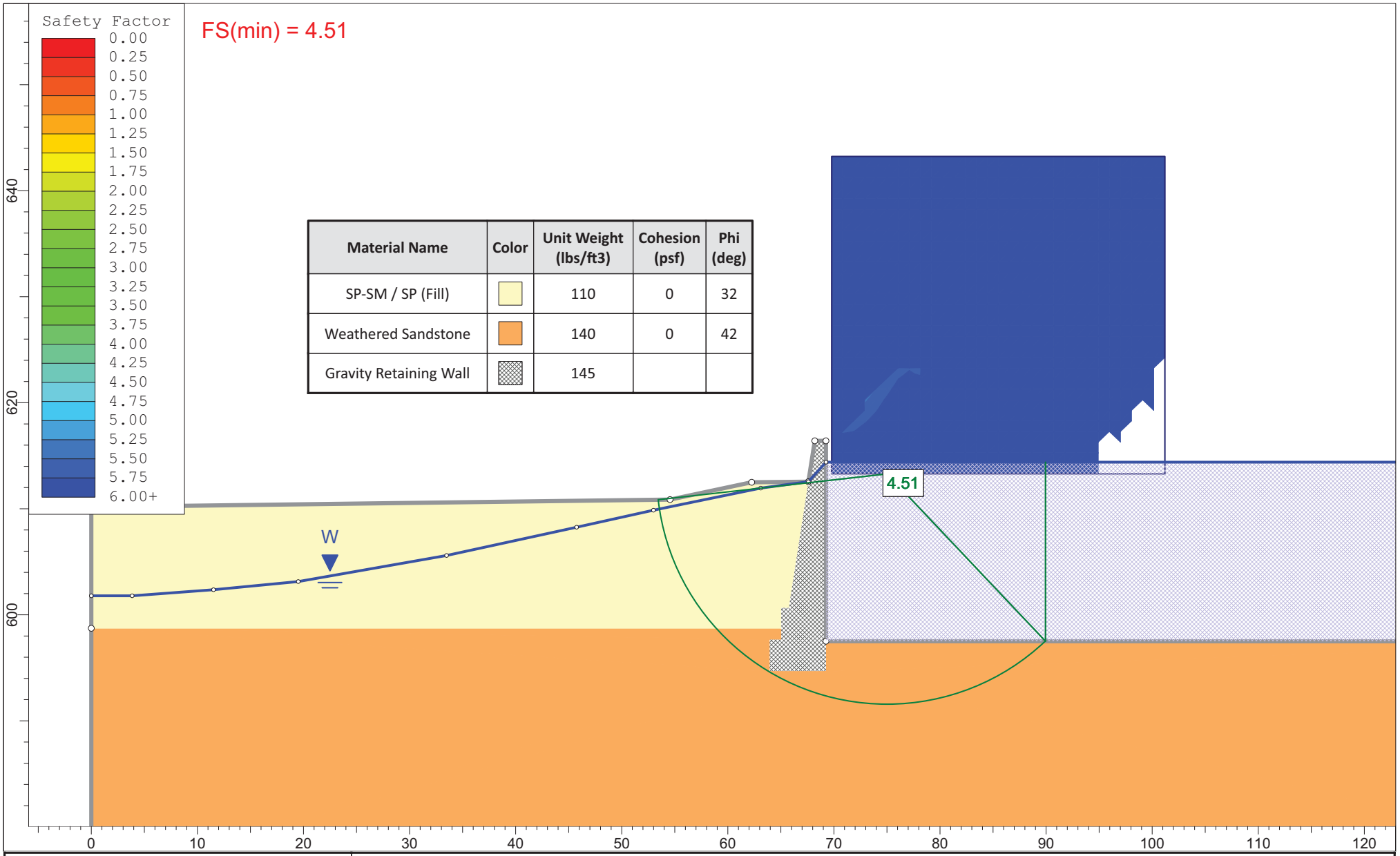
rocscience	Project	Grand River Rapids Restoration	
	Analysis Description	Section 2W - Proposed - OLW = 601.8	
	Drawn By	TM	Company MTC
	Date	6-2-2015	File Name Case 1, Section 2W - Proposed - OLW.slim

SLIDEINTERPRET 6.035



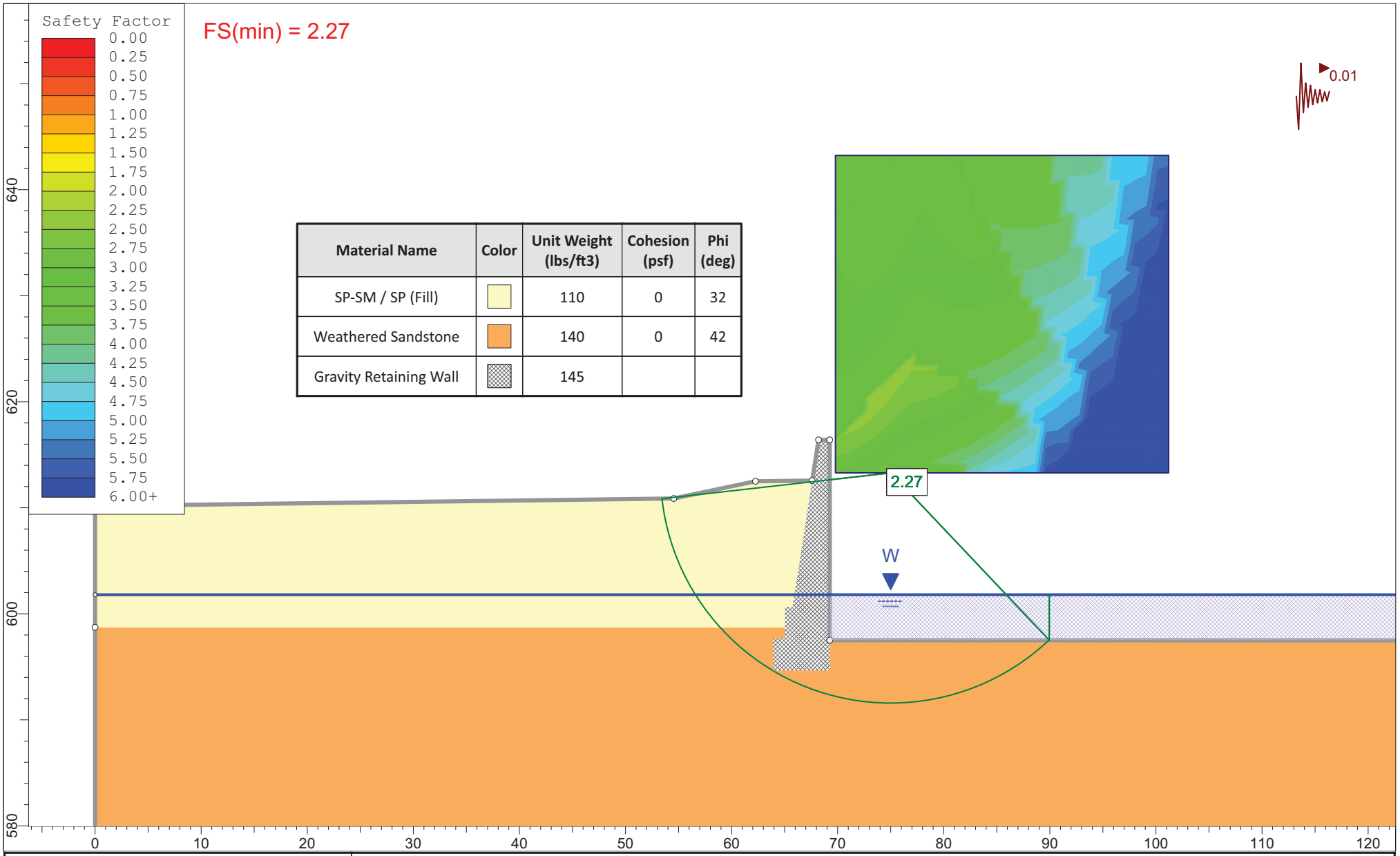
rocscience	Project	Grand River Rapids Restoration	
	Analysis Description	Section 2W - Proposed - Drawdown	
	Drawn By	TM	Company MTC
	Date	6-2-2015	File Name Case 2, Section 2W - Proposed - Drawdown.slim

SLIDEINTERPRET 6.035



rocscience	Project	Grand River Rapids Restoration	
	Analysis Description	Section 2W - Proposed - Steady State Seepage	
	Drawn By	TM	Company MTC
	Date	6-2-2015	File Name Case 3, Section 2W - Proposed - Steady State Seepage.slim

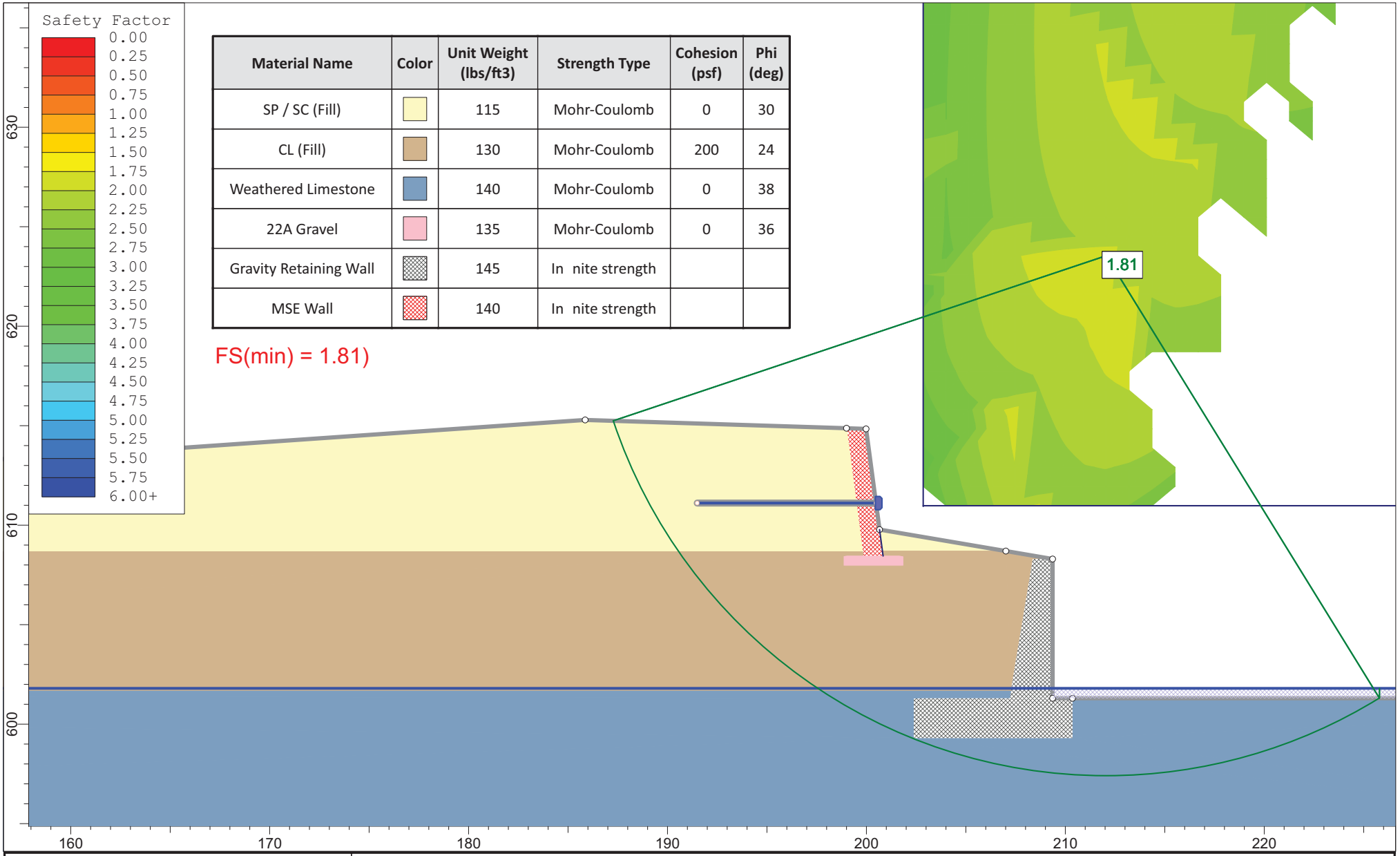
SLIDEINTERPRET 6.035



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SP-SM / SP (Fill)		110	0	32
Weathered Sandstone		140	0	42
Gravity Retaining Wall		145		

Project	Grand River Rapids Restoration		
Analysis Description	Section 2W - Proposed - Earthquake		
Drawn By	TM	Company	MTC
Date	6-2-2015	File Name	Case 4, Section 2W - Proposed - EQ.slim

SLIDEINTERPRET 6.035

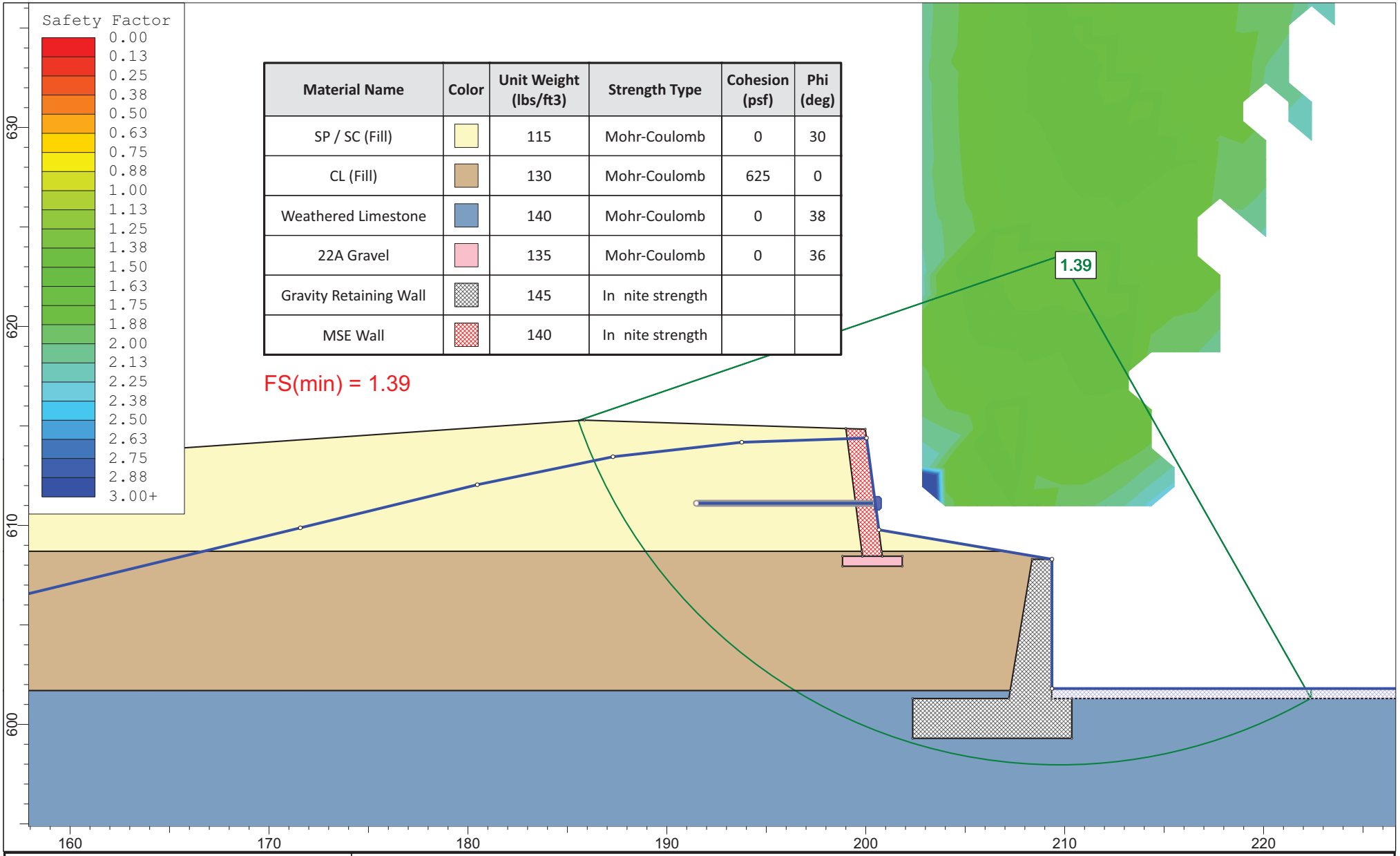


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	200	24
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	In nite strength		
MSE Wall		140	In nite strength		

FS(min) = 1.81)

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 2E - Proposed - OLW = 601.8	
	Drawn By	TM	*Company* MTC
	Date	6-5-2015	*File Name* Case 1, Section 2E - Proposed - OLW = 601.8.slim

SLIDEINTERPRET 6.035

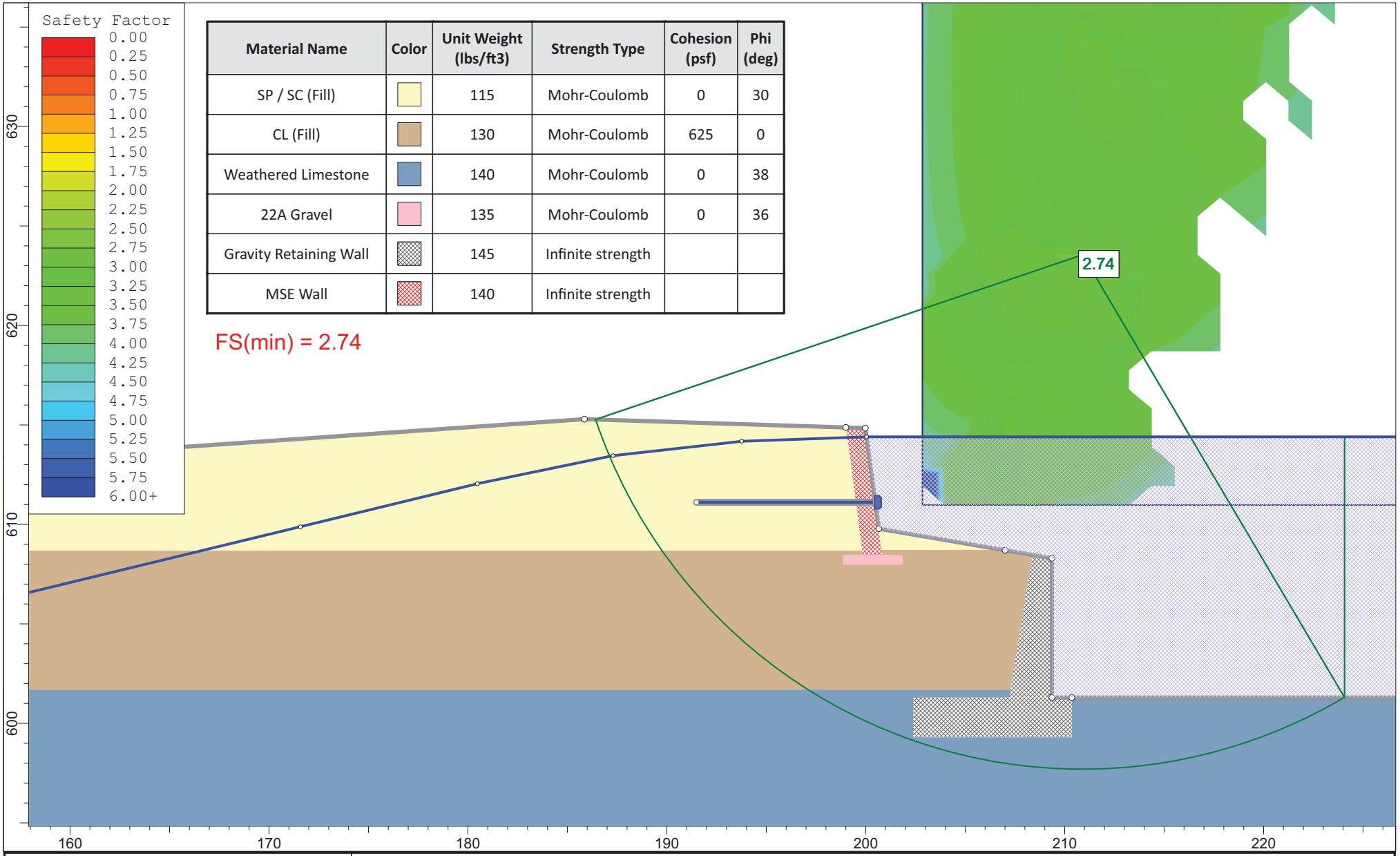


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	625	0
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	In nite strength		
MSE Wall		140	In nite strength		

FS(min) = 1.39

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 2E - Proposed - Drawdown	
	Drawn By	TM	*Company* MTC
	Date	6-5-2015	*File Name* Case 2, Section 2E - Proposed - Drawdown.slim

SLIDEINTERPRET 6.035

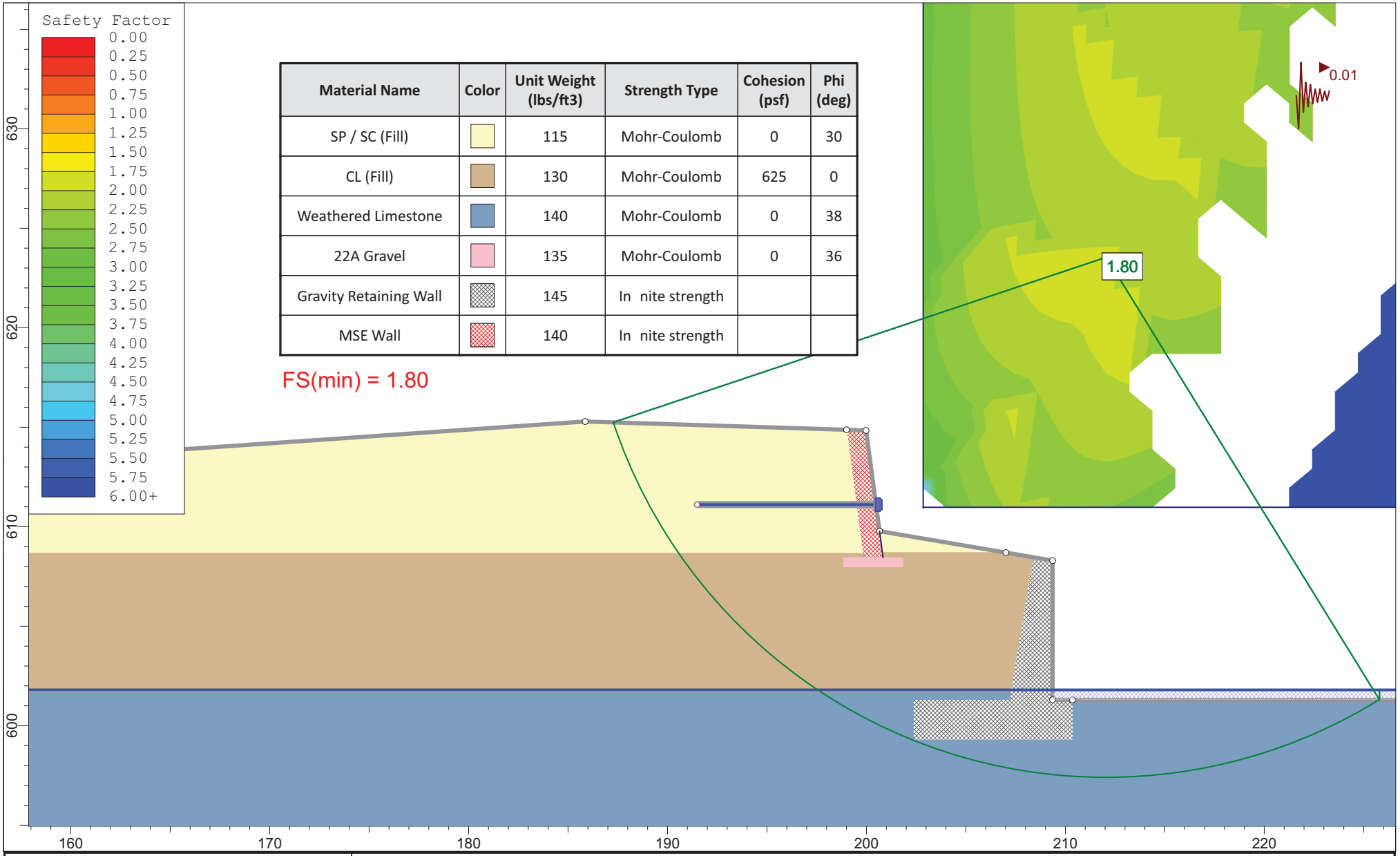


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	625	0
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	Infinite strength		
MSE Wall		140	Infinite strength		

FS(min) = 2.74

Project	Grand River Rapids Restoration		
Analysis Description	Section 2E - Proposed - Steady State Seepage		
Drawn By	TM	Company	MTC
Date	6-5-2015	File Name	Case 3, Section 2E - Proposed - Steady State Seepage.slim

SLIDEINTERPRET 6.035

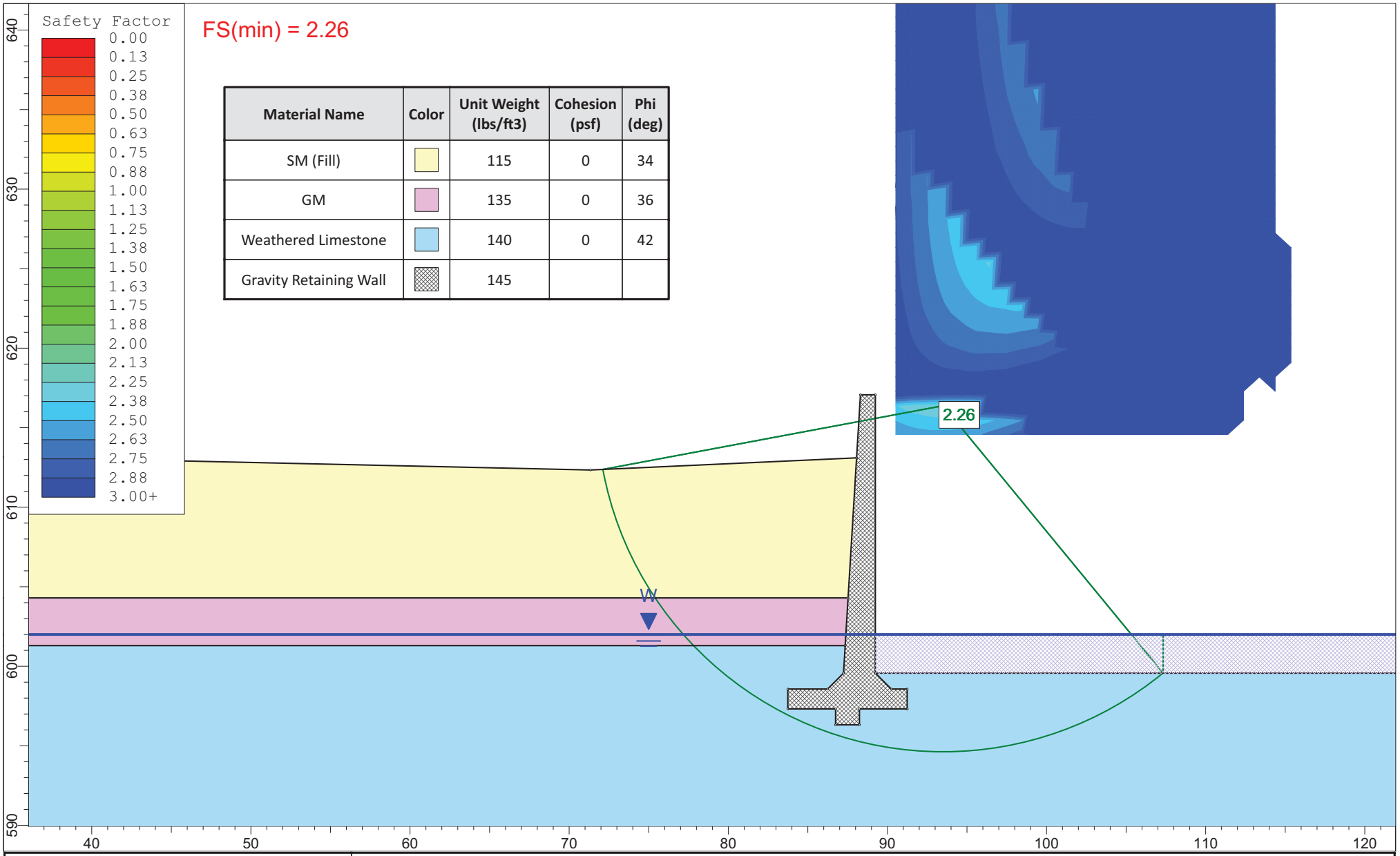


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	625	0
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	In nite strength		
MSE Wall		140	In nite strength		

FS(min) = 1.80

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 2E - Proposed - Earthquake	
	Drawn By	TM	*Company* MTC
	Date	6-5-2015	*File Name* Case 4, Section 2E - Proposed - Earthquake.slim

SLIDEINTERPRET 6.035

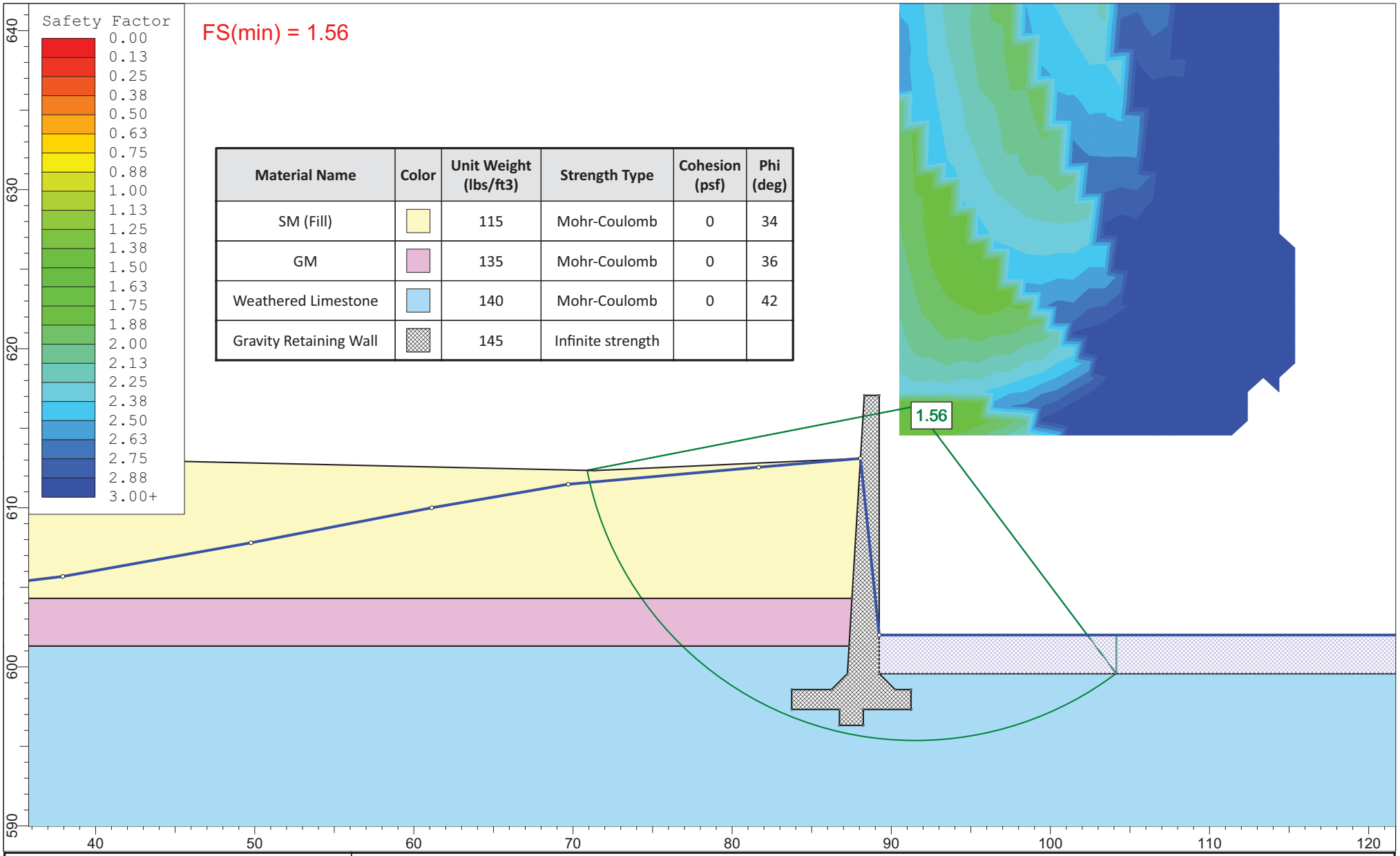


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SM (Fill)		115	0	34
GM		135	0	36
Weathered Limestone		140	0	42
Gravity Retaining Wall		145		

rocscience

SLIDEINTERPRET 6.035

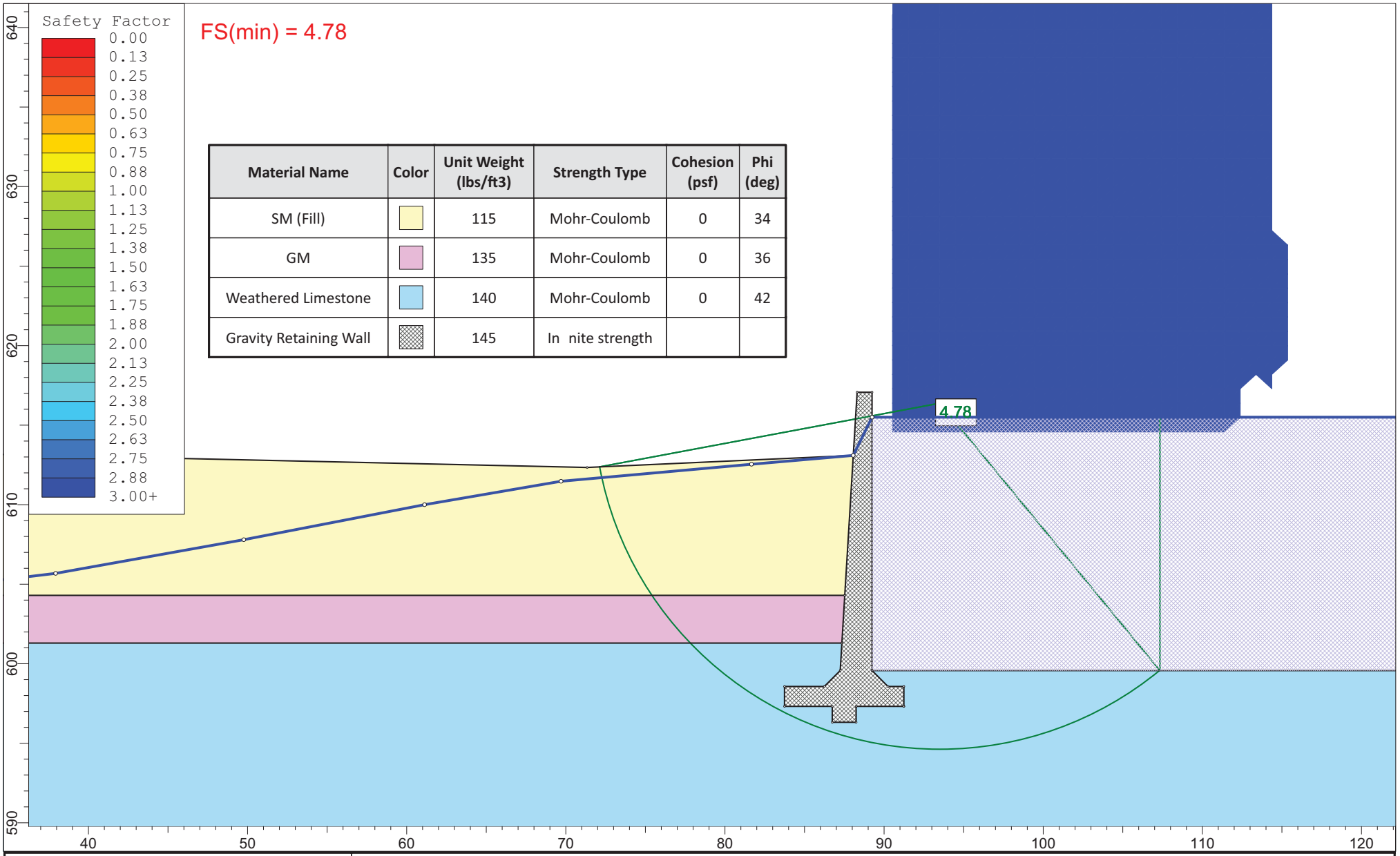
Project	Grand River Rapids Restoration		
Analysis Description	Section 3W - Proposed - OLW = 602		
Drawn By	TM	*Company*	MTC
Date	6-2-2015	*File Name*	Case 1, Section 3W - Proposed OLW.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	34
GM		135	Mohr-Coulomb	0	36
Weathered Limestone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	Infinite strength		

SLIDEINTERPRET 6.035

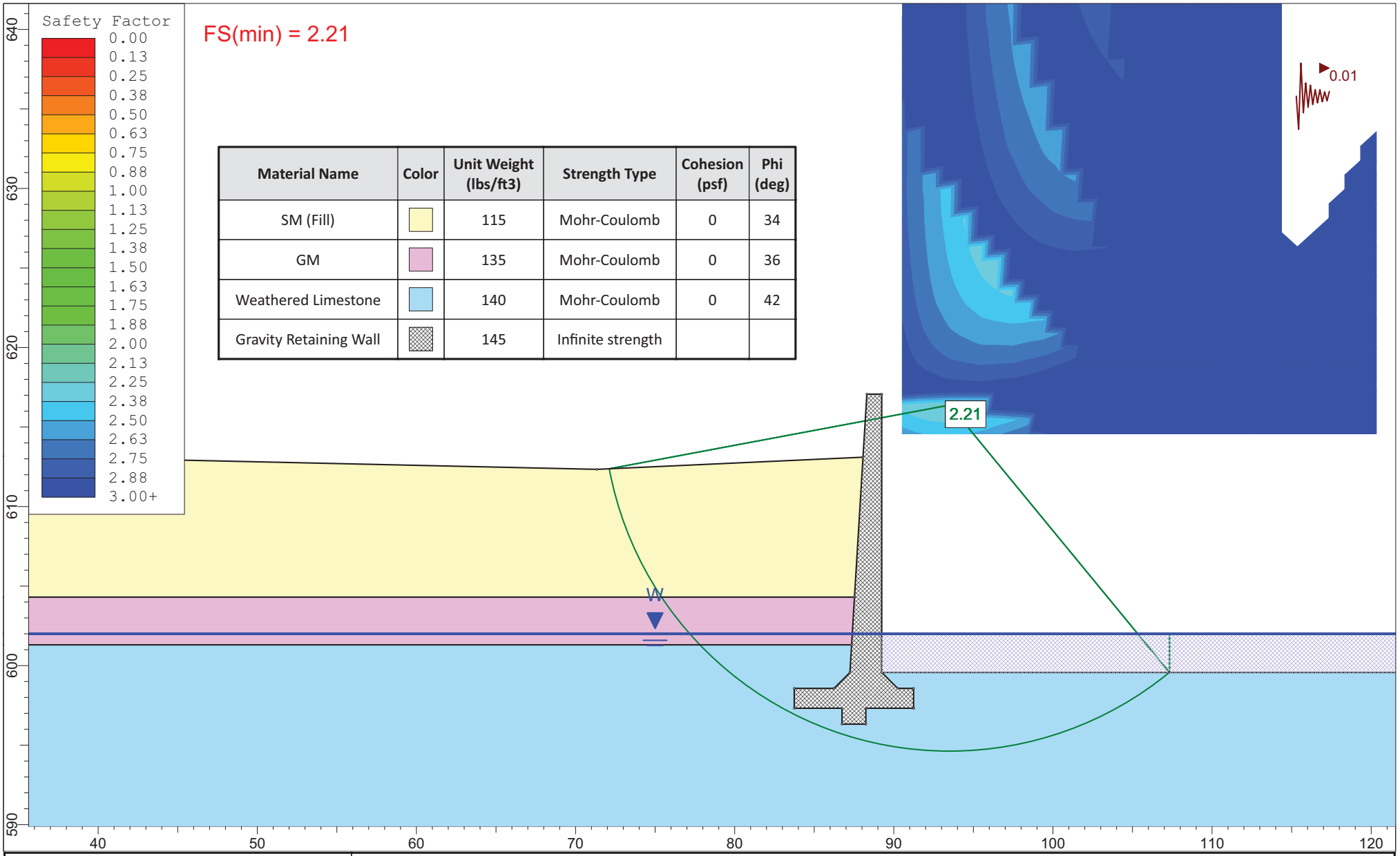
Project	Grand River Rapids Restoration		
Analysis Description	Section 3W - Proposed - Drawdown		
Drawn By	TM	*Company*	MTC
Date	6-3-2015	*File Name*	Case 2, Section 3W - Proposed - Drawdown.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	34
GM		135	Mohr-Coulomb	0	36
Weathered Limestone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	In nite strength		

	Project	Grand River Rapids Restoration	
	Analysis Description	Section 3W - Proposed - Steady State Seepage	
	Drawn By	TM	*Company* MTC
	Date	6-3-2015	*File Name* Case 3, Section 3W - Proposed - Steady State Seepage.slim

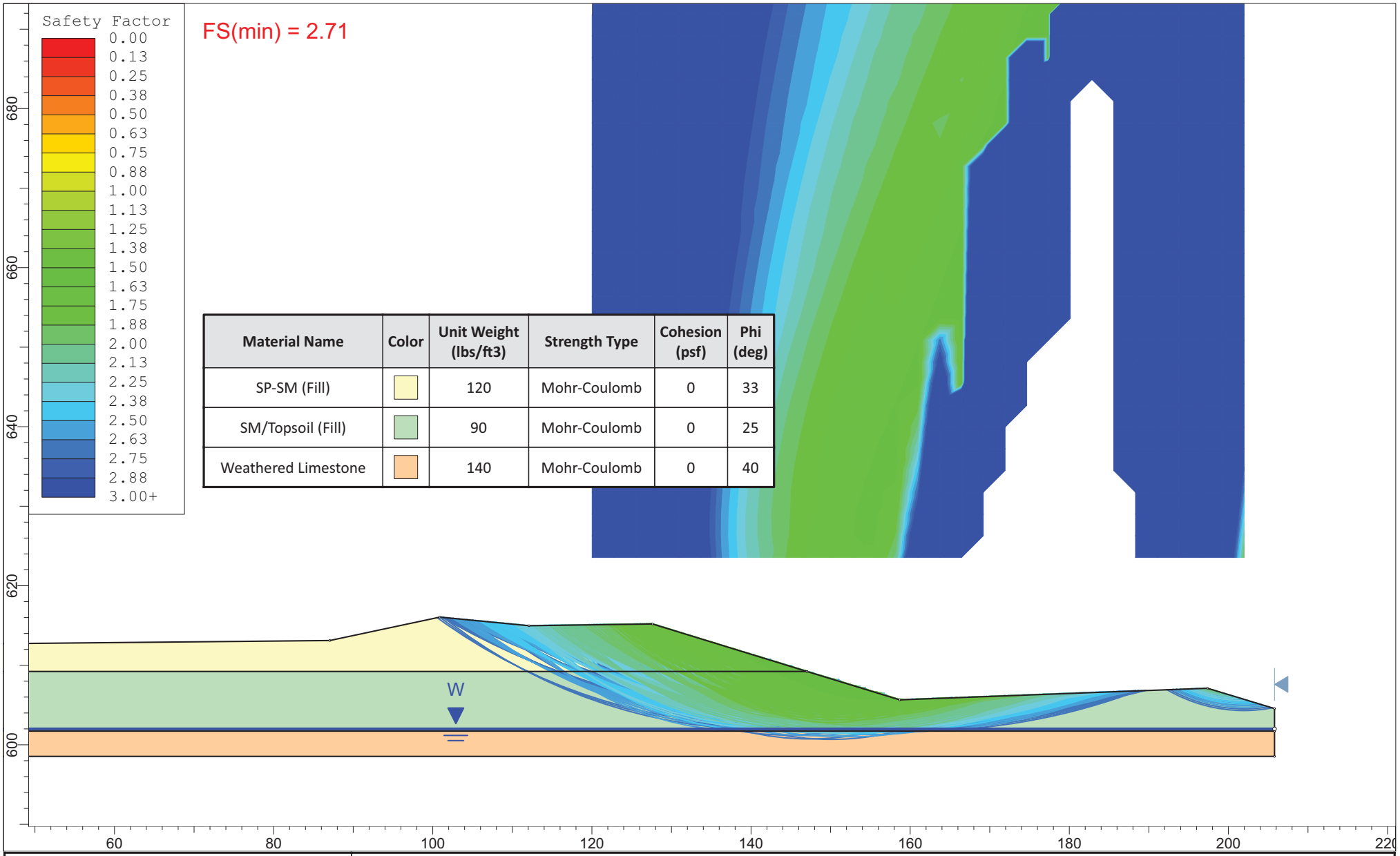
SLIDEINTERPRET 6.035



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	34
GM		135	Mohr-Coulomb	0	36
Weathered Limestone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	Infinite strength		

Project	Grand River Rapids Restoration		
Analysis Description	Section 3W - Proposed - Earthquake		
Drawn By	TM	*Company*	MTC
Date	6-3-2015	*File Name*	Case 4, Section 3W - Proposed - EQ.slim

SLIDEINTERPRET 6.035

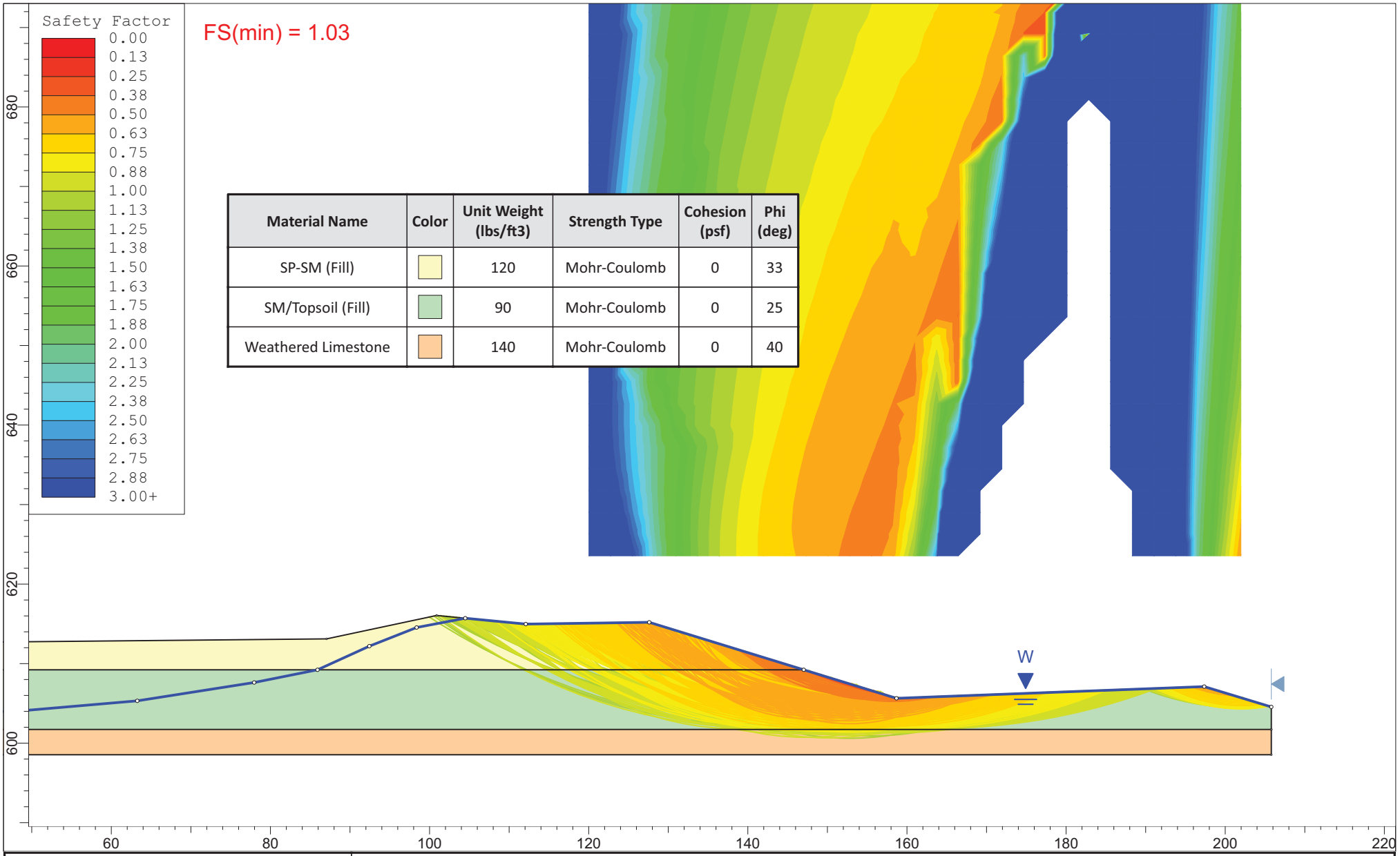


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

rocscience

SLIDEINTERPRET 6.035

Project	Grand River Rapids Restoration		
Analysis Description	Section 3E - Proposed - OLW = 602		
Drawn By	TM	*Company*	MTC
Date	6-5-2015	*File Name*	Case 1, Section 3E - Proposed - OLW = 602.slim

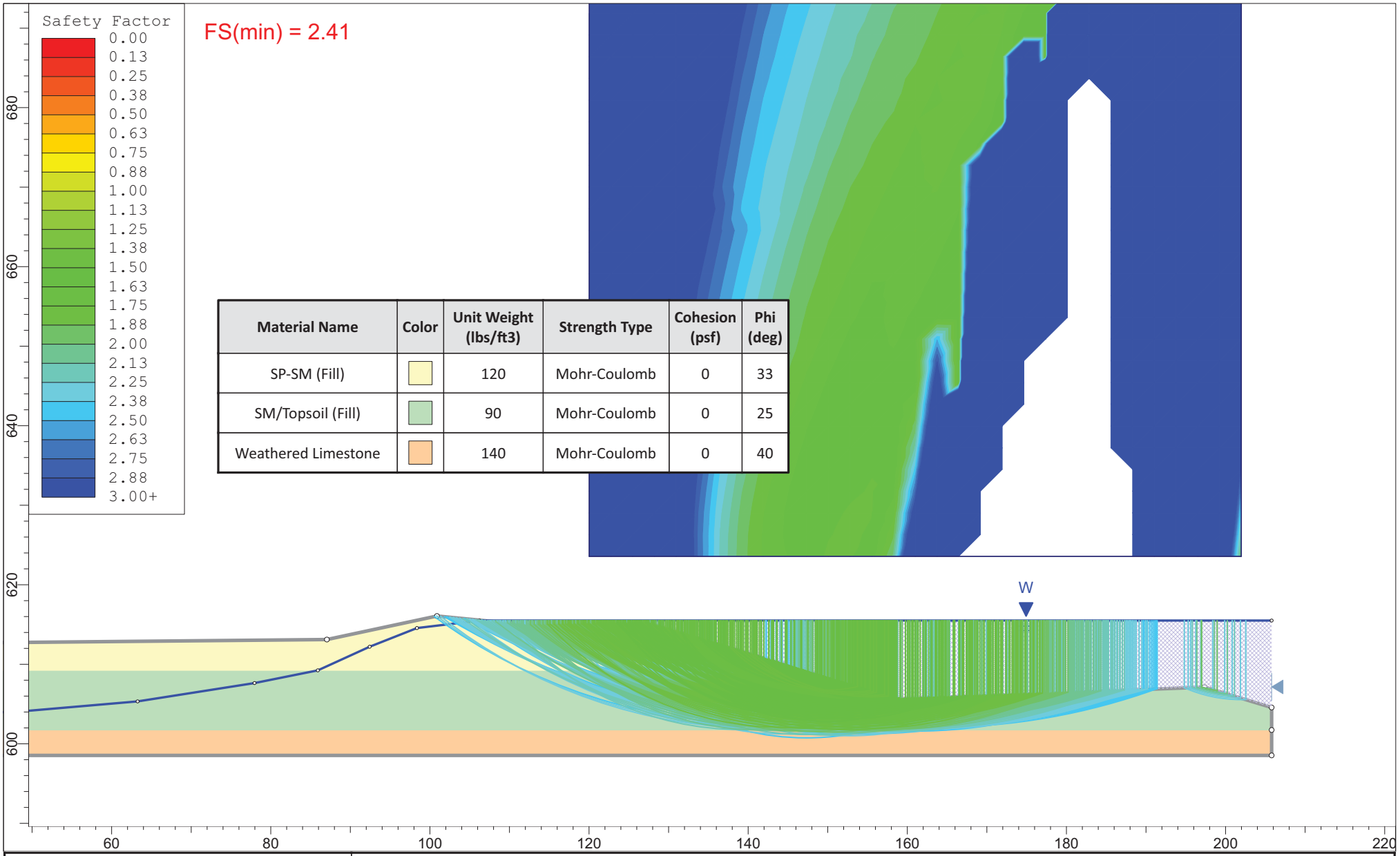


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

rocscience

SLIDEINTERPRET 6.035

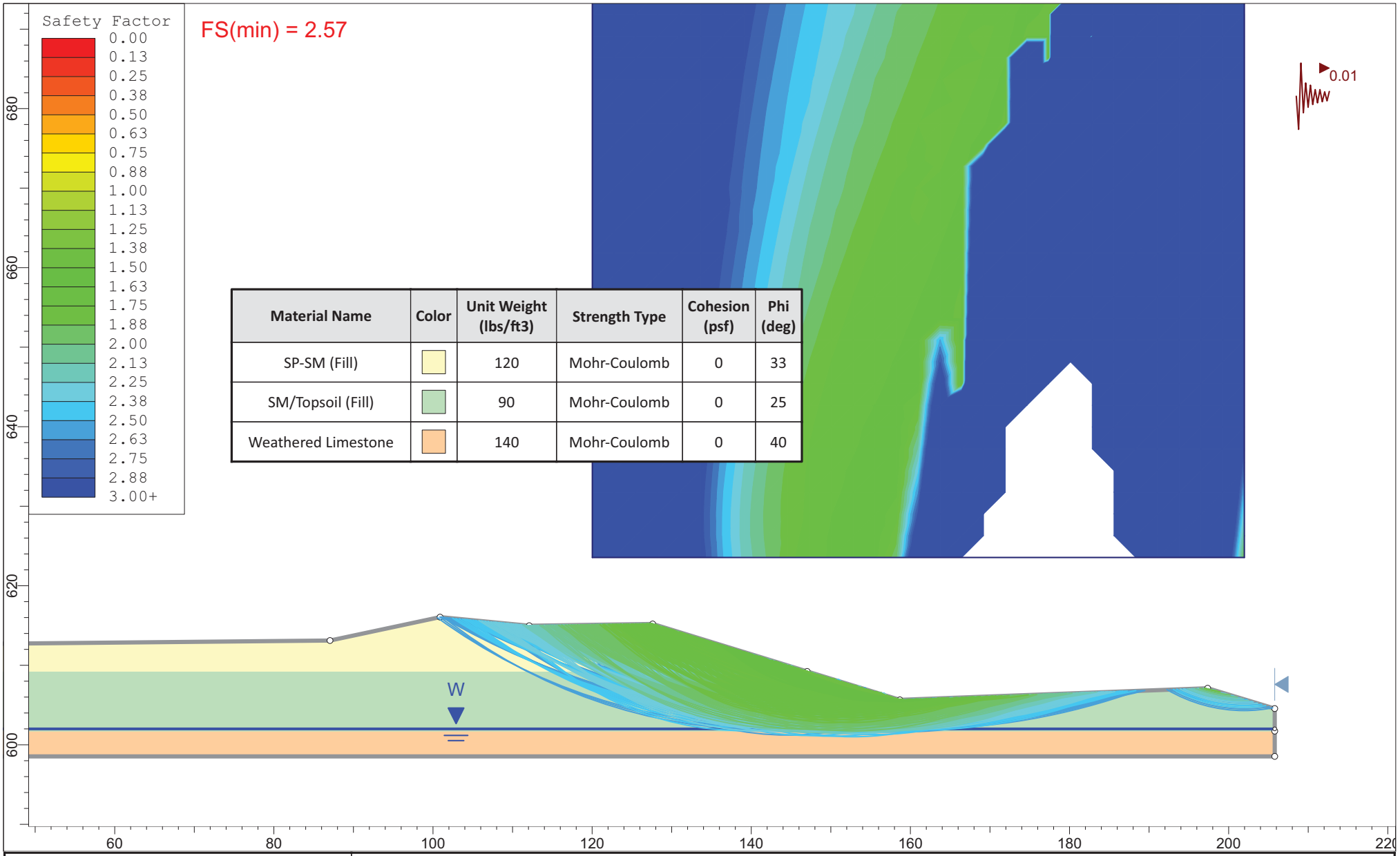
Project	Grand River Rapids Restoration		
Analysis Description	Section 3E - Proposed - Drawdown		
Drawn By	TM	*Company*	MTC
Date	6-5-2015	*File Name*	Case 2, Section 3E - Proposed - Drawdown.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 3E - Proposed - Steady State Seepage	
	Drawn By	TM	*Company* MTC
	Date	6-5-2015	*File Name* Case 3, Section 3E - Proposed - Steady State Seepage.slim

SLIDEINTERPRET 6.035

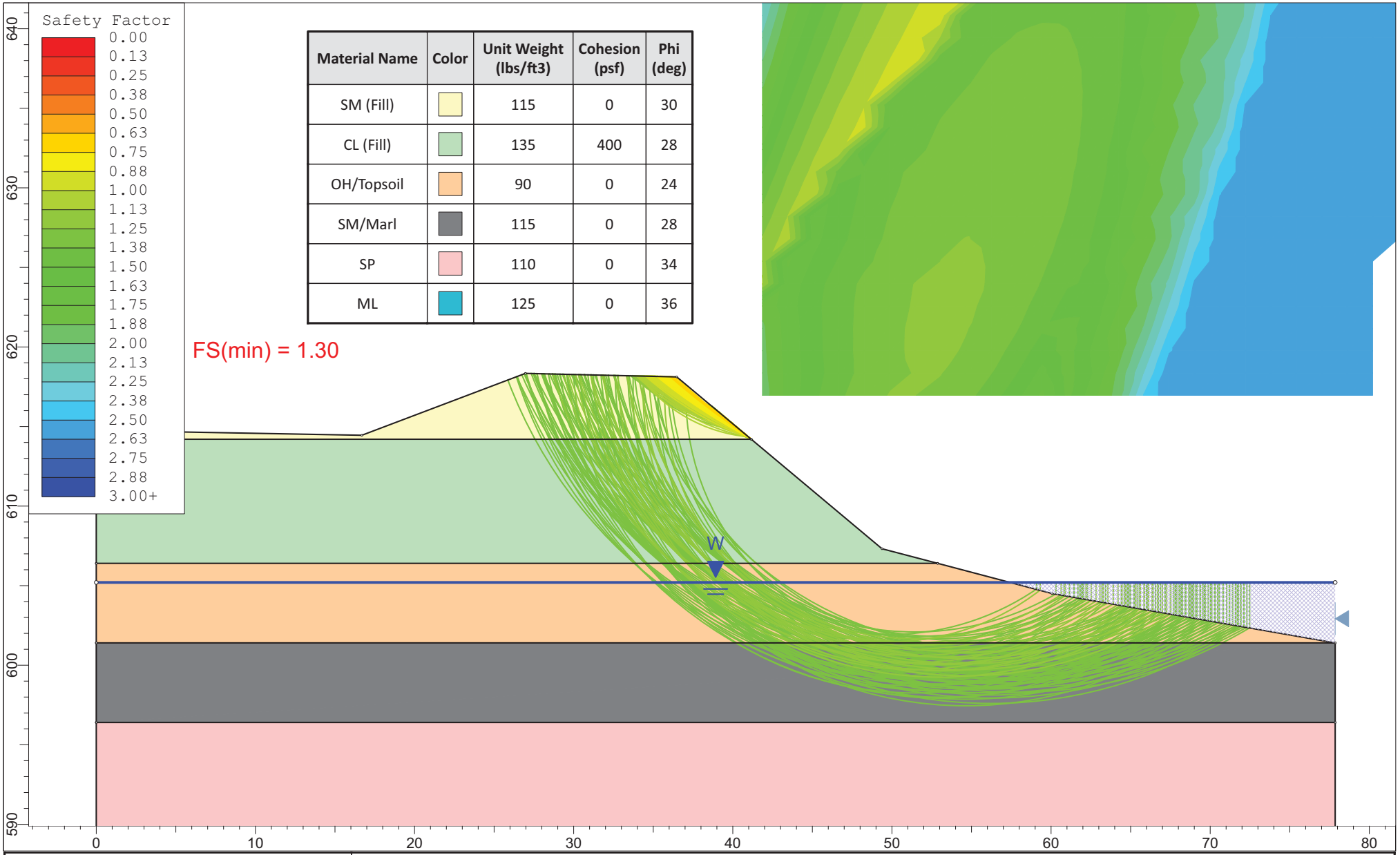


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

rocscience

SLIDEINTERPRET 6.035

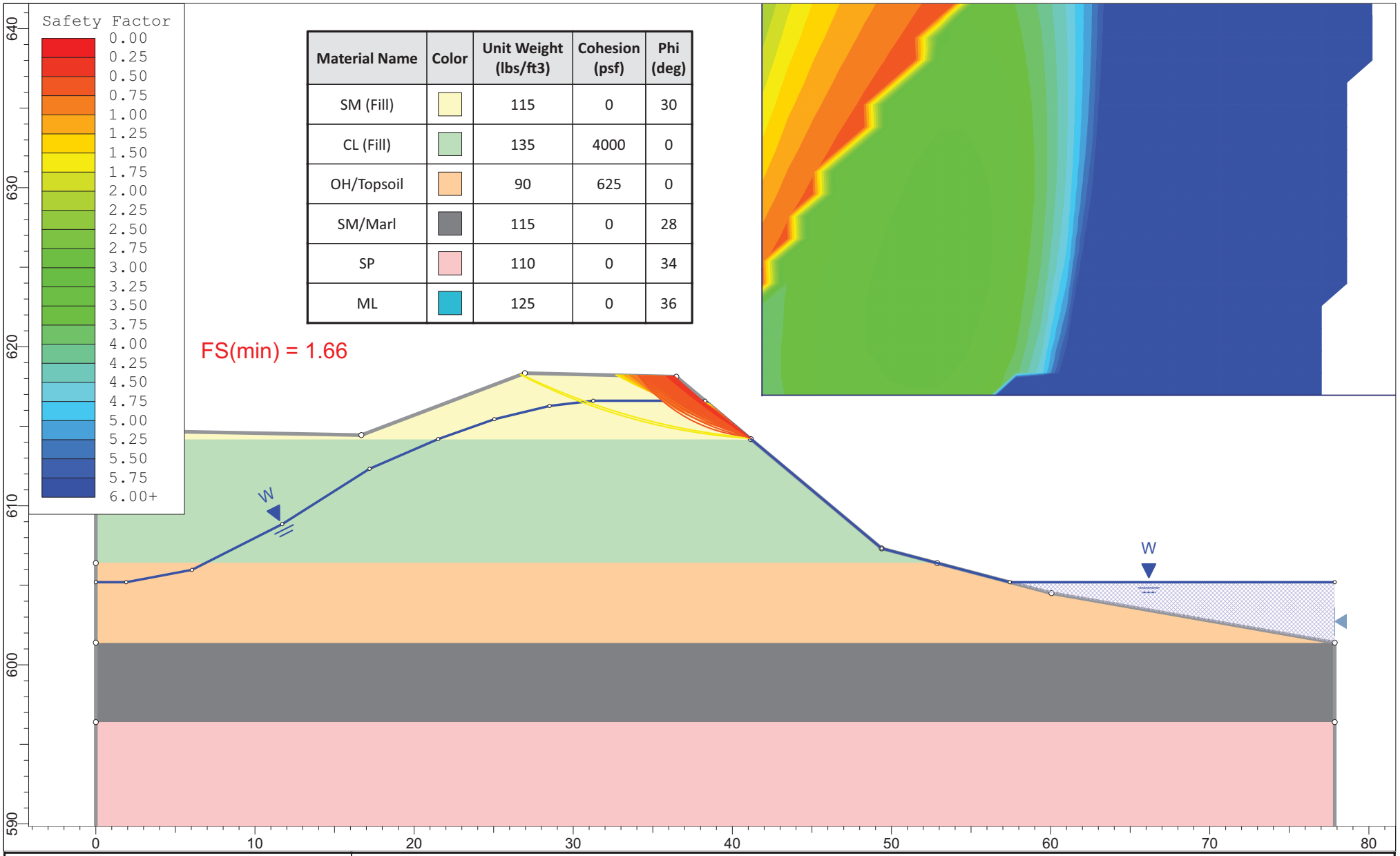
Project	Grand River Rapids Restoration		
Analysis Description	Section 3E - Proposed - Earthquake		
Drawn By	TM	*Company*	MTC
Date	6-5-2015	*File Name*	Case 4, Section 3E - Proposed - Earthquake.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SM (Fill)		115	0	30
CL (Fill)		135	400	28
OH/Topsoil		90	0	24
SM/Marl		115	0	28
SP		110	0	34
ML		125	0	36

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 4E - Proposed - OLW = 605.2	
	Drawn By	TM	*Company* MTC
	Date	6-3-2015	*File Name* Case 1, Section 4E Proposed OLW = 605.2.slim

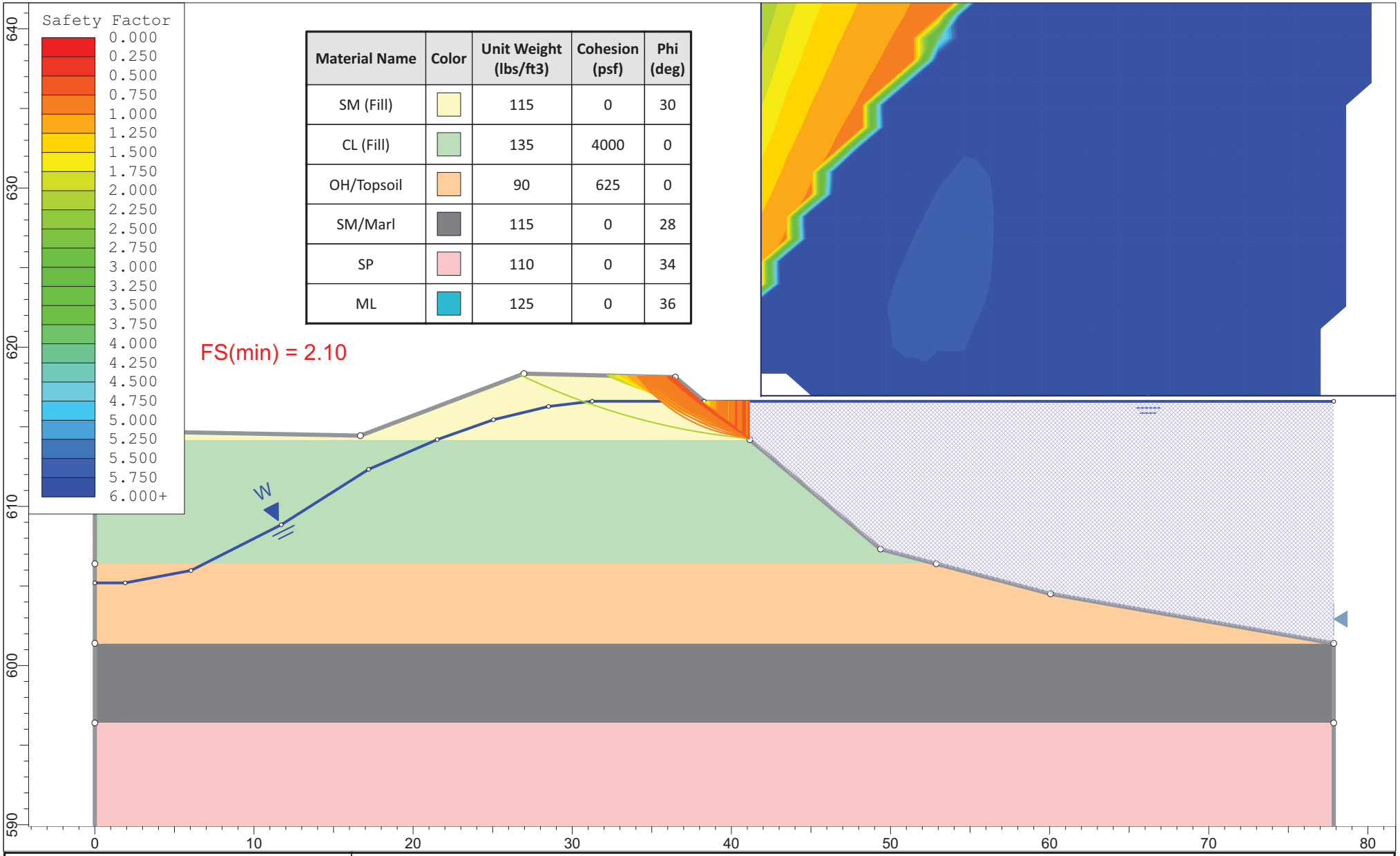
SLIDEINTERPRET 6.035



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SM (Fill)		115	0	30
CL (Fill)		135	4000	0
OH/Topsoil		90	625	0
SM/Marl		115	0	28
SP		110	0	34
ML		125	0	36

rocscience	*Project*	Grand River Rapids Restoration	
	Analysis Description	Section 4E - Proposed - Drawdown	
	Drawn By	TM	*Company* MTC
	Date	6-3-2015	*File Name* Case 2, Section 4E - Proposed - Drawdown.slim

SLIDEINTERPRET 6.035

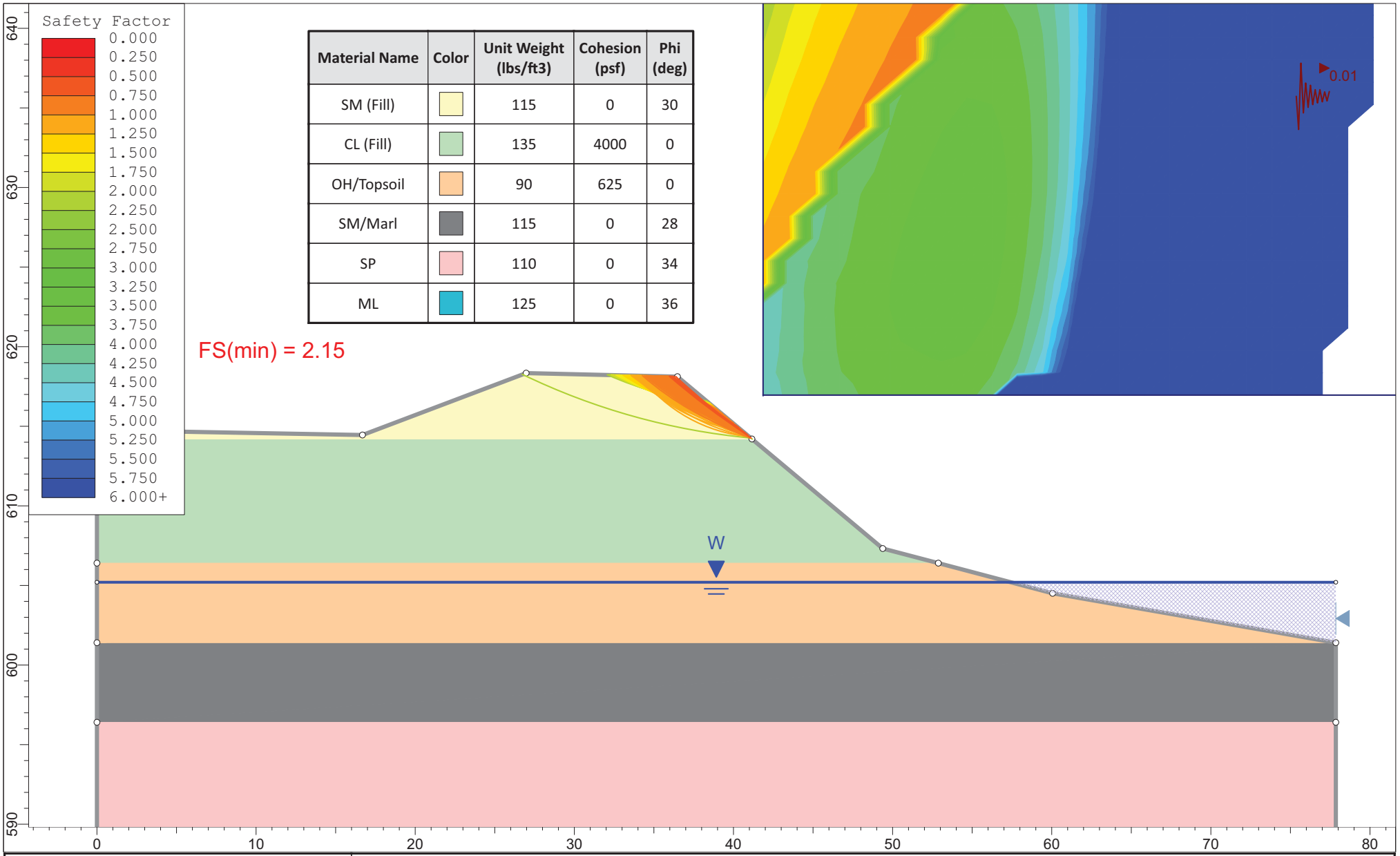


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SM (Fill)		115	0	30
CL (Fill)		135	4000	0
OH/Topsoil		90	625	0
SM/Marl		115	0	28
SP		110	0	34
ML		125	0	36

rocscience

SLIDEINTERPRET 6.035

Project	Grand River Rapids Restoration		
Analysis Description	Section 4E - Proposed - Steady State Seepage		
Drawn By	TM	*Company*	MTC
Date	6-3-2015	*File Name*	Case 3, Section 4E - Proposed - Steady State Seepage.slim



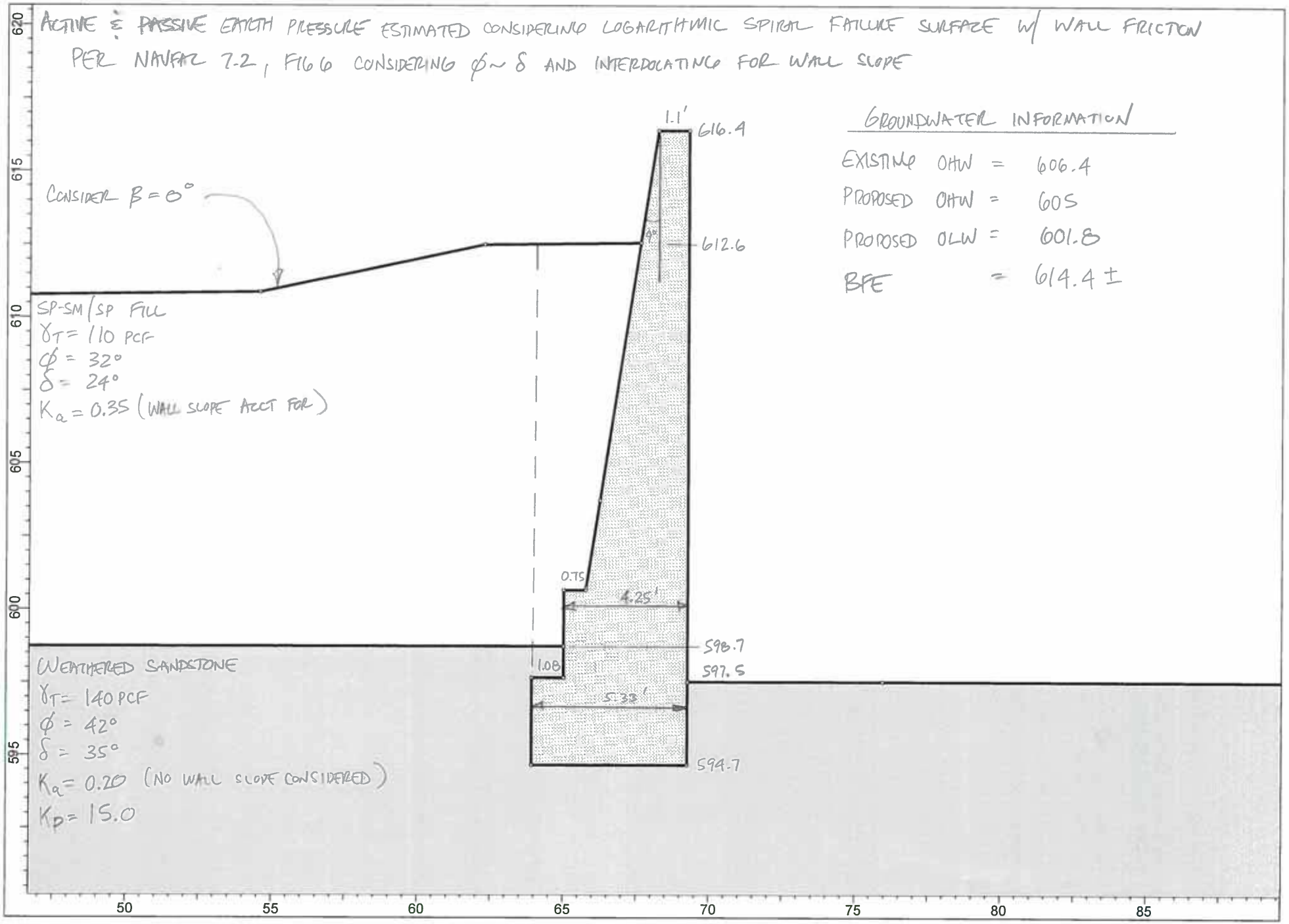
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SM (Fill)		115	0	30
CL (Fill)		135	4000	0
OH/Topsoil		90	625	0
SM/Marl		115	0	28
SP		110	0	34
ML		125	0	36

Project	Grand River Rapids Restoration		
Analysis Description	Section 4E - Proposed - Earthquake		
Drawn By	TM	Company	MTC
Date	6-3-2015	File Name	Case 4, Section 4E - Proposed - EQ.slim

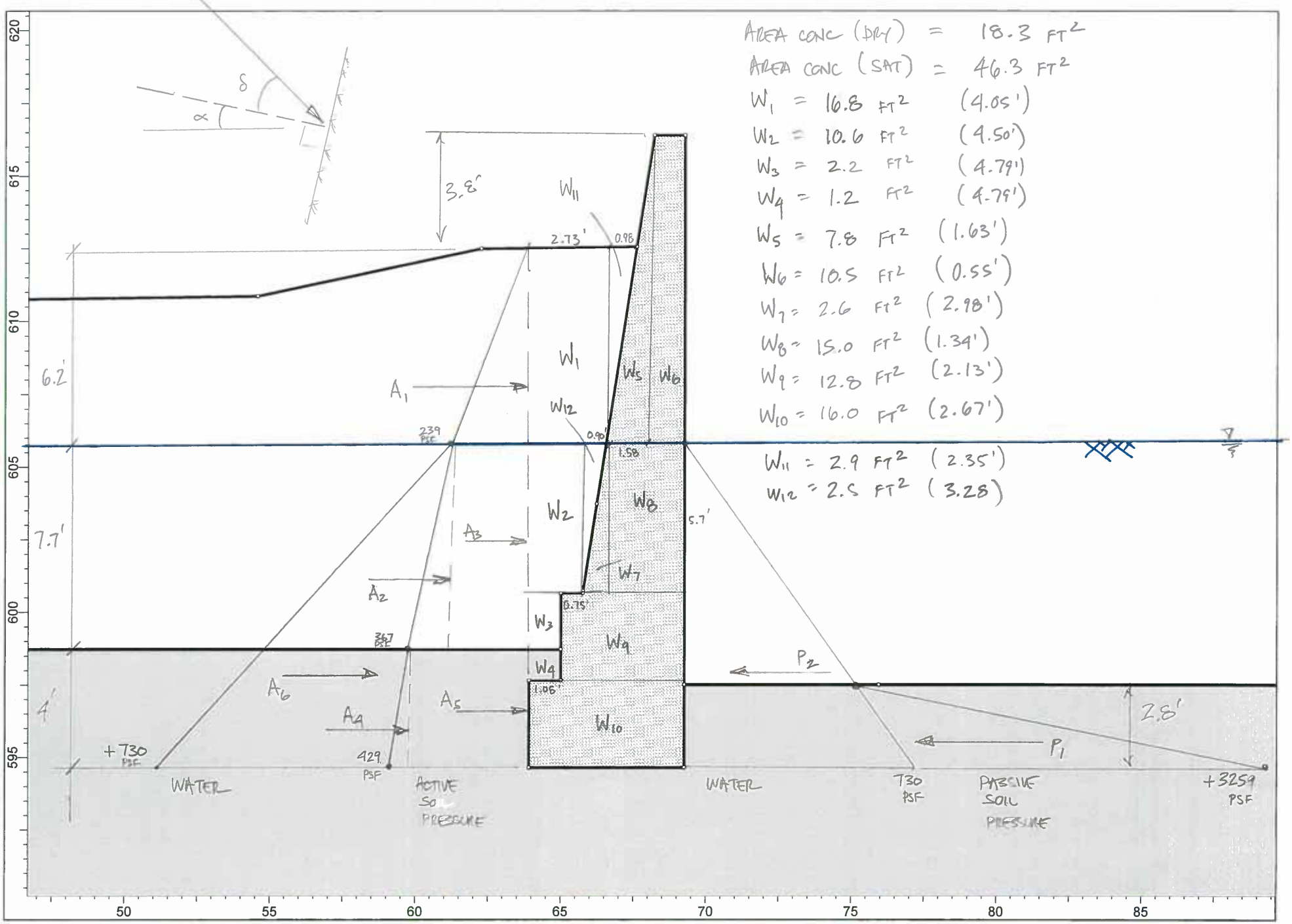
SLIDEINTERPRET 6.035

Appendix B: Floodwall Stability Analysis Results

SECTION 2W


ACTIVE & PASSIVE EARTH PRESSURE ESTIMATED CONSIDERING LOGARITHMIC SPIRAL FAILURE SURFACE W/ WALL FRICTION PER NAVFAC 7.2, FIG 6 CONSIDERING φ ~ δ AND INTERPOLATING FOR WALL SLOPE
GROUNDWATER INFORMATION
EXISTING OHW = 606.4
PROPOSED OHW = 605
PROPOSED OLW = 601.8
BFE = 614.4 ±
CONSIDER β = 0°
1.1'
616.4
4°
612.6
SP-SM/SP FILL
γT = 110 PCF
φ = 32°
δ = 24°
Ka = 0.35 (WALL SLOPE ACCT FOR)
0.75
4.25'
598.7
1.08
597.5
5.33'
594.7
WEATHERED SANDSTONE
γT = 140 PCF
φ = 42°
δ = 35°
Ka = 0.20 (NO WALL SLOPE CONSIDERED)
KP = 15.0
620
615
610
605
600
595
50
55
60
65
70
75
80
85

EXISTING OHW = 606.4



141579 Grand River Rapids Restoration
Section 2W
Existing OHW = 606.4

Active Earth Pressure and Water (Driving Loads)

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	9	741	621	404	13.8	5.3	8556	2152
A2	24	9	493	413	268	6.6	5.3	2715	1431
A3	24	9	1840	1543	1002	7.9	5.3	12116	5345
A4	35	0	124	102	71	1.3	5.3	135	379
A5	35	0	1468	1203	842	2.0	5.3	2405	4490
A6 - Water	0	0	4271	4271	0	3.9	5.3	16655	0
				8153	**2587**			**42582**	**13798**

Passive Earth Pressure and Water (Resisting Loads)

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	4563	3738	2617	0.9	0.0	3476	0
P2 - Water	0	0	4271	4271	0	3.9	0.0	16657	0
				8009	**2617**			**20133**	

Vertical Loads

Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	16.8	110	1848	4.1	7484
W2	10.6	47.6	505	4.5	2271
W3	2.2	47.6	105	4.8	502
W4	1.2	77.6	93	4.8	446
W5	7.8	145	1131	1.6	1844
W6	10.5	145	1523	0.6	837
W7	2.6	82.6	215	3.0	640
W8	15	82.6	1239	1.3	1660
W9	12.8	82.6	1057	2.1	2252
W10	16	82.6	1322	2.7	3529
W11	2.9	110	319	2.4	750
W12	2.5	47.6	119	3.3	390
			9475		**22604**

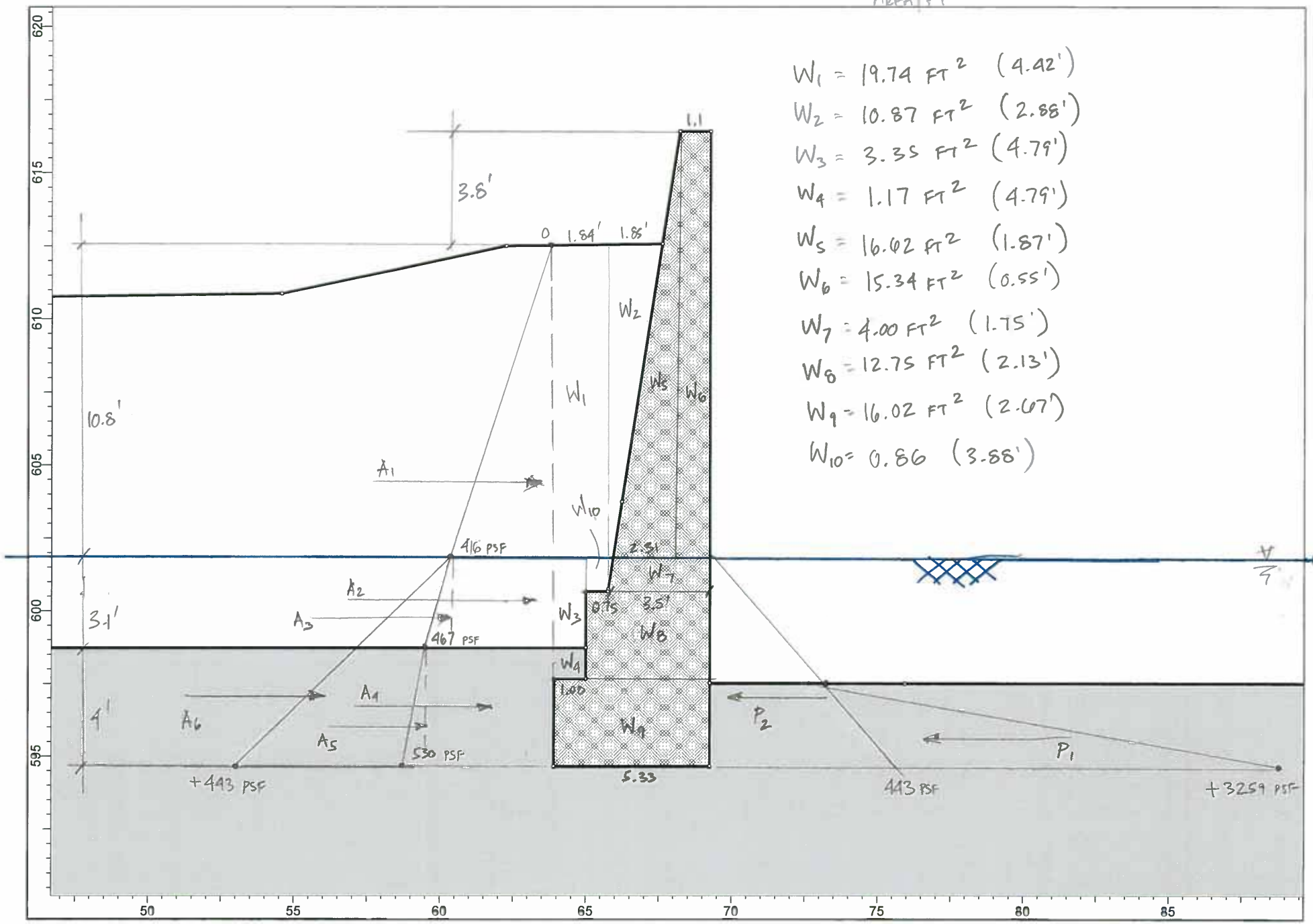
Stability Analysis Results

FS (Overturning) =	**1.48**
FS (Sliding) =	**1.79**
Summation M (ft-lbs/ft) =	**13,953**
Summation P (lbs/ft) =	**9,445**
e (ft) =	**1.19**

Resultant is Not Within Middle Third of Footing

PROPOSED OLW = 601.8

AREA / FT



$W_1 = 19.74\ FT^2$ (4.42')
$W_2 = 10.87\ FT^2$ (2.88')
$W_3 = 3.35\ FT^2$ (4.79')
$W_4 = 1.17\ FT^2$ (4.79')
$W_5 = 16.02\ FT^2$ (1.87')
$W_6 = 15.34\ FT^2$ (0.55')
$W_7 = 4.00\ FT^2$ (1.75')
$W_8 = 12.75\ FT^2$ (2.13')
$W_9 = 16.02\ FT^2$ (2.07')
$W_{10} = 0.86$ (3.88')

141579 Grand River Rapids Restoration
Section 2W
Proposed OLW = 601.8

Active Earth Pressure and Water (Driving Loads)

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	9	2246	1884	1223	10.7	5.3	20159	6525
A2	24	9	1290	1082	702	5.6	5.3	6003	3746
A3	24	9	79	66	43	5.0	5.3	333	230
A4	35	0	1868	1530	1071	2.0	5.3	3060	5714
A5	35	0	126	103	72	1.3	5.3	137	385
A6 - Water	0	0	1573	1573	0	2.4	5.3	3721	0
				6238	**3113**			**33413**	**16600**

Passive Earth Pressure and Water (Resisting Loads)

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	4563	3738	2617	0.9	0.0	3476	0
P2 - Water	0	0	1573	1573	0	2.4	0.0	3722	0
				5310	**2617**			**7198**	

Vertical Loads

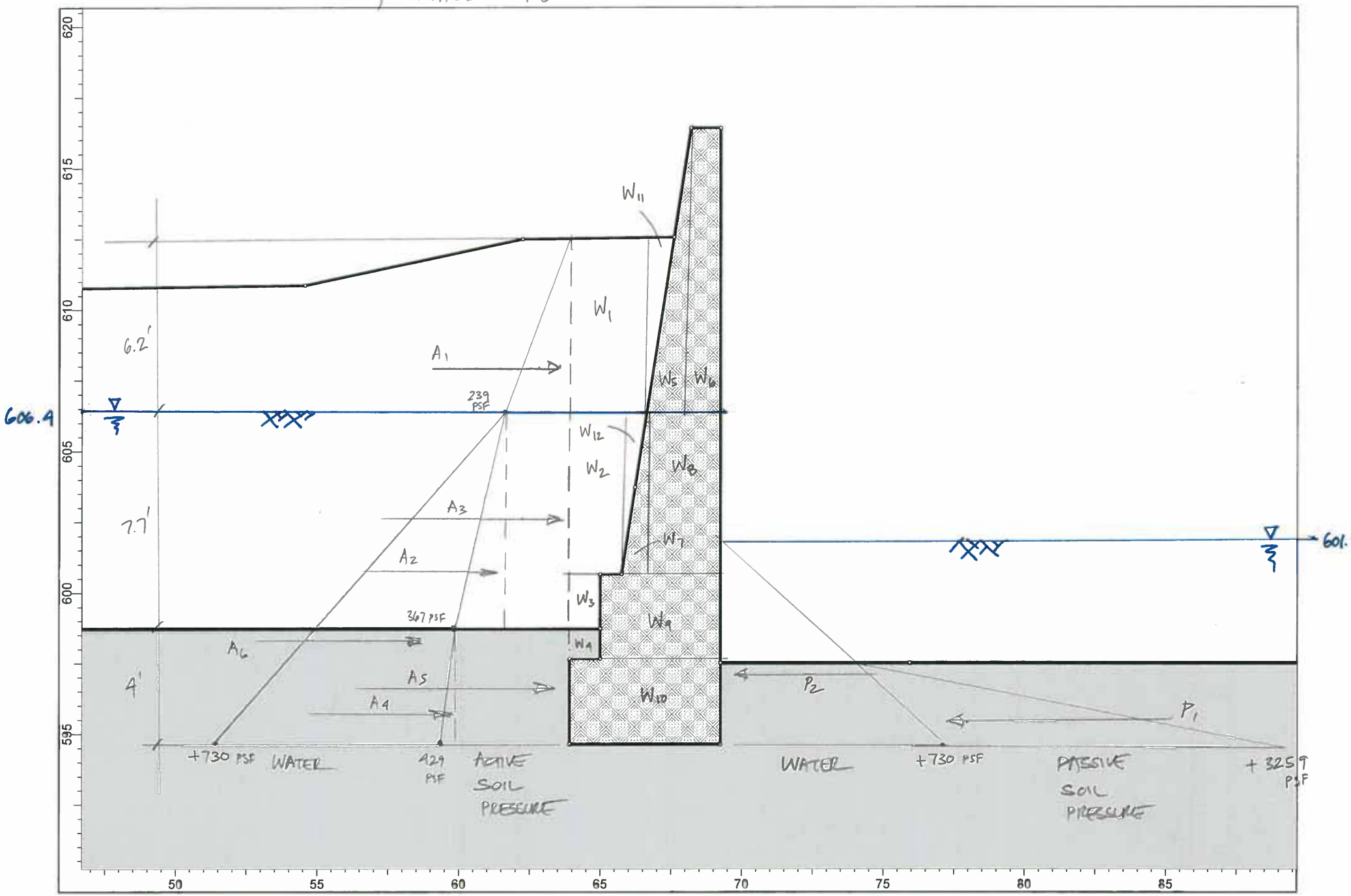
Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	19.74	110	2171	4.1	8794
W2	10.87	110	1196	4.5	5381
W3	3.35	47.6	159	4.8	764
W4	1.17	77.6	91	4.8	435
W5	16.62	145	2410	1.6	3928
W6	15.34	145	2224	0.6	1223
W7	4	82.6	330	3.0	985
W8	12.75	82.6	1053	1.3	1411
W9	16.02	82.6	1323	2.1	2819
W10	0.86	47.6	41	2.7	109
			10999		**25849**

Stability Analysis Results

FS (Overturning) =	**1.97**
FS (Sliding) =	**2.14**
Summation M (ft-lbs/ft) =	**16,233**
Summation P (lbs/ft) =	**11,495**
e (ft) =	**1.25**

Resultant is Not Within Middle Third of Footing

SECTION 2W – DRAWDOWN, ΔHEAD = 4.6'



141579 Grand River Rapids Restoration
Section 2W
Drawndown to Proposed OLW = 601.8
Δ Head = (606.4 to 601.8) = 4.6 ft

Active Earth Pressure and Water (Driving Loads)

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	9	741	621	404	13.8	5.3	8556	2152
A2	24	9	493	413	268	6.6	5.3	2715	1431
A3	24	9	1840	1543	1002	7.9	5.3	12116	5345
A4	35	0	124	102	71	1.3	5.3	135	379
A5	35	0	1468	1203	842	2.0	5.3	2405	4490
A6 - Water	0	0	4271	4271	0	3.9	5.3	16655	0
				8153	**2587**			**42582**	**13798**

Passive Earth Pressure and Water (Resisting Loads)

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	4563	3738	2617	0.9	0.0	3476	0
P2 - Water	0	0	1573	1573	0	2.4	0.0	3722	0
				5310	**2617**			**7198**	

Vertical Loads

Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	16.8	110	1848	4.1	7484
W2	10.6	47.6	505	4.5	2271
W3	2.2	47.6	105	4.8	502
W4	1.2	77.6	93	4.8	446
W5	7.8	145	1131	1.6	1844
W6	10.5	145	1523	0.6	837
W7	2.6	82.6	215	3.0	640
W8	15	82.6	1239	1.3	1660
W9	12.8	82.6	1057	2.1	2252
W10	16	82.6	1322	2.7	3529
W11	2.9	110	319	2.4	750
W12	2.5	47.6	119	3.3	390
			9475		**22604**

Stability Analysis Results

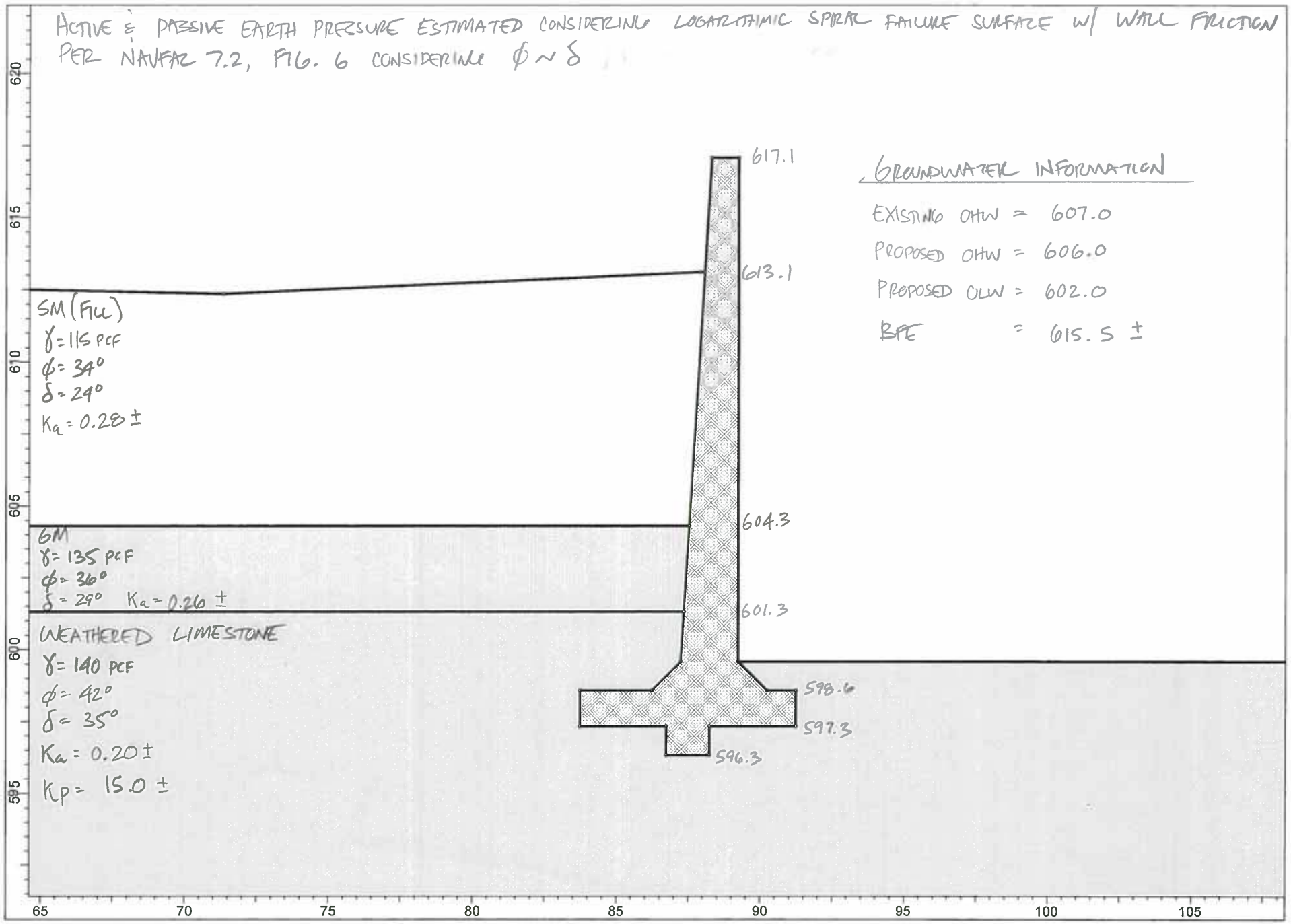
FS (Overturning) =	**1.04**
FS (Sliding) =	**1.46**
Summation M (ft-lbs/ft) =	**1,018**
Summation P (lbs/ft) =	**9,445**
e (ft) =	**2.56**

Resultant is Not Within Middle Third of Footing

SECTION 3W

6-2-15

ACTIVE & PASSIVE EARTH PRESSURE ESTIMATED CONSIDERING LOGARITHMIC SPIRAL FAILURE SURFACE W/ WALL FRICTION PER NAVFAC 7.2, FIG. 6 CONSIDERING $\phi \sim \delta$



GROUNDWATER INFORMATION

EXISTING OHW = 607.0

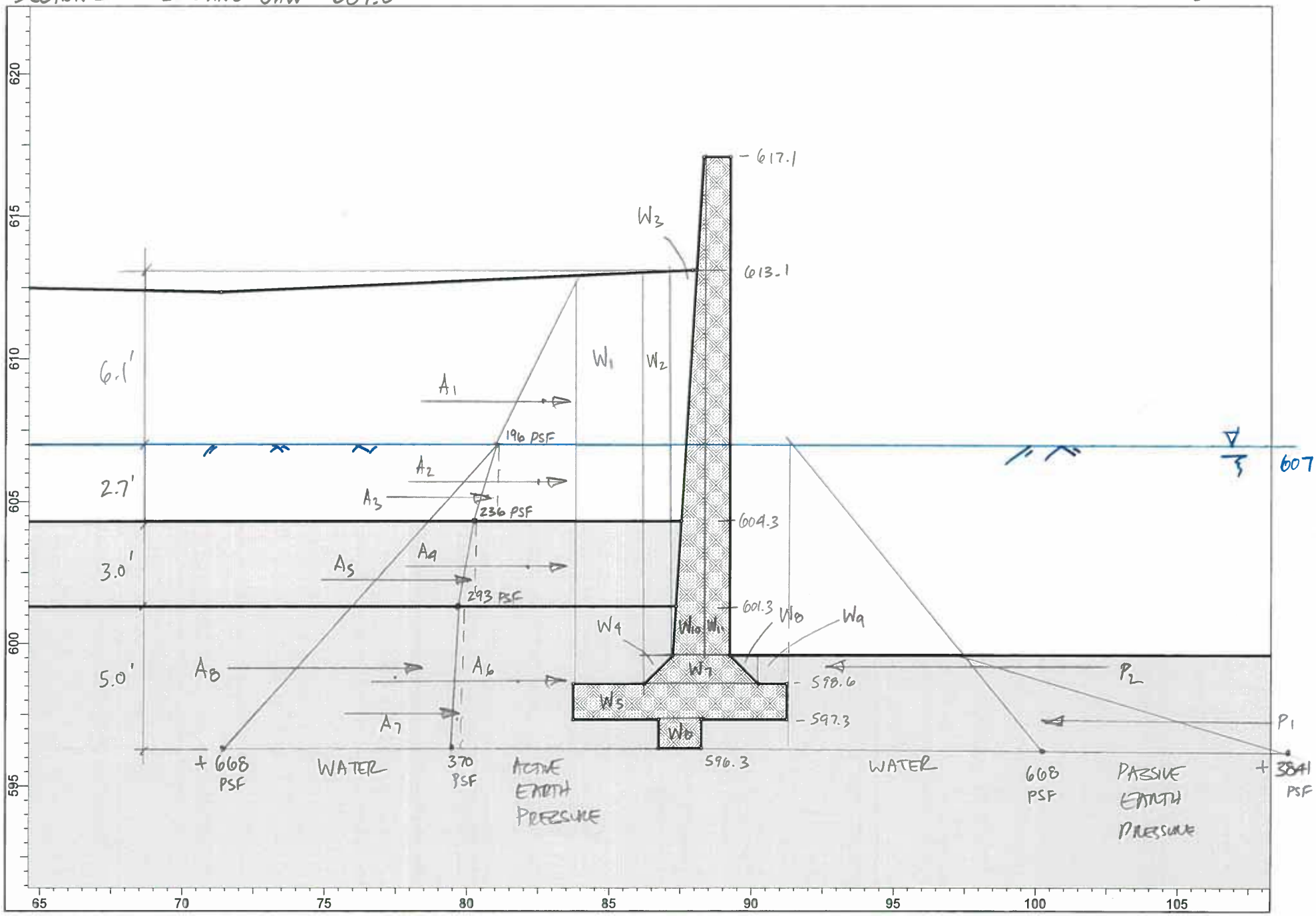
PROPOSED OHW = 606.0

PROPOSED OLW = 602.0

RFE = 615.5 ±

SECTION 3W – EXISTING OHW = 607.0

6-2-15



141579 Grand River Rapids Restoration
Section 3W
Existing OHW = 607.0

Driving Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	3	598	533	271	12.7	7.5	6782	2035
A2	24	3	529	472	240	9.4	7.5	4409	1802
A3	24	3	54	48	25	8.9	7.5	428	184
A4	29	3	708	600	375	6.5	7.5	3903	2814
A5	29	3	86	73	45	6.0	7.5	435	340
A6	35	0	1465	1200	840	2.5	7.5	3000	6302
A7	35	0	193	158	110	1.7	7.5	265	828
A8 - Water	0	0	3574	3574	0	3.6	7.5	12747	0
				6657	**1907**			**31968**	**14305**

Resisting Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	6338	5191	3635	1.1	0.0	5711	0
P2 - Water	0	0	3574	3574	0	3.6	0.0	12747	0
				8765	**3635**			**18457**	

Resisting Loads

Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	36.0	87.6	3154	6.3	19710
W2	13.5	88.4	1193	4.5	5370
W3	5.5	99.2	546	3.8	2046
W4	0.5	77.6	39	4.7	181
W5	9.4	82.6	776	3.8	2912
W6	1.5	82.6	124	3.8	465
W7	3.0	82.6	248	2.9	729
W8	0.5	77.6	39	1.3	52
W9	1.0	77.6	78	0.5	39
W10	9.3	103.2	960	3.3	3162
W11	16.5	118.4	1954	2.5	4827
			9109		**39492**

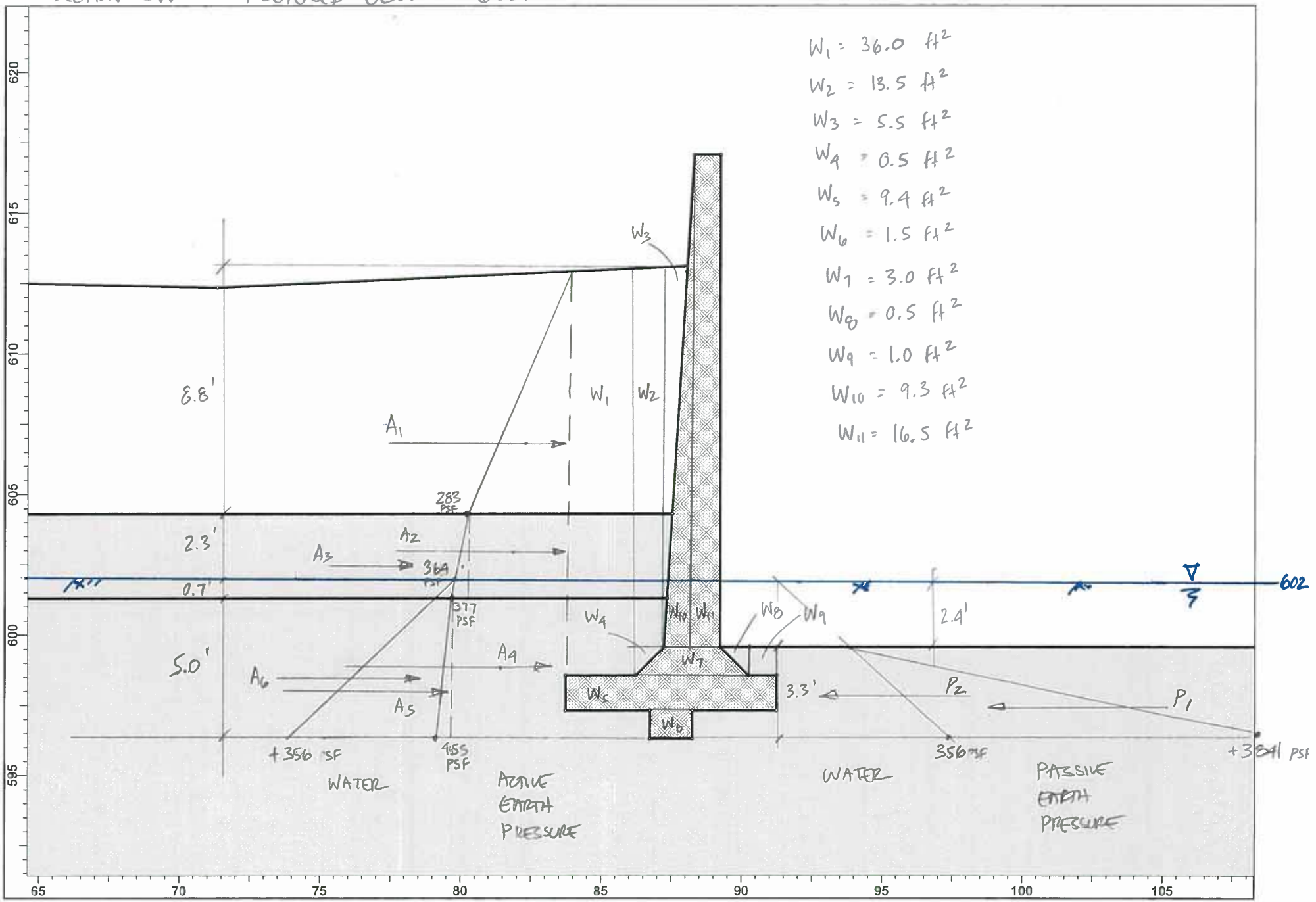
Stability Analysis Results

FS (Overturning) =	**3.28**
FS (Sliding) =	**2.09**
Summation M (ft-lbs) =	**40,286**
Summation P (lbs) =	**7,382**
e (ft) =	**-1.71**

Resultant is Not Within Middle Third of Footing

SECTION 3W – PROPOSED OLW = 602.0

6-2-15



141579 Grand River Rapids Restoration

Section 3W

Proposed OLW = 602.0

Driving Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	3	1245	1109	565	10.9	7.5	12130	4240
A2	29	3	849	720	450	6.5	7.5	4680	3374
A3	29	3	141	120	75	6.0	7.5	717	560
A4	35	0	1885	1544	1081	2.5	7.5	3860	8109
A5	35	0	195	160	112	1.7	7.5	266	839
A6 - Water	0	0	1014	1014	0	1.9	7.5	1927	0
				4667	**2283**			**23581**	**17122**

Resisting Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	6338	5191	3635	1.1	0.0	5711	0
P2 - Water	0	0	1014	1014	0	1.9	0.0	1927	0
				6205	**3635**			**7637**	

Resisting Loads

Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	36.0	103.8	3737	6.3	23355
W2	13.5	111.5	1505	4.5	6774
W3	5.5	116.1	639	3.8	2395
W4	0.5	77.6	39	4.7	181
W5	9.4	82.6	776	3.8	2912
W6	1.5	82.6	124	3.8	465
W7	3.0	82.6	248	2.9	729
W8	0.5	77.6	39	1.3	52
W9	1.0	77.6	78	0.5	39
W10	9.3	128.9	1199	3.3	3949
W11	16.5	136.4	2251	2.5	5561
			10633		**46410**

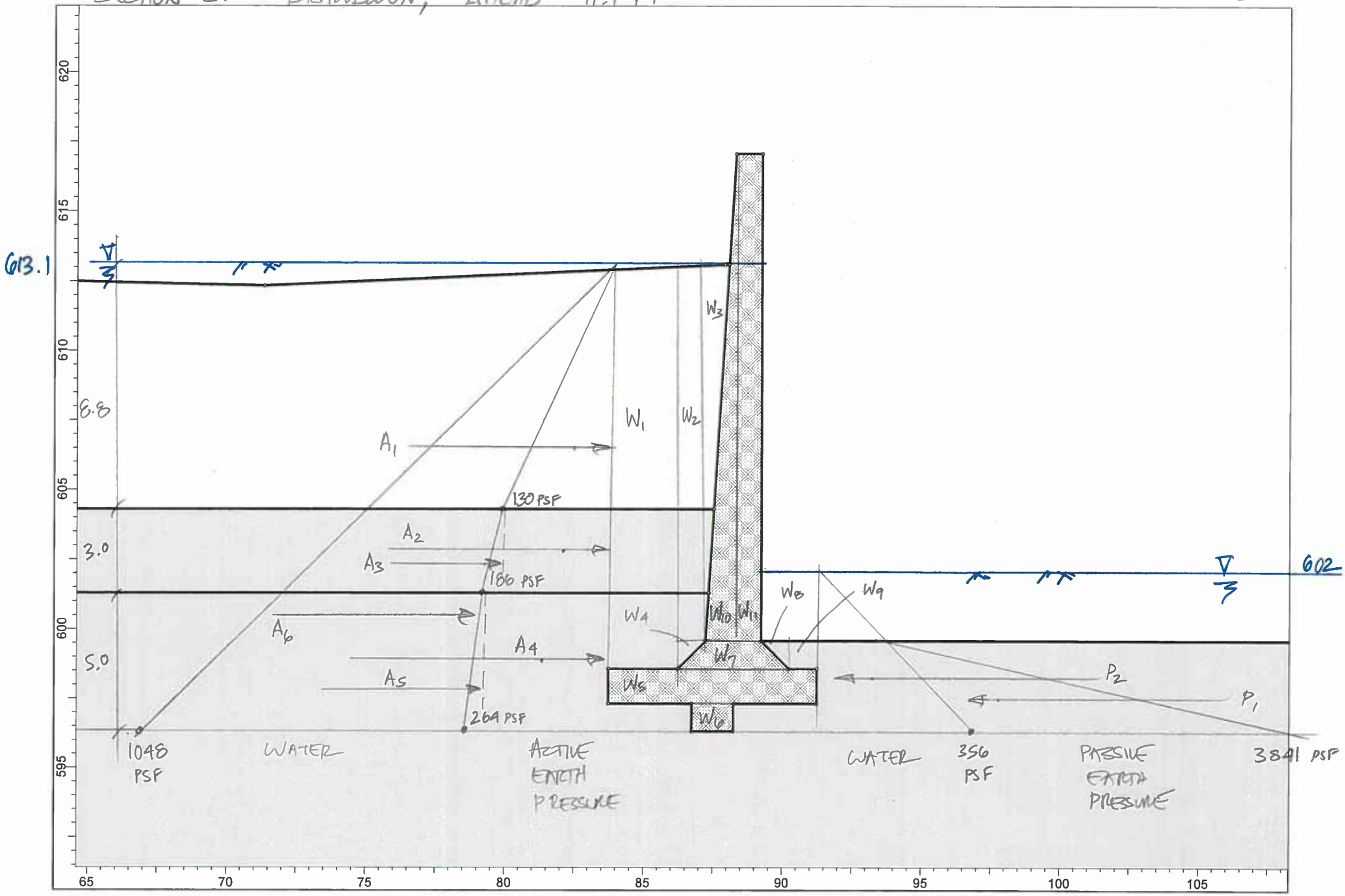
Stability Analysis Results

FS (Overturning) =	**8.37**
FS (Sliding) =	**2.72**
Summation M (ft-lbs) =	**47,589**
Summation P (lbs) =	**9,281**
e (ft) =	**-1.38**

Resultant is Not Within Middle Third of Footing

SECTION 3W - DRAWDOWN, ΔHEAD = 11.1 FT

6-2-15



6/9

141579 Grand River Rapids Restoration
Section 3W
Drawndown to Proposed OLW = 602.0
Δ Head = (613.1 to 602.0) = 11.1 ft

Driving Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	3	572	510	260	10.9	7.5	5572	1948
A2	29	3	390	331	207	6.5	7.5	2150	1550
A3	29	3	84	71	45	6.0	7.5	427	334
A4	35	0	930	762	533	2.5	7.5	1905	4001
A5	35	0	195	160	112	1.7	7.5	266	839
A6 - Water	0	0	8803	8803	0	5.6	7.5	49298	0
				10636	**1156**			**59618**	**8671**

Resisting Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	6338	5191	3635	1.1	0.0	5711	0
P2 - Water	0	0	1014	1014	0	1.9	0.0	1927	0
				6205	**3635**			**7637**	

Resisting Loads

Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	36.0	61.4	2210	6.3	13815
W2	13.5	60.2	813	4.5	3657
W3	5.5	55.8	307	3.8	1151
W4	0.5	77.6	39	4.7	181
W5	9.4	82.6	776	3.8	2912
W6	1.5	82.6	124	3.8	465
W7	3.0	82.6	248	2.9	729
W8	0.5	77.6	39	1.3	52
W9	1.0	77.6	78	0.5	39
W10	9.3	85.8	798	3.3	2629
W11	16.5	96.7	1596	2.5	3942
			7697		**31427**

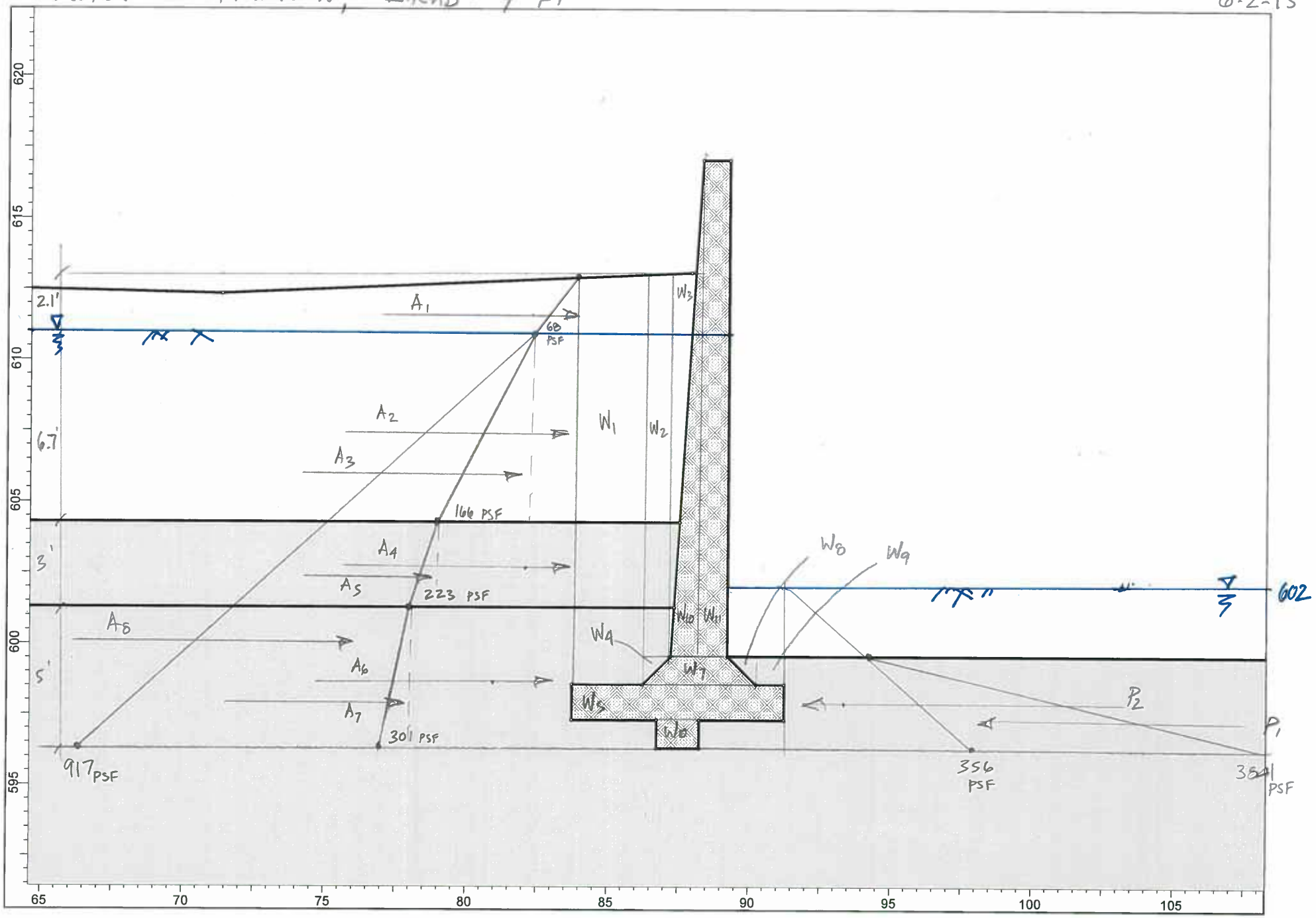
Stability Analysis Results

FS (Overturning) =	**0.77**
FS (Sliding) =	**0.93**
Summation M (ft-lbs) =	**-11,883**
Summation P (lbs) =	**5,218**
e (ft) =	**6.03**

Resultant is Not Within Middle Third of Footing

SECTION 3W - DRAWDOWN, ΔHEAD = 9 FT

6-2-15



8/9

141579 Grand River Rapids Restoration
Section 3W
Drawndown to Proposed OLW = 602.0
Δ Head = (611 .0 to 602.0) = 9 ft

Driving Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
A1	24	3	71	64	32	15.4	7.5	980	243
A2	24	3	456	406	207	11.4	7.5	4607	1551
A3	24	3	328	293	149	10.2	7.5	2993	1118
A4	29	3	498	422	264	6.5	7.5	2745	1979
A5	29	3	86	73	45	6.0	7.5	435	340
A6	35	0	1115	913	640	2.5	7.5	2283	4797
A7	35	0	195	160	112	1.7	7.5	266	839
A8 - Water	0	0	6740	6740	0	4.9	7.5	33026	0
				9070	**1449**			**47336**	**10867**

Resisting Loads

Load	δ (deg)	α (deg)	Pult (lbs/ft)	Px (lbs/ft)	Py (lbs/ft)	MAx (ft)	MAy (ft)	Mx (ft-lbs/ft)	My (ft-lbs/ft)
P1	35	0	6338	5191	3635	1.1	0.0	5711	0
P2 - Water	0	0	1014	1014	0	1.9	0.0	1927	0
				6205	**3635**			**7637**	

Resisting Loads

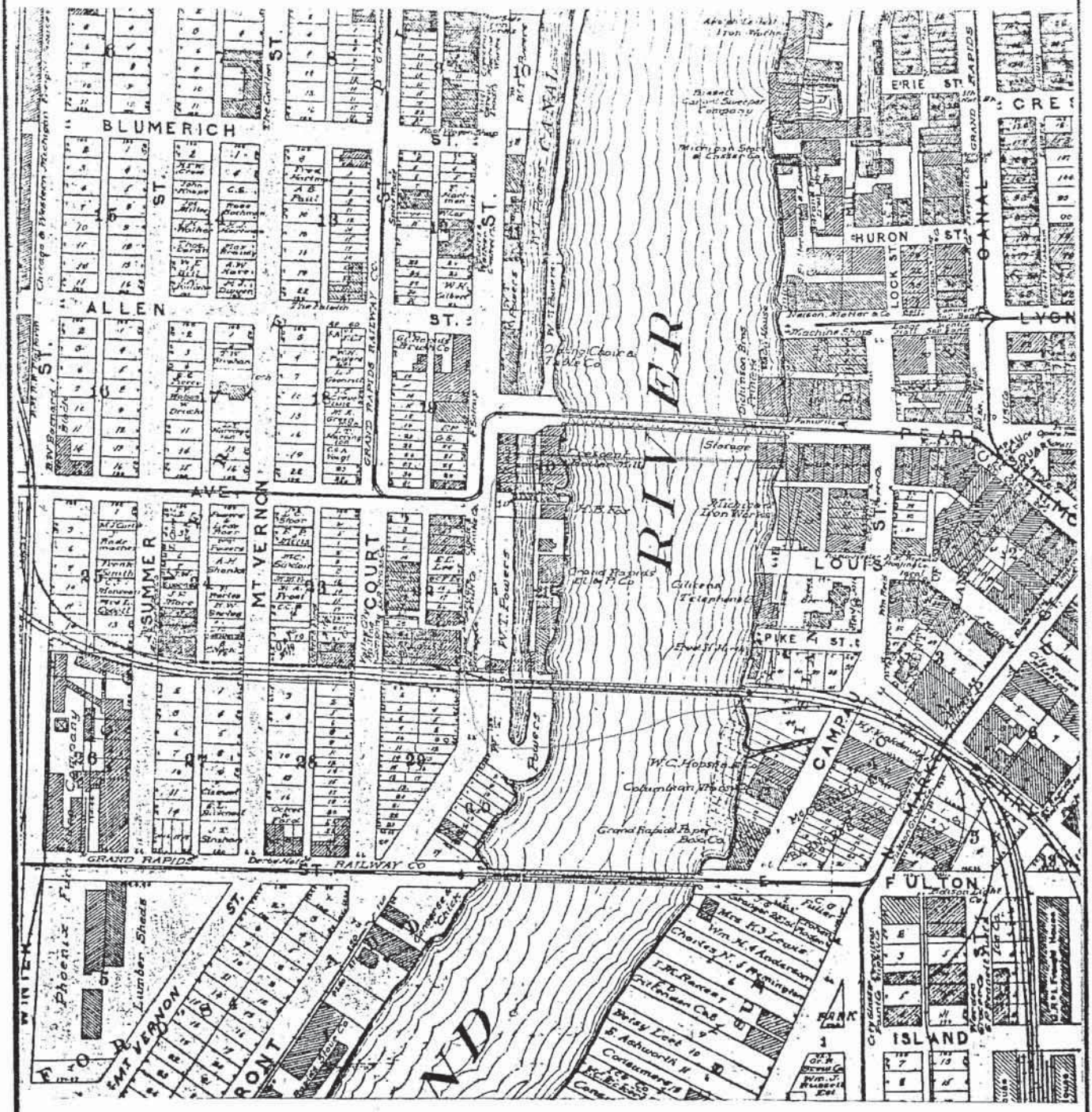
Load	A (ft^2)	γ' (pcf)	Wult (lbs/ft)	MAy (ft)	My (ft-lbs/ft)
W1	36.0	70.4	2535	6.3	15847
W2	13.5	69.9	944	4.5	4246
W3	5.5	73.7	405	3.8	1520
W4	0.5	77.6	39	4.7	181
W5	9.4	82.6	776	3.8	2912
W6	1.5	82.6	124	3.8	465
W7	3.0	82.6	248	2.9	729
W8	0.5	77.6	39	1.3	52
W9	1.0	77.6	78	0.5	39
W10	9.3	90.1	838	3.3	2760
W11	16.5	104.2	1719	2.5	4248
			7745		**32999**

Stability Analysis Results

FS (Overturning) =	**1.11**
FS (Sliding) =	**1.11**
Summation M (ft-lbs) =	**4,166**
Summation P (lbs) =	**5,559**
e (ft) =	**3.00**

Resultant is Not Within Middle Third of Footing

Appendix C: Powers Mine Documentation



Materials Testing Consultants, Inc.
693 PLYMOUTH N.E., GRAND RAPIDS, MICH. 49505 • PHONE 616/456-5469

VICINITY MAP

Map Source: Standard Atlas of Kent County
Geo. A. Ogle & Co., 1907

SCALE: None	DATE: 11/14/85	JOB NO. 128J

ART AND MUSEUM COMMISSION
[illegible] F. IDEMA, PRESIDENT HOLLIS S. BAKER, VICE-PRESIDENT MRS. SANFORD P. WILCOX, SECRETARY J. BOYD PANTLIND BENJAMIN J. BOKEMA

GRAND RAPIDS PUBLIC MUSEUM
FRANK L. DuMOND, DIRECTOR
CORNER WASHINGTON AND JEFFERSON
GRAND RAPIDS 2, MICHIGAN

APR 13 1955

April 11, 1955

from files of
MICH. DEPT. OF NATURAL RESOURCES
MINING & ECONOMIC GEOLOGY UNIT
GEOLOGICAL SURVEY DIVISION
4/20/56

Mr. Harry Hardenberg
Geological Survey Division
Michigan Department of Conservation
Lansing, Michigan

Dear Harry,

Enclosed is a map of greater Grand Rapids with all of the past and present gypsum operations marked on it. You are aware of the present ones, but here is the whole works as much as I know. Hope it will be of some use to you.

1. First gypsum quarry. Water filled, exposures along shore.
2. Abandoned Alabastine quarry. Water filled, exposures along shore.
3. Burned out Alabastine shaft.
4. Abandoned U.S. Gypsum Co. shaft. About 100 feet from road, no exposures.
5. Abandoned Pitsburgh Plate Glass Co. shaft. Now covered by small white pump building, no exposures.
6. Unidentified diggings. Remains of calcining kettles and scattered exposures. Opposite Jarecki Tool and Die Co. building. Follow railroad spur about 1000 feet. old Beverly Mine
7. Abandoned Powers Mine shaft. Under Grand River, now filled.
8. Grand Rapids Plaster Co.
9. Certain-Teed Products Co.

Not Marked

Grandville---Just east off Wilson Ave., a few blocks from M-21. A couple of old quarries, water filled and a few exposures although houses have been built around the edge.

Sincerely,

Mary Jane Dockeray

Mary Jane Dockeray

R. DEPT. OF NATURAL RESOURCES
MINING & ECONOMIC DIVISION UNIT
GEOLOGICAL SURVEY
9/20/80

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE O
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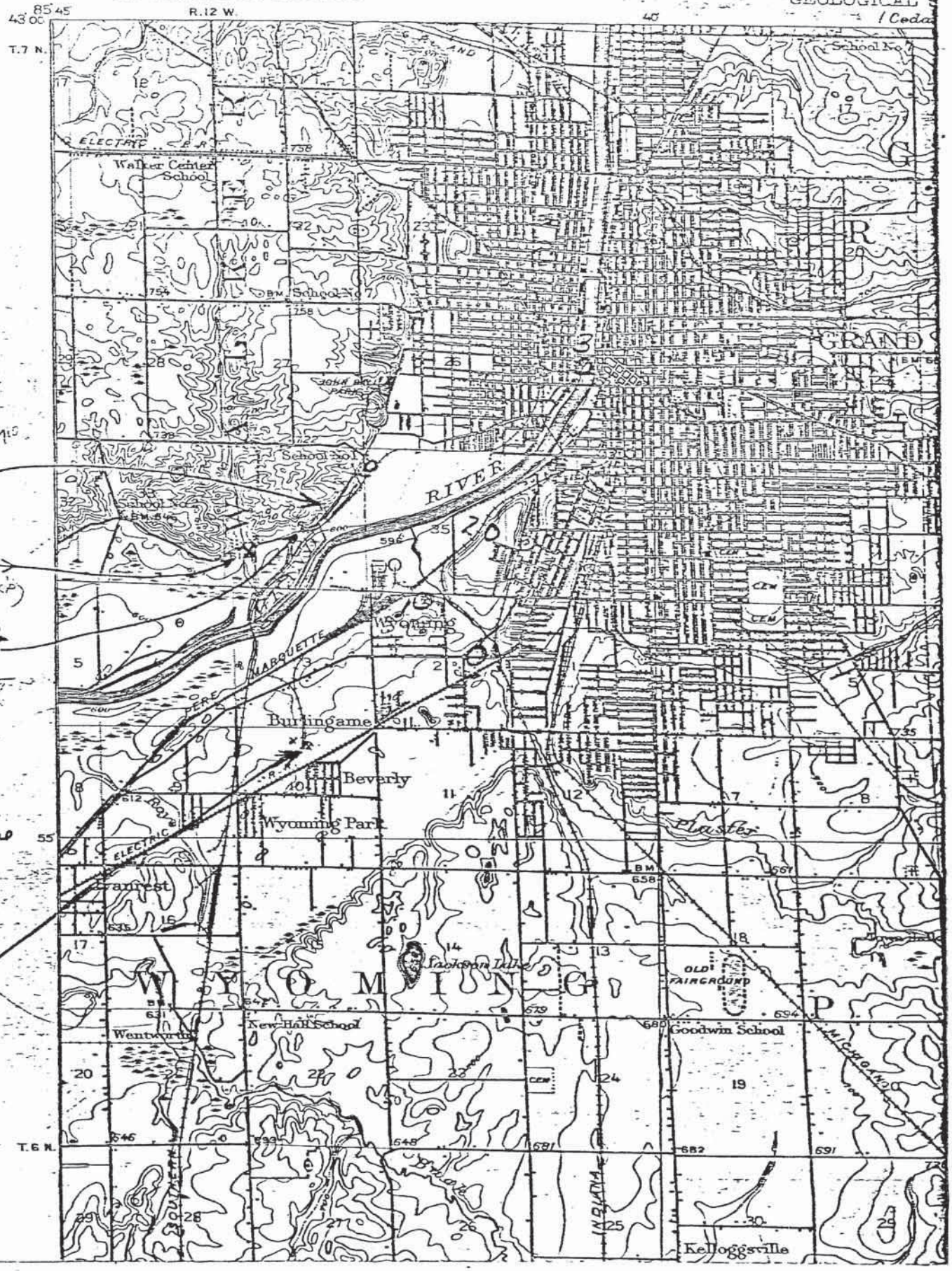


Grand Rapids Plaster Co
SHAFT NO 2

Certain-Teed Products Corp
GEORGIA-PACIFIC CORP)
BESTWALL MINE

U.S. GYPSUM Co
(abandoned)
MIDLAND SHAFT

1 Alabaster Mine
2. Godfrey
3 Powers Mine

Certain-Teed
Products Corp
(old mine shaft)

T7N R14W

GYPSUM PRODUCTS MANUFACTURING COMPANY
J. W. Spooner, Gen. Mgr., 44 Powers TheatreBldg., Gd. Rap

This company owns about 8 acres on the west side of the river, mostly under the river, at the SE corner of Front and Pearl streets in the city of Grand Rapids.

There is a small mill on the property.

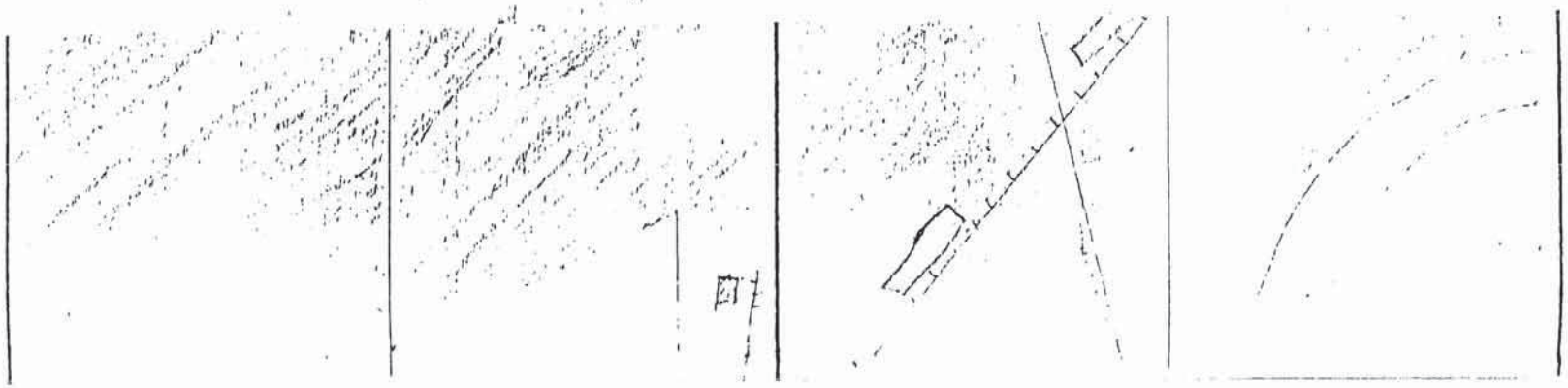
Operations are carried on in a 12 foot stratum of gypsum 80 feet below the surface. About 75% of the rock has been mined from about 1 acre of the ground. 2000 tons were mined last year and a like amount in 1909.

The mine was opened in 1896 and has been running about a quarter of the time since then.

The roof is not good, being full of faults or seams which makes the mine pretty wet. They are pumping about 150 gal. per minute.

Mr. Spooner states that the property is on too small a scale to be profitable and that he intends to shut it down during the coming year.

Powers Mine



From Grimsley, G. P., 1904, The Gypsum of Michigan and the Plaster Industry: Geological Survey of Michigan, Vol. IX, Pt. 2

The old work at the Godfrey mine was on the 11 foot ledge which has been removed over a large area extending from the wagon road at the east to the railroad switch to the mill at the west. The rock as far as we can judge from the fragments scattered around the quarry and from the account of the former foreman, Mr. A. J. Wright, was of the same general character as at the Alabastine mill.

A large portion of the old mill is still standing to the northwest of the quarry. It was a two and one-half story frame building equipped with a Godfrey double nipper and cracker for crushing the rock, and with two vertical disintegrators made by Butterworth and Lowe, for the fine

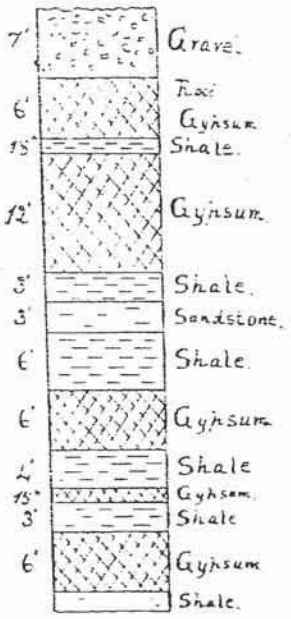


FIG. 14. Section at Powers' shaft.

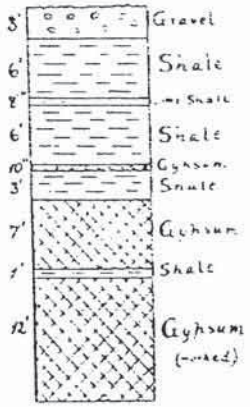


FIG. 15 Section Grand Rapids Plaster Co. mine.

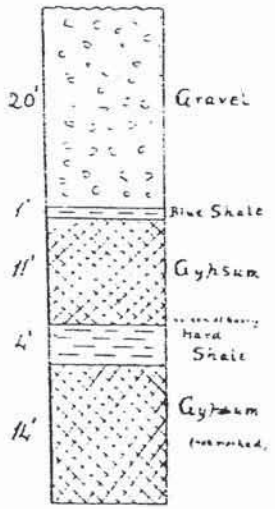


FIG. 16. Section Durr Mine

crushing and a single run of buhr stones. The mill was run by water power from Plaster creek. A separate building contained two ten foot kettles and the storage bins, but this was destroyed by fire a couple of years ago. A large roofed storage shed was built just south of the quarry and the rock was hauled in dump carts to the mill. The property is now idle and is owned by the Godfrey estate.

Powers Mine and Mill.

This property is located within the city on the west bank of the Grand river about midway between the Pearl and Fulton street bridges. Mr. Wm. T. Powers organized the company and sunk the shaft in 1896. The

mine goes 50 feet below the bed of the river and the framework of the shaft is built up 35 feet more to the floor of the mill. The record of the shaft has been lost and the section represented in Figure 14. is given from the memory of Mr. Powers of the boring made to the roof gypsum and 60 feet below it. The company owns 30 acres of this gypsum land. The upper ledge six to eight feet thick is left for a roof and the mine is worked on a room and pillar system with rooms about 50 feet square and the pillars 20 feet.

It is estimated that by this system about three-fourths of the gypsum can be removed.

The mill was built on the bank above in 1898, and was burned in the

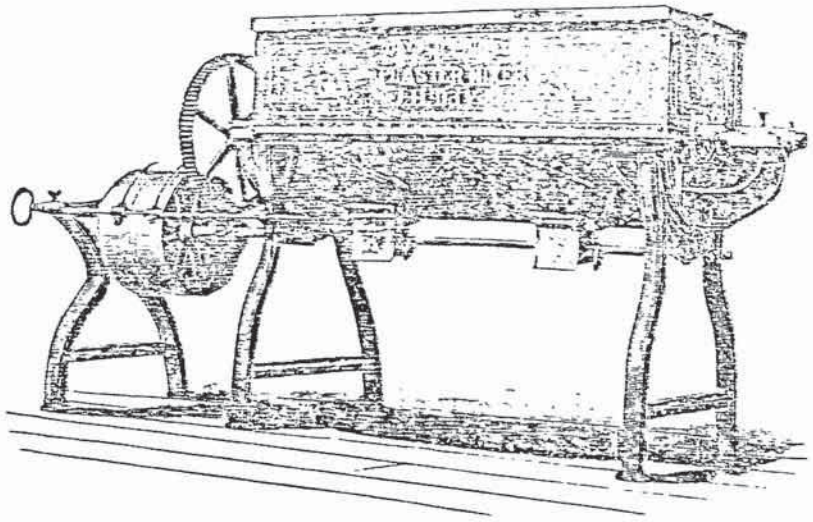


FIG. 17. Day's Lightning Plaster Mixer.

spring of 1903, and the company is known as the Gypsum Products Co. The frame mill was built in an L shape, 130 feet long east and west, and 25 to 50 feet wide with a storage shed built to the east 20 by 20 feet. The wareroom to the west was two stories high and the wider portion was three stories. On the second floor were placed the nipper and cracker and the buhrs below them in two sets, one of 36-inch for ordinary grinding, and a pair of 30-inch buhrs for regrinding. A part of the flour gypsum was carried by conveyors to the west part of the room and sacked for land plaster, and part was elevated to the third story over the kettle placed in the north part of the L extension. The gypsum then passed into the Powers patent kettle which was ten feet in diameter with a new design of flues described in the chapter on Technology, and it was heated by a wood fire. The finished plaster was dumped into fire brick bins and elevated to bins over the Broughton mixer where it was mixed with retarder to form wall plaster.

A special feature of the manufacture at this mill was the granite wall plaster, a sanded mixture ready to be mixed with water and applied to the wall. For this purpose there was on the basement floor a revolving cylinder sand dryer heated with wood fuel. The dried sand and retarder were mixed with the plaster of Paris in a Day's Lightning Plaster Mixer, as shown in Figure 17.

Grand Rapids Plaster Company Mines and Mills. (Plates X, XI, XV.)

On the north side of the river the gypsum is obtained from under the hill by an inclined hillside double entry tunnel. The Grand Rapids Plaster Co. have two double entry mines, one at each of their Eagle mills, known as mine No. 1 and mine No. 2. The main entry runs north and starts into the hill about the top of the 12 foot ledge. The section of the hill for 26 feet above the entry is given in Figure 15, a section which extends from the fence down, in Plate XV. About three feet of gravel are underlaid by 12 feet of shale separated at the center by eight inches of shaly limestone. Below the shale is a ten inch layer of gypsum seen in the photograph above the entry, and separated by three feet of shale from the six to seven foot upper ledge of gypsum. One foot of shale divides the upper from the 12 foot gypsum rock. The hill extends above to the wagon road 40 to 45 feet above the entry, and north of the road the hill rises 100 feet higher though not shown in the photograph.

The seven foot ledge is left for a roof and the 12 foot ledge is quarried for plaster rock. This is worked by a room and pillar system with rooms about 40 feet square and is mined by drilling holes in the upper half of the face of the rock and blasting down with dynamite. This leaves a bench or ledge six feet high which is then drilled vertically and blasted; all of the mining is carried on by this drift and bench system without any undercutting. Pillars of gypsum are left to support the roof, 15 to 20 feet in diameter and between the pillars intermediate timber posts are placed making the mines or caves as they are locally called, perfectly safe. No accidents from caving roof have ever occurred in mine No. 1. In No. 2 there has been no caving of the roof since 1881. At that time the roof covering about five acres fell in one night. The cause was in the placing the pillars too far apart, and the lack of sufficient intermediate posts. Since that time water has been somewhat troublesome in this mine, and about 150,000 gallons are pumped out in a week.

Mine No. 2 is similar to mine No. 1, and now the two are connected, and in all about 45 acres have been worked out. The character of the gypsum is about the same as in the quarries south of the river, showing a compact rock cut by numerous dark seams and with the red rock and the pencil rock at the bottom.

REPORT OF THE POWER'S MINE LOCATION
FOR THE
WEST RIVERBANK MIXED USE DEVELOPMENT
CITY OF GRAND RAPIDS

It has come to the attention of WBDC, while in the process of site analysis for the West Riverbank Mixed Use Development for the City of Grand Rapids, of the possible existance of an abandoned gypsum mine somewhere under the site. The following report may clarify some of the questions concerning location, size, and depth of the abandoned mine.

On Friday, September 28, 1894, the Evening Press ran an article on Page 3 about plans for a gypsum mine in the City of Grand Rapids. William T. Powers, a local industrial pioneer, stated that a vein of gypsum had been discovered on his property on the West Bank of the Grand River between Fulton and Pearl Streets. The article states that "the strata of rock is fourty feet thick and lies about eighty feet below the surface". It was Mr. Power's intention to sink a shaft, mine the gypsum and set up a gypsum products company on the riverbank. County records show that on June 2, 1896, Articles of Association were recorded and the Gypsum Products Manufacturing Company was formed. On record at the County Deeds Office is a deed selling property owned by William T. Powers and wife to Gypsum Products Mfg. Co. for the sum of $20,000.00. The following property description was given. "Commencing at a point on the south line of Pearl Street and fifty (50) feet east of the south east corner of Front and Pearl Streets thence south parallel with Front Street five hundred and sixteen (516) feet, thence west fifty feet (50) to the

east line of Front Street, thence south of the east line of Front Street one hundred and sixty six (166) feet, thence east one hundred (100) feet thence south parallel with Front Street one hundred and fifty (150) feet, thence south westerly about seventy five (75) feet to the north line of Lot Eight (8) Block Thirty (30) converse addition, before the same was vacated, thence southeasterly on the north line of Lot Eight (8) Block Thirty (30) to the center of Grand River, thence north on the center line of Grand River to the south line of Pearl Street bridge, thence west on the said south line of Pearl Street to the place of beginning." This description gives the boundaries of the Gypsum Products Mfg. Co.'s property and its mining limits.

According to the Geological Survey of Michigan, Vol. IX, Part II, The Gypsum of Michigan and the Plaster Industry by G.P. Grimsley dated 1901, William T. Powers began a 12' x 12' shaft in 1896. The shaft was located at the west end of the G.R. & I.R.R. bridge (presently the Penn Railroad Co. bridge) and mining was in a 12' layer of gypsum "about 60' below the riverbed". The article also made mention that the shaft was 85' in depth.

On July 23, 1901, a portion of the property described above was sold to the Grand Rapids Electric Light Company. Although the property was sold, the mining rights were retained. The Gypsum Products Mfg. Co. sold other land holdings around the mine, but always retained the mining rights to the limits that were previously described.

The most accurate information as to the exact location and size of the mine was recorded on July 9, 1907. Records at the Kent County Land Surveyor's Office show a survey of the mine for Valley City Milling Co. as follows:

FROM R & W 1-61
Survey of American Plaster Co. for Valley City Milling Co.
July 9, 1907

Measured E. along center of North
main track (G.R. & I.R.R.) from E. line of
Cold Storage Building
238' opposite center of shaft
52.3 N. from center of track to center of shaft

In mine ran from shaft N 82° 45' W

20'	52' RT.		55 LT.
40'	Pillar		Pillar
60'	55 RT. 40 LT.	73' RT. 42 LT. 15 RT.	59'
80'	Pillar		Pillar
100'	14' RT.		23'
115'	End of Working		

Ran from shaft S 44°E 79'

	S20° 45' W	93'	
86°RT.	N76° 30' W	72'	
76° 35' L	S27° 15' W	95'	11 RT. to edge of working

The survey not only pinpoints the exact location of the mine shaft, but also gives an indication of the size of the excavations. A map from a City atlas dated approximately 1910, shows the location of the Gypsum Products Mfg. Co. and surrounding buildings. Along with the preceding survey, the exact location in 1907 can be determined with fairly reliable accuracy (see attached Map #1).

The State Geological Survey has a short note on file concerning the Gypsum Products Mfg. Co.'s mine from a 1911 tax assessor's visit. Its contents are as follows:

Gypsum Products Manufacturing Company
J.W. Spooner General Manager, 44 Powers Theatre Building, Grand Rapids

This company owns about 8 acres on the west side of the River, mostly under the River, at the southeast corner of Front and Pearl Streets in the City of Grand Rapids. There is a small mill on the property. Operations are carried on in a 12 foot stratum of gypsum 80 feet below the surface. About 75% of the rock has been mined from about 1 acre of the ground. 2000 tons were mined last year and a like amount in 1909. The mine was opened in 1896 and has been running about a quarter of the time since then. The roof is not good, being full of faults or seams which makes the mine pretty wet. They are pumping about 150 gallons per minute. Mr. Spooner states that the property is on too small a scale to be profitable and that he intends to shut it down during the coming year.

County records indicate that the Gypsum Products Mfg. Co. was "dissolved by sale of property and franchises" in March of 1914, as recorded on January 25, 1915. A record of a deed also indicates on February 4, 1913, Gypsum Products Mfg. Co. sold its property and all its mining rights to the Michigan Railway Engineering Company. This transaction was recorded at the County Deeds Office on September 18, 1913.

There has been a great deal of speculation as to the true location of the Gypsum Products Mfg. Co.'s (or Power's) mine. After extensive research of City and County documents and records that resulted in the information given above, the following conclusions can be drawn with a reliable amount of accuracy.

Mr. William T. Powers began the mine in 1896. That same year, he formed the Gypsum Products Mfg. Co. and sold the land he owned along the Grand River where the mine was located to the Company for $20,000.00. Mr. Powers also acted as the head of the Company until his death in 1910.

At that time, he was succeeded by his son-in-law, J.W. Spooner. In the years following the founding of the Company, the balance of the land around the mine was sold to various interests. In each case, the Gypsum Products Mfg. Co. sold the land up to the river, and retained all the mining rights under the land being sold. It is interesting to note that the original land the Company owned went to the center of the Grand River, but when some of their holdings were sold, the property sold only went to the edge of the River. By 1910, the extent of the property that the Company owned was a small parcel on the bank of the River where the mine shaft and production buildings were located, and half of the River from just south of the railroad bridge to Pearl Street (see Map #2). The Company still had the mining rights to the entire original parcel. In 1907, we have a clear picture of the actual size of the mine from the Valley City Milling Co. survey (see Map #2). The mine was still in operation 5 years later and had grown to an area of about 1 acre in size at a depth of approximately 80'. The Gypsum Products Mfg. Co. was dissolved in 1914 and all property along with mining rights was sold the previous year to the railroad. There is no indication that the railroad continued the mining operation or sold the mine, and/or right to mine, to another holding. I could find no information that the mine has been filled following its close, as some have speculated. It is obvious that the shaft has been filled since an inspection of the site shows no indication of an open shaft. The condition of the mine at present time is pure speculation. The history of the mine shows a bad water problem and poor ceiling conditions, which would support the theory that in the past 70 years the mine cavity has been filled through natural actions.

Written by: Thomas VanHattum, AIA
:nh

OCKER & FORD M.F.G. CO.

NIGHT WATCHMAN WITH CLOCK - 3 STATIONS
HEAT STEAM - LIGHTS ELECTRIC
BARRELS AND PAILS OF WATER.
BLOWERS FROM ALL MACHINERY.

MAP #1 (APROX. 1910)

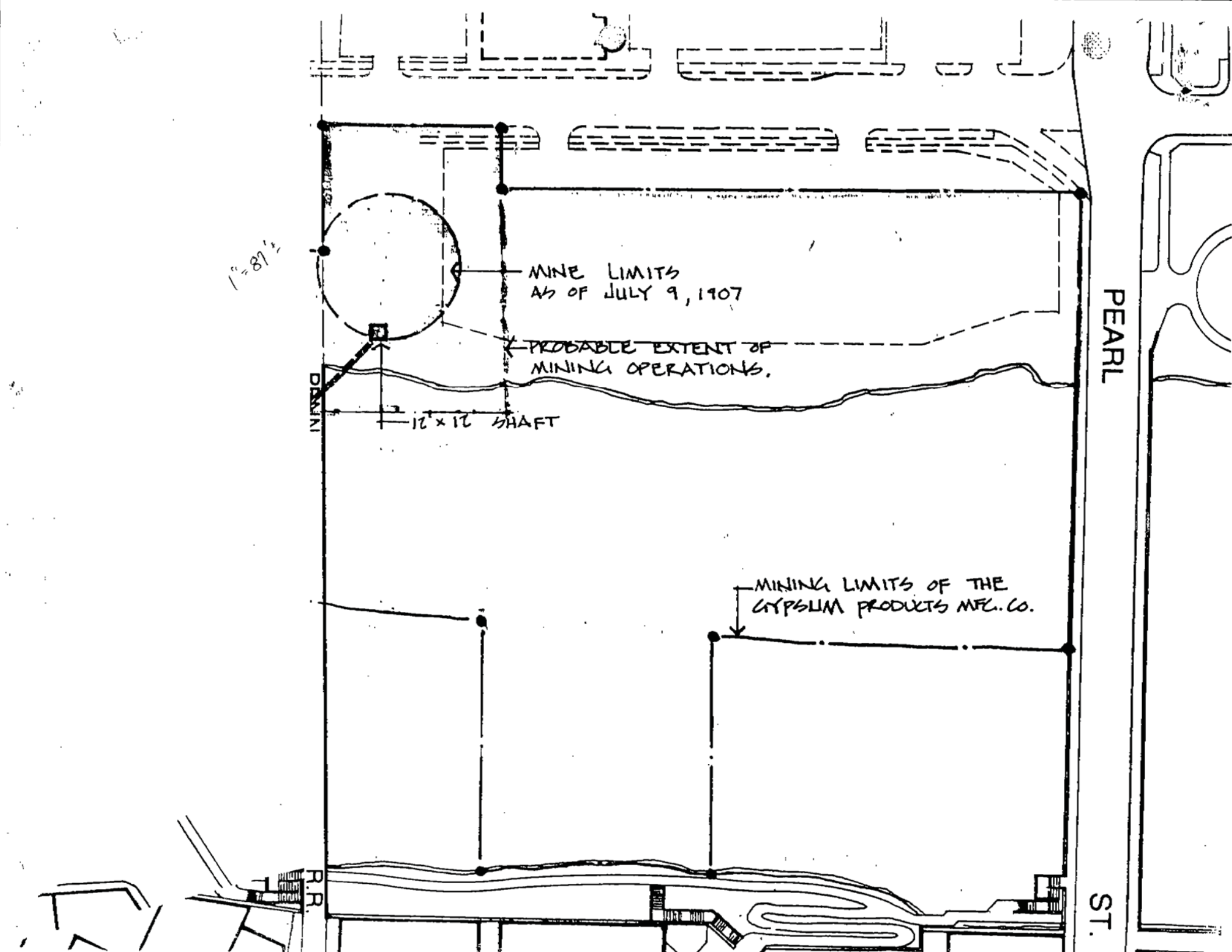
IND RAPIDS ELECTRIC LIGHT AND POWER CO.

WORK NIGHT AND DAY POWER: STEAM AND WATER HEAT: STEAM AND STOVES. LIGHTS: ELECTRIC. FUEL: COAL. 50' OF 1½" HOSE ATTACHED IN DYNAMO ROOM AS SHOWN. 50' OF ½" HOSE IN BOILER ROOM.

GYPSUM PRODUCTS MFG. CO.

NO WATCHMAN HEAT: ONE STOVE. LIGHTS: ELECTRIC NO FIRE APPS. POWER: WATER

7 DYNAMOS
ENG. 180 H.P.
ENG. 160 H.P.
IRON CLAD STRUCTURE ON ROOF
STORE RM'T.
ONE RUN OF STONE 4' ROCK BREAKER & GRINDER 2'
FLUME
IRON ST.
IR. CH.
COMPOUND ENG. 400 H.P.
12 DYNAMOS.
STORE RM'T. 2d
HYD. & 50' OF ½" HOSE 1st
M. CH. ON BR BASE.
ARC DYNAMOS.
COMMERCIAL PLANT. (BL. 21)
OIL HO.
WOODEN BRIDGE
W. HO.
STONE PLATFORM
POWER CANAL
21
22
SECT
12" W. PIPE
2" W. PIPE
200
75'
TR. H.
193 195 197 199
FRONT
179 front
163
GRAND RAPIDS COLD STORAGE CO.
2 Engs.
FLOORS WATER PROOF CONSTRUCTION WITH TAR PAPER LINING BETWEEN FLOORING.
To be Storage of Fruit & Produce.
W. HO. C
Cap. 7000 Bbls.
Awning
Boarding
Boarding
Boarding


1"=87½'
MINE LIMITS
AS OF JULY 9, 1907
PROBABLE EXTENT OF
MINING OPERATIONS.
DOWN
12' x 12' SHAFT
MINING LIMITS OF THE
GYPSUM PRODUCTS MFG. CO.
PEARL
ST.
R.R.

APPENDIX E

Other Supporting Information

141579 Grand River Sediment Sampling Report

3/6/2017

Materials Testing Consultants, INC.

Corporate Office
693 Plymouth NE • Grand Rapids, MI 49505 • (616) 456.5469 • FAX (616) 456.5784

Southeast Michigan
253 Dino Drive, Suite B • Ann Arbor, MI 48103 • (800) 968.8378 • (734) 619.6868

MATERIALS Engineers, Independent TESTING Laboratories, Geotechnical & Environmental CONSULTANTS — Since 1968

March 6, 2017
Project No. 141579

RiverRestoration
P.O. Box 248
Carbondale, Colorado 81623

Attention: Quinn Donnelly, P.E.

Reference: Summary of Grand River Sediment Sampling
Grand River Rapids Restoration
Grand Rapids, Michigan

Dear Mr. Donnelly:

We have completed sediment sampling at the twelve requested locations within the Grand River located downstream of the 6th Street Dam and upstream of the Fulton Street Bridge. The samples were collected using a petite Ponar Grab sampler on February 20, 2016. The Ponar sampler was lowered from a boat at the sampling locations to the river bottom, released to collect the sample and raised by hand after which the sample was retrieved by an MTC engineer. Retrieved samples were transported to our laboratory for gradation testing.

At each sampling location, approximately 12 to 15 attempts were made to collect a sample of the sediment at the river bottom using the Ponar sampler. Multiple attempts were necessary due to the presence of cobble and possible boulder which frequently resulted in little to no recover. At Sample Location 3, we were not able to collect a representative sample of the sediment.

Supplementary probing was performed along the sides of the boat in a repeatable pattern to subjectively evaluate the consistency of the river bottom based on (1) presence of cobble and boulder greater than or equal to 6-inches in size and (2) presence of sand, gravel and cobble smaller than 6-inches in size. A summary of sampling locations and the river bottom consistency based on probing efforts is provided in Table 1.

Table 1 – Sampling Location Summary

Sample Location	Location (MI State Plane South)		Water Depth (ft)	River Bottom Consistency Based on Probing (%)	
	Northing	Easting		< 6-inches	≥ 6-inches
1	536129	12773066	4.5	25	75
2	536295	12772921	4.0	10	90
3	536623	12772963	4.2	10	90
4	536936	12773212	2.5	15	85
5	537353	12773028	3.7	50	50
6	537428	12773240	3.0	60	40
7	537827	12773063	2.7	75	25
8	538296	12773381	3.9	40	60
9	538890	12773427	5.8	85	15
10	539147	12773180	3.5	50	50
11	539485	12773506	6.8	Suspected bedrock	
12	539801	12773238	3.7	15	85

Sieve analyses were performed on retrieved samples per ASTM D6913 with material larger than 2-inches measured individually using calipers. Photographs and sieve analysis results are attached.

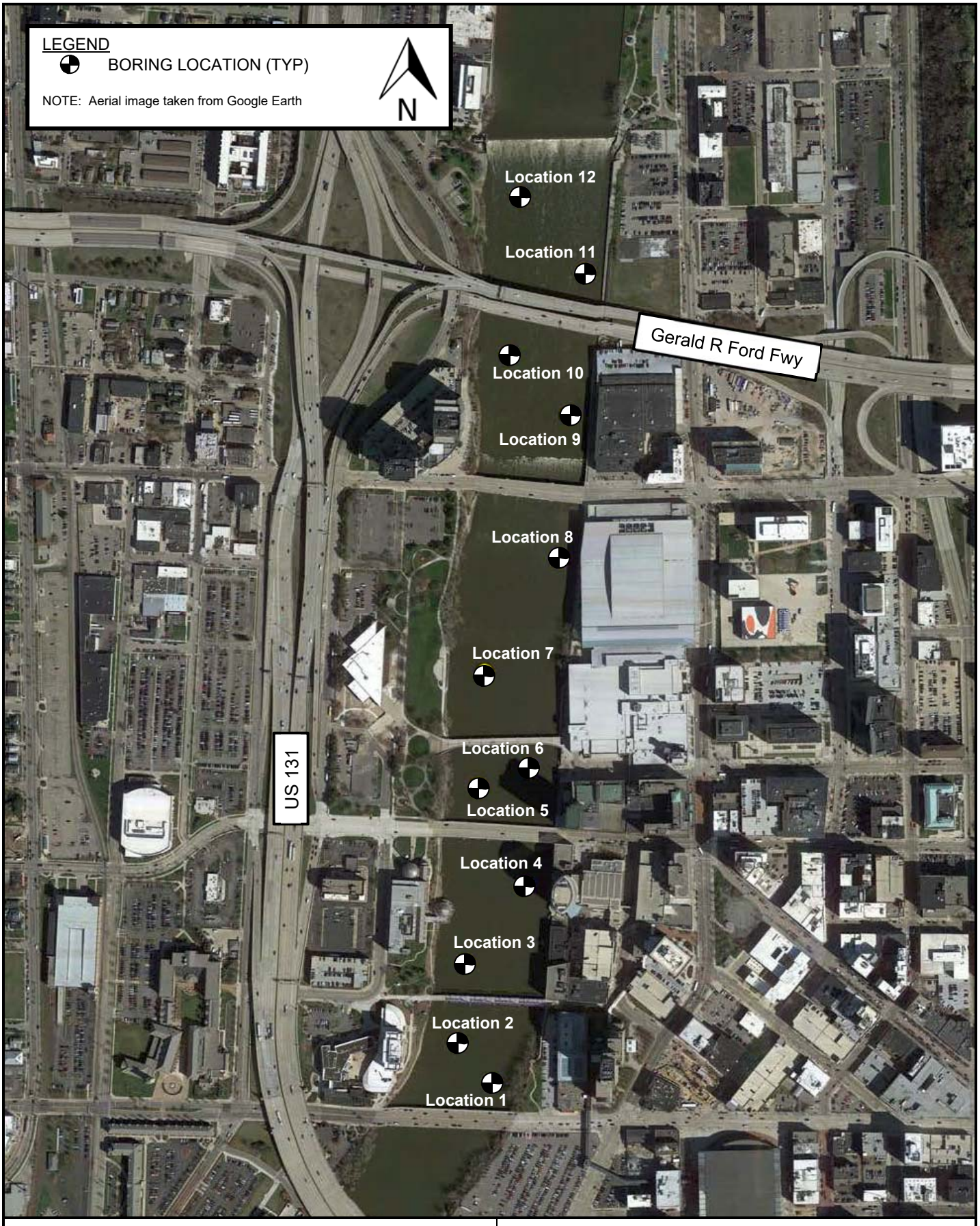
We appreciate the opportunity to provide this service to you on this project. Should you have any questions or require further assistance, please contact our office.

Sincerely,

MATERIALS TESTING CONSULTANTS, INC.

Todd D. Munger, P.E.
Senior Project Engineer

Attachments: Figure No. 1 – Sediment Sampling Location Plan
Appendix
- Sieve Analysis Results
- Sediment Sample Photographs



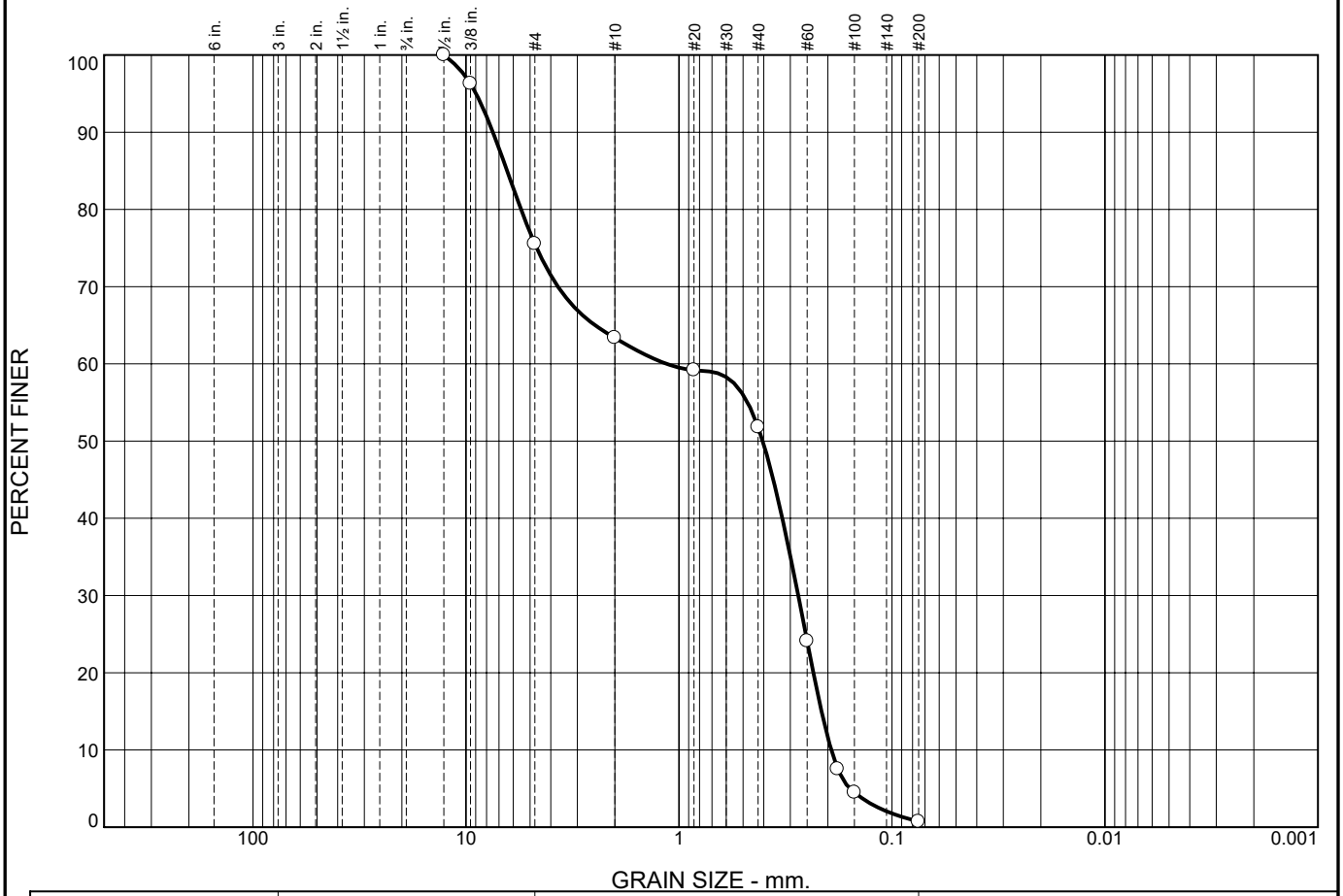
TITLE: SEDIMENT SAMPLING LOCATION PLAN		PROJECT: GRAND RIVER RAPIDS RESTORATION
SCALE: NTS	DATE: 2/24/17	PROJECT NO.:141579
FIG. NO.: 1	DR. BY: CK	REV. BY: TM

Materials Testing Consultants, INC.

APPENDIX

- **Sieve Analysis Results**
- **Sediment Sample Photographs**

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	24.5	12.1	11.6	51.1	0.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			6.4095	1.1416	0.4042	0.2754	0.2141	0.1930	0.34	5.91

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 1 **Sample Number:** 122896

Remarks:

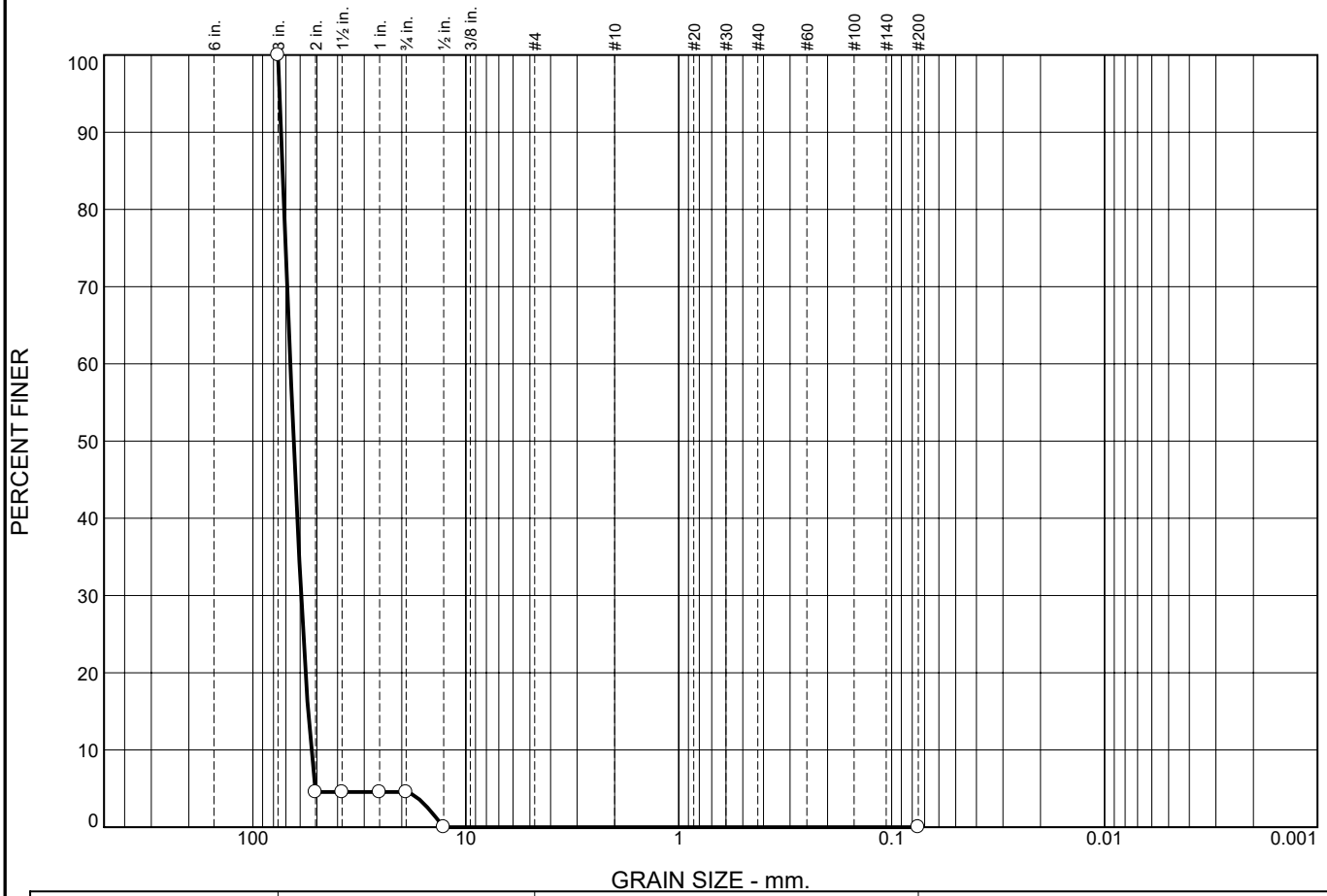
○100% of the Material Passes the 1/2" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	95.4	4.6	0.0	0.0	0.0	0.0	0.0

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			72.5626	66.6852	64.3235	59.3598	55.0269	53.2622	0.99	1.25

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 2 **Sample Number:** 122897

Remarks:

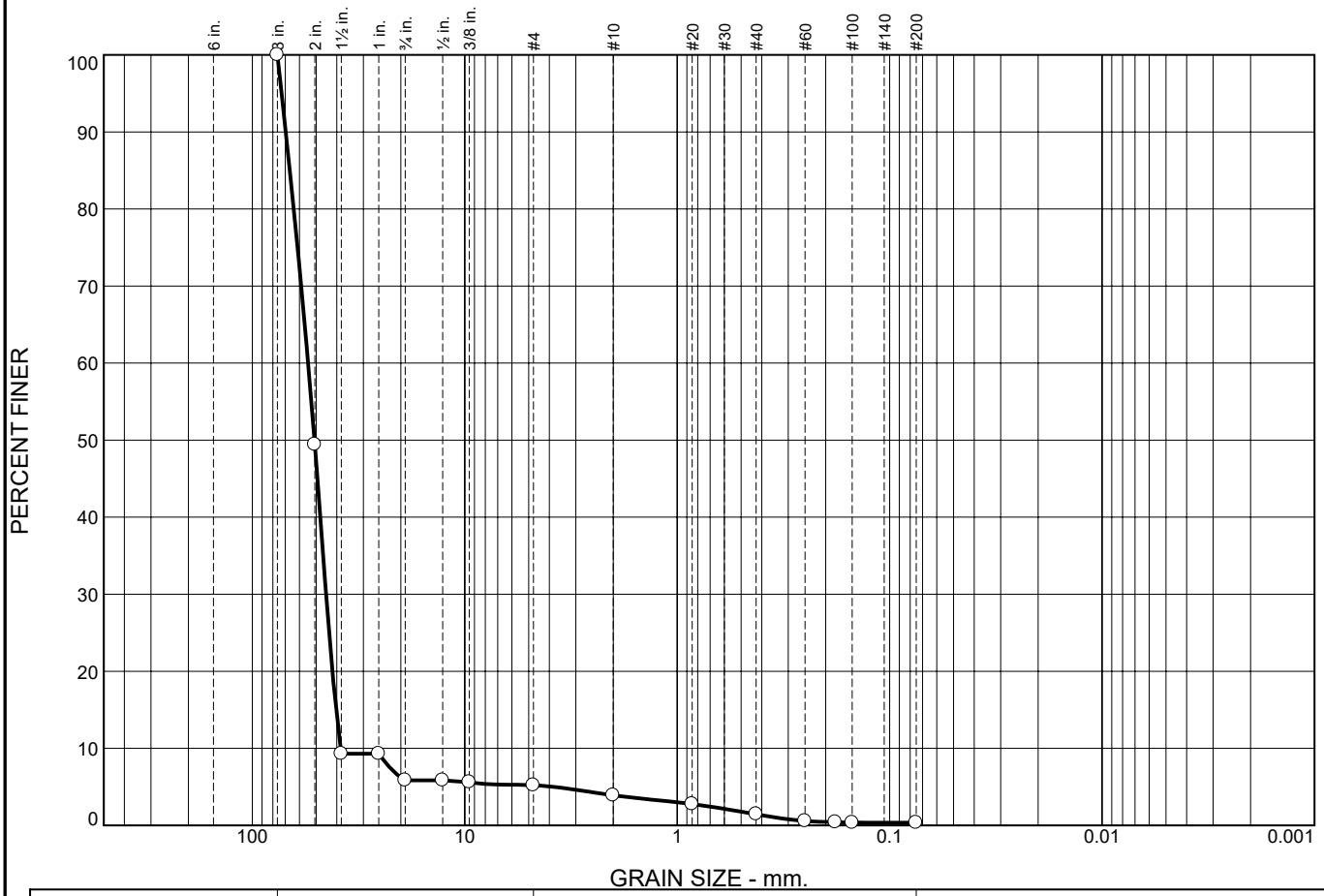
○100% of the Material Passes the 3" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	94.2	0.6	1.3	2.5	1.1	0.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			66.6267	54.5997	50.9909	44.9563	40.3643	38.4266	0.96	1.42

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 4 **Sample Number:** 122898

Remarks:

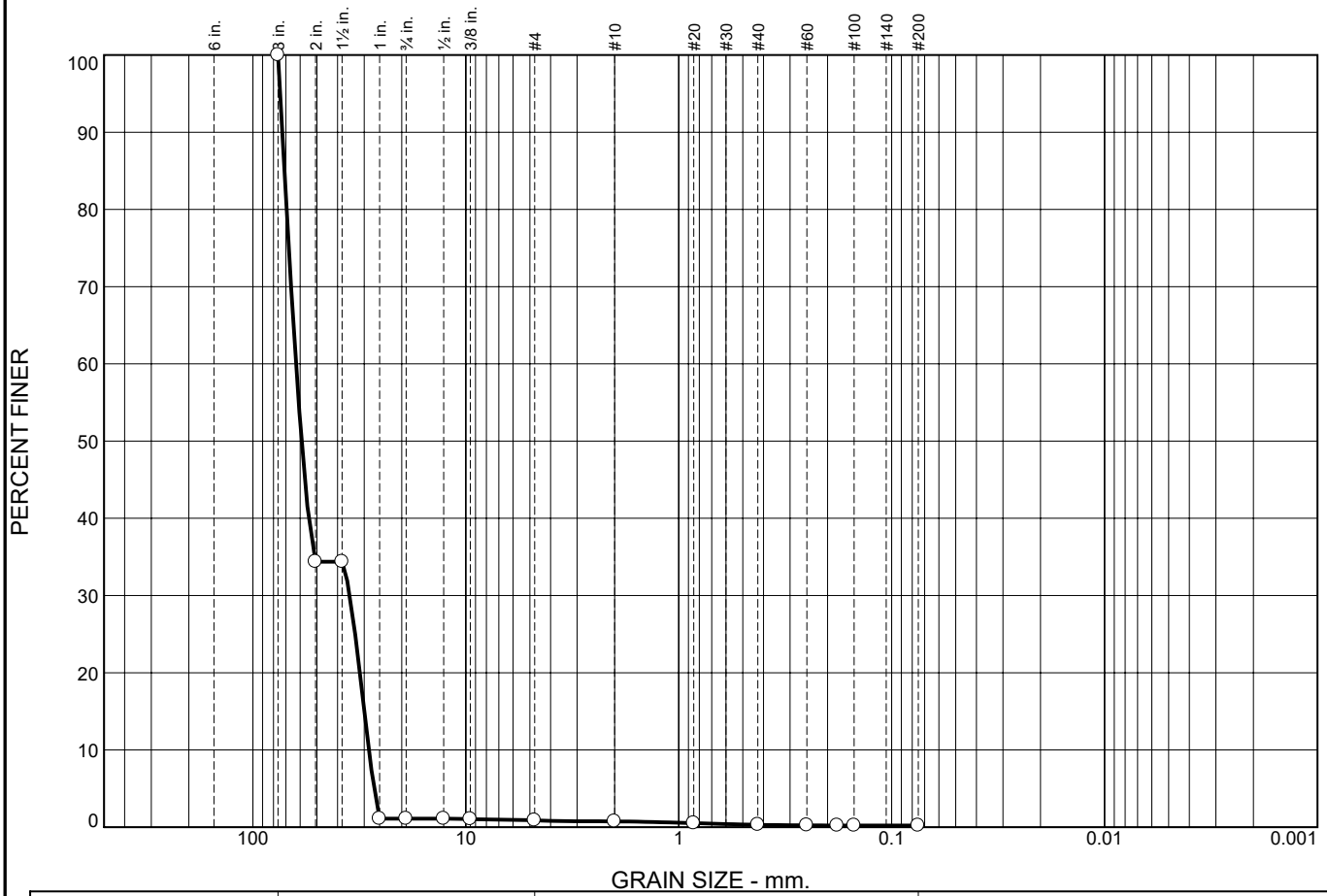
○100% of the Material Passes the 3" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	98.9	0.2	0.2	0.4	0.1	0.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			71.1199	62.7482	59.0847	35.0532	29.9623	28.5141	0.69	2.20

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 5 **Sample Number:** 122899

Remarks:

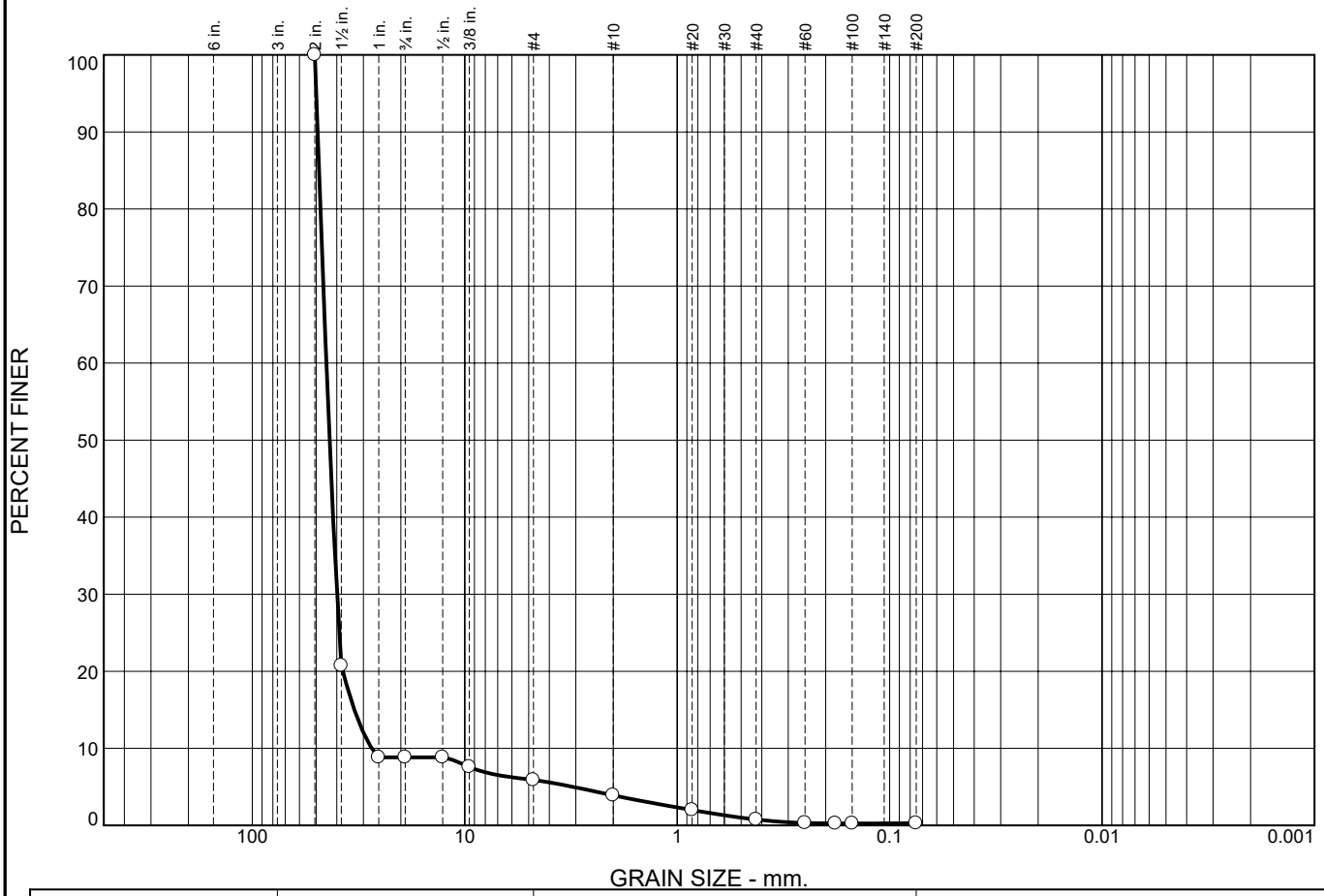
○100% of the Material Passes the 3" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	91.2	2.9	2.0	3.1	0.5	0.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			48.5307	44.8192	43.2979	39.9732	33.0704	27.4007	1.30	1.64

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 6 **Sample Number:** 122900

Remarks:

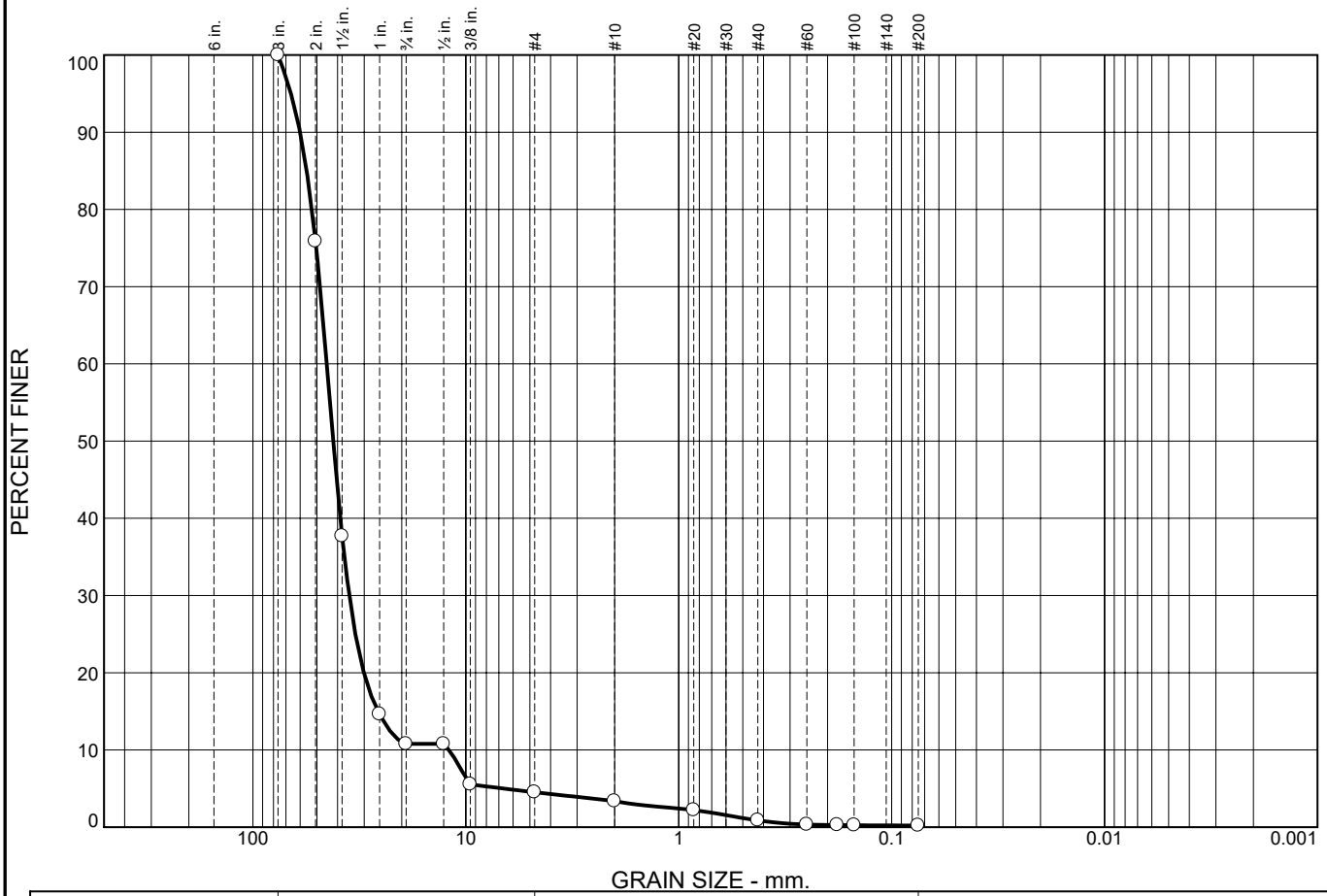
○100% of the Material Passes the 2" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	89.2	6.3	1.1	2.5	0.7	0.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			55.8731	44.9938	41.9217	35.2620	25.7989	11.9853	2.31	3.75

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 7 **Sample Number:** 122901

Remarks:

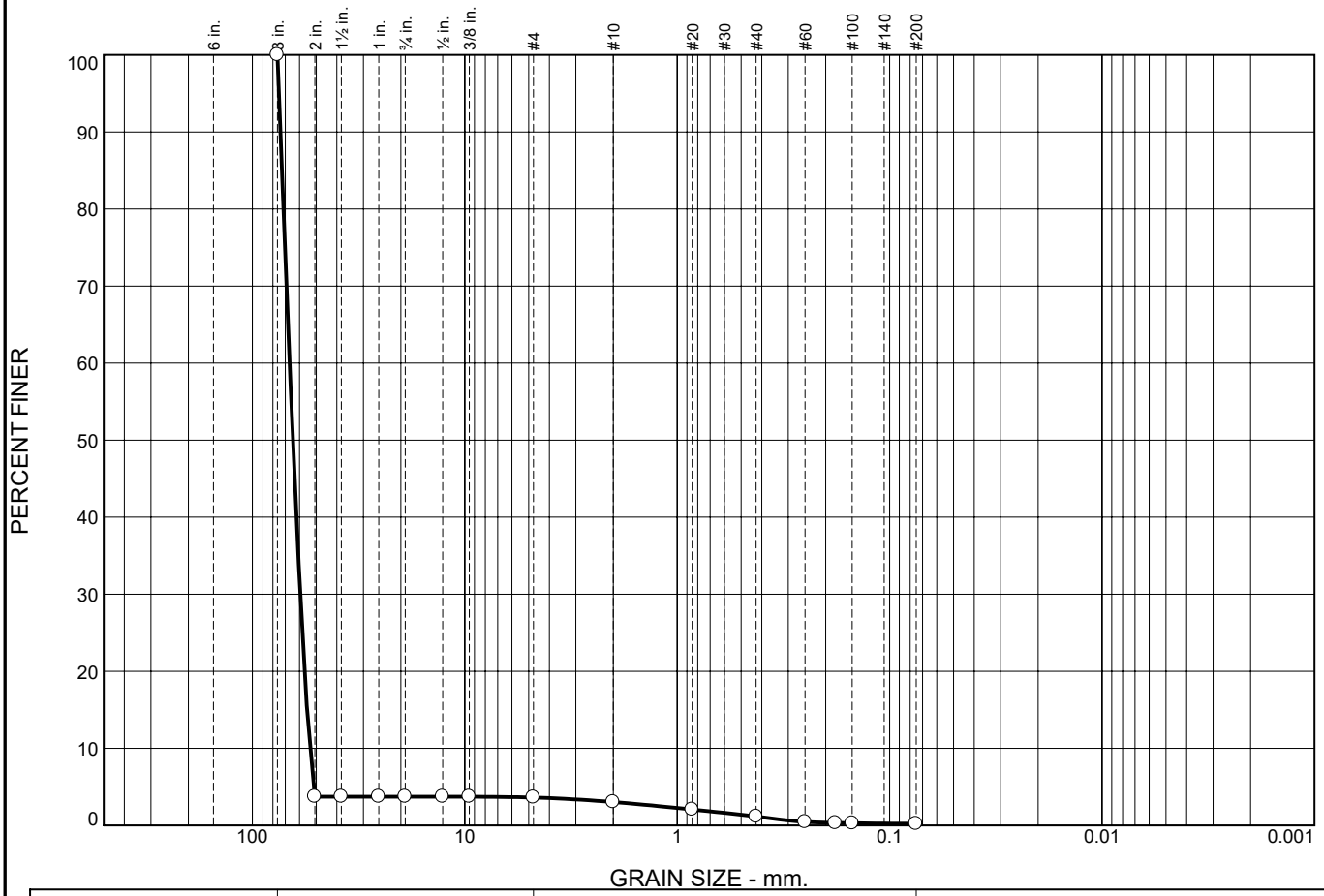
○100% of the Material Passes the 3" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	96.3	0.1	0.6	1.8	1.0	0.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			72.5929	66.7648	64.4247	59.5165	55.2634	53.5548	0.99	1.25

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 8 **Sample Number:** 122902

Remarks:

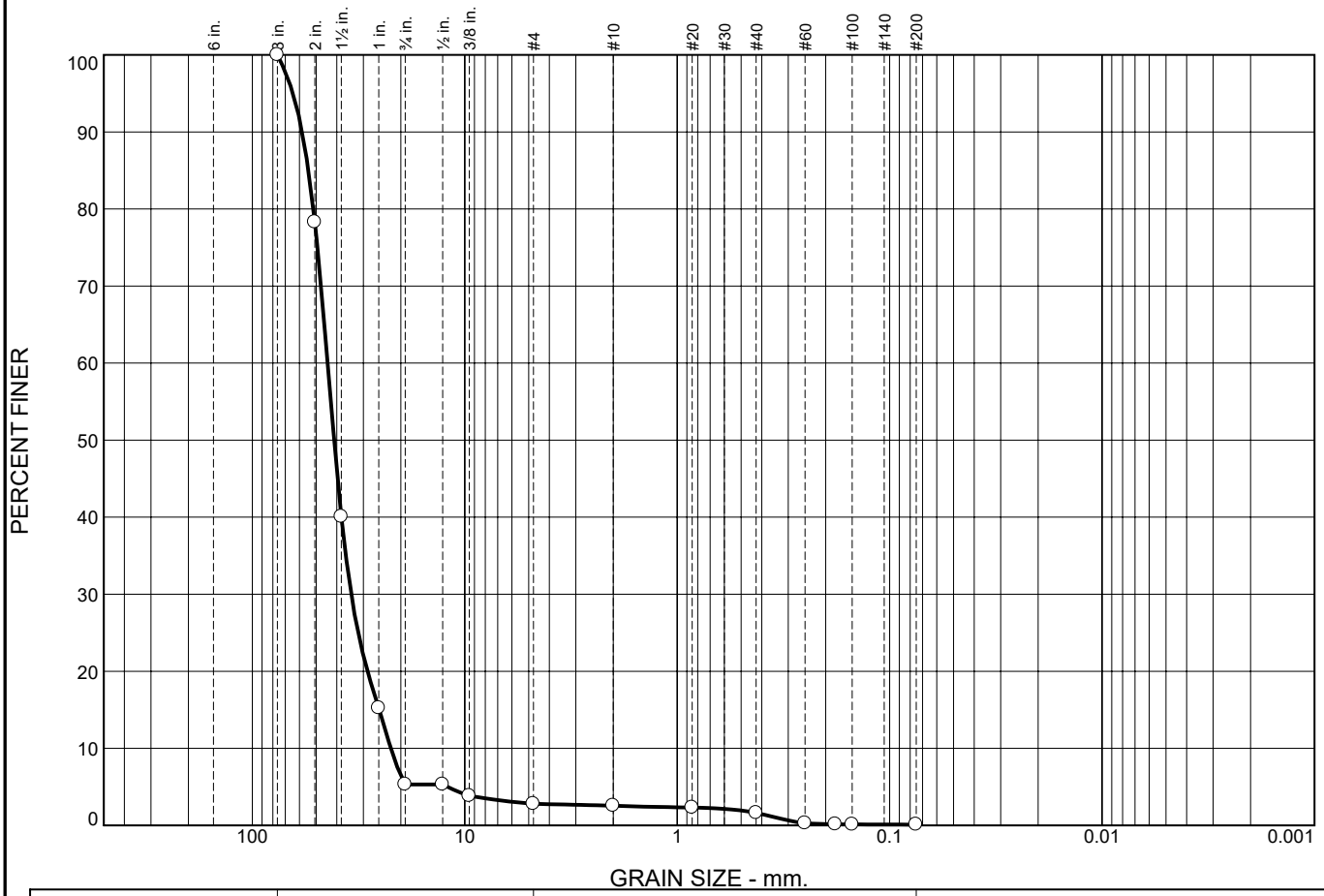
○100% of the Material Passes the 3" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	94.7	2.5	0.2	1.0	1.5	0.1	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			54.4065	44.2162	41.1950	34.2370	25.2586	22.2664	1.19	1.99

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 9 **Sample Number:** 122903

Remarks:

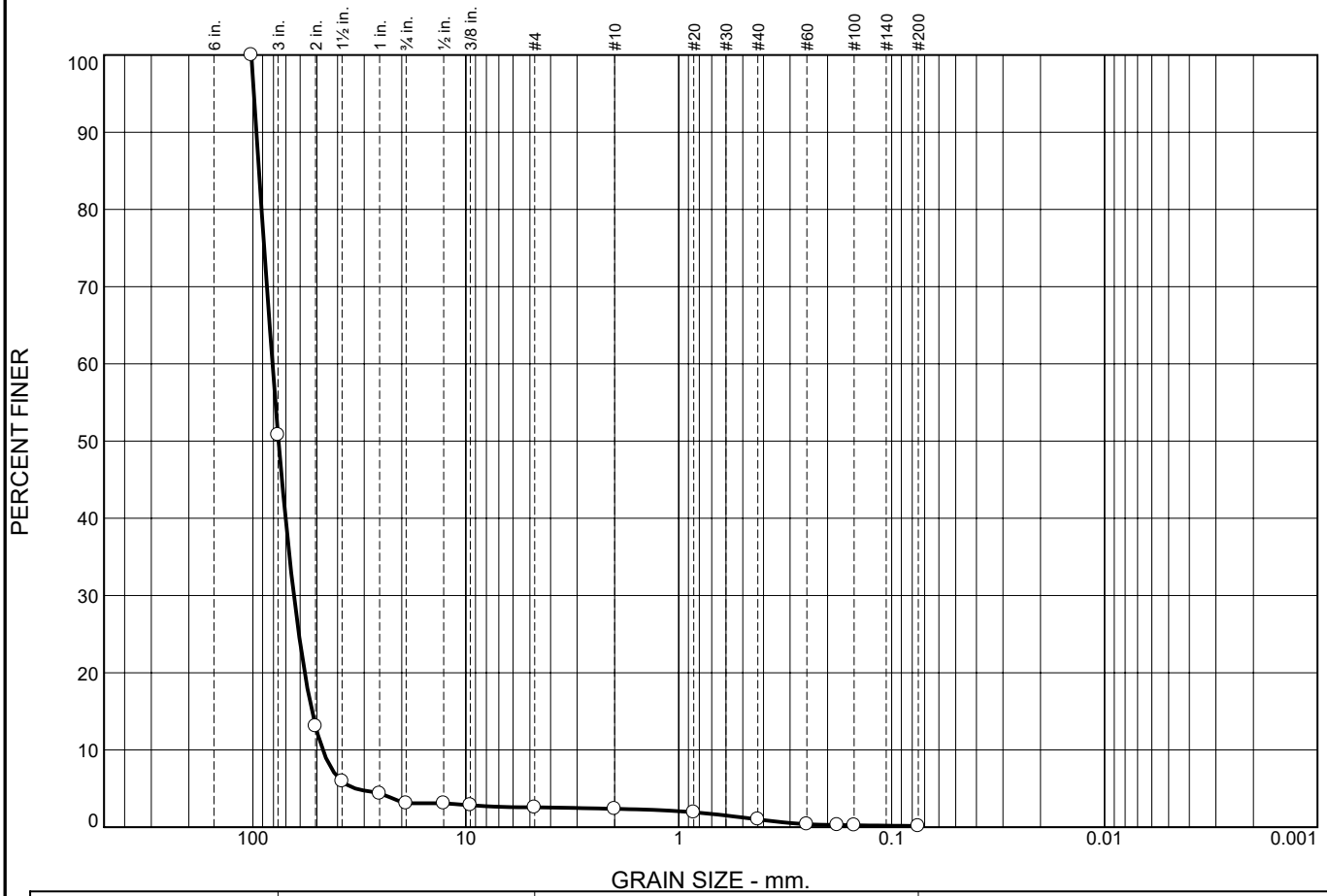
○100% of the Material Passes the 3" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	49.2	47.7	0.5	0.2	1.4	0.8	0.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			93.6164	80.9494	75.7759	64.1987	52.7549	46.9883	1.08	1.72

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 10 **Sample Number:** 122904

Remarks:

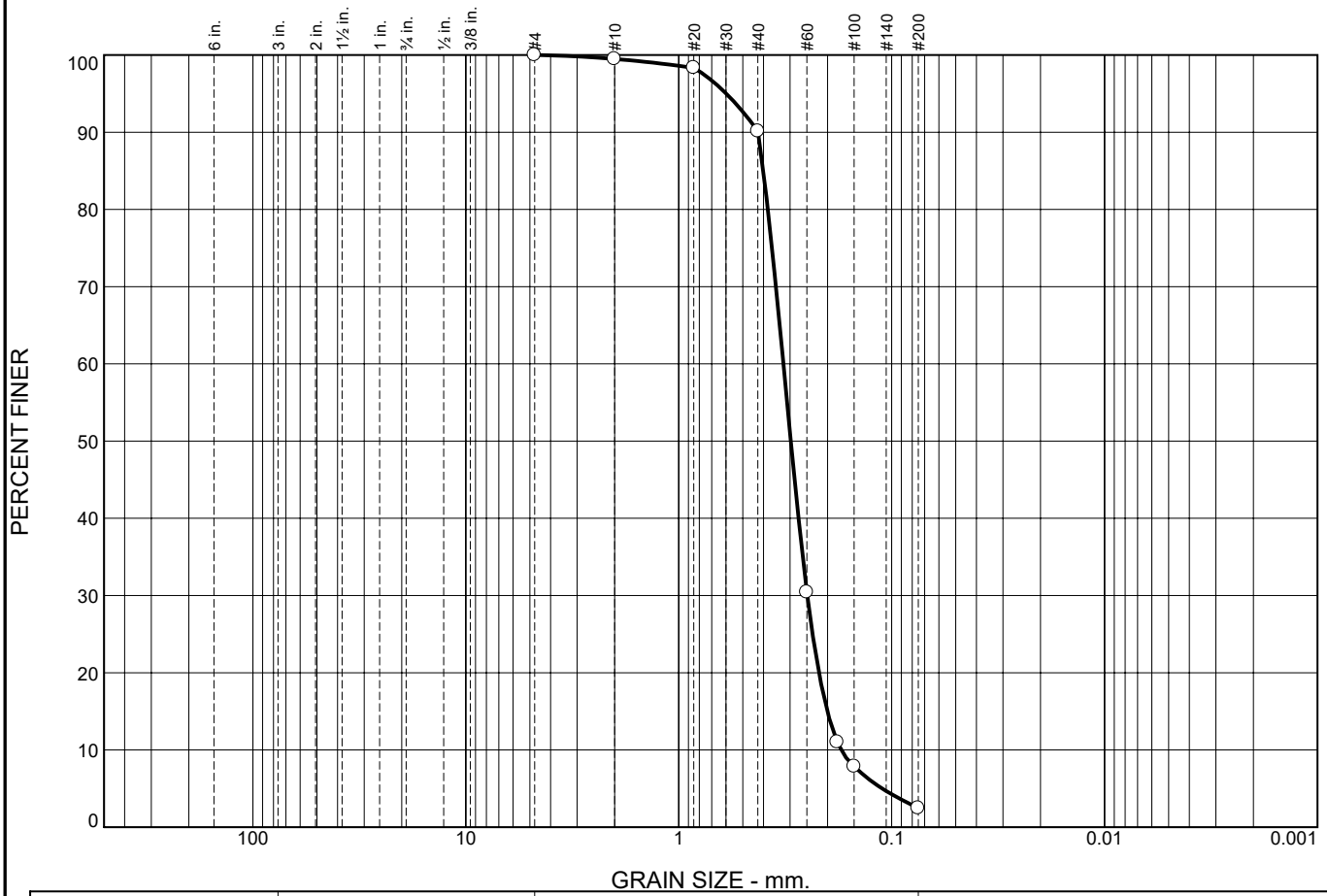
○100% of the Material Passes the 4" Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.5	9.4	87.6	2.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.4008	0.3223	0.2976	0.2489	0.2006	0.1727	1.11	1.87

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 11 **Sample Number:** 122905

Remarks:

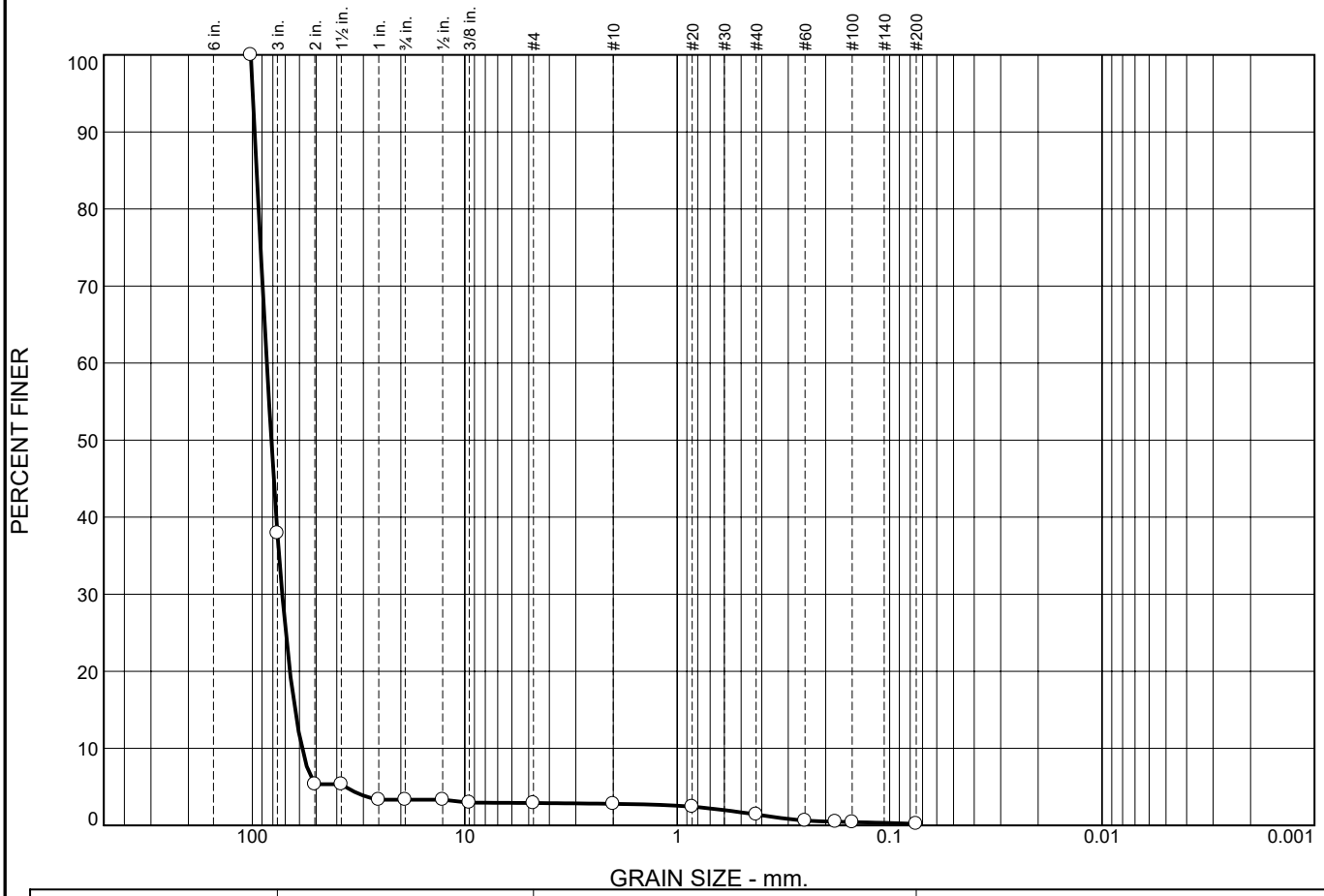
○100% of the Material Passes the #4 Sieve

MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	62.1	34.6	0.4	0.1	1.4	1.2	0.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			95.4387	85.5047	81.4428	72.3382	62.9698	58.3744	1.05	1.46

	Material Description	USCS	AASHTO
○			

Project No. 141579 **Client:** RiverRestoration

Project: Grand Rapids River Restoration

○ **Location:** 12 **Sample Number:** 122906

Remarks:

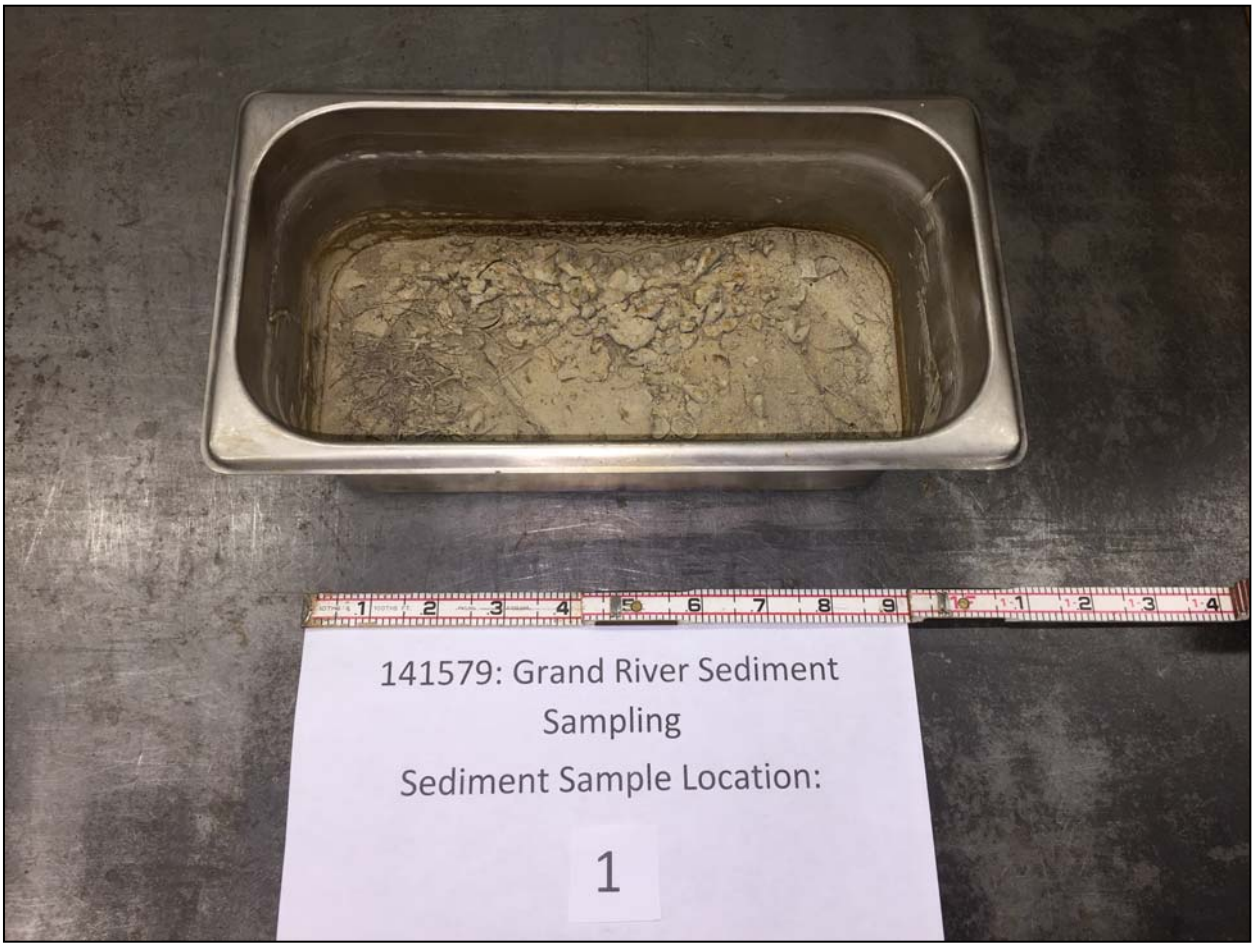
○100% of the Material Passes the 4" Sieve

MATERIALS TESTING CONSULTANTS, INC.

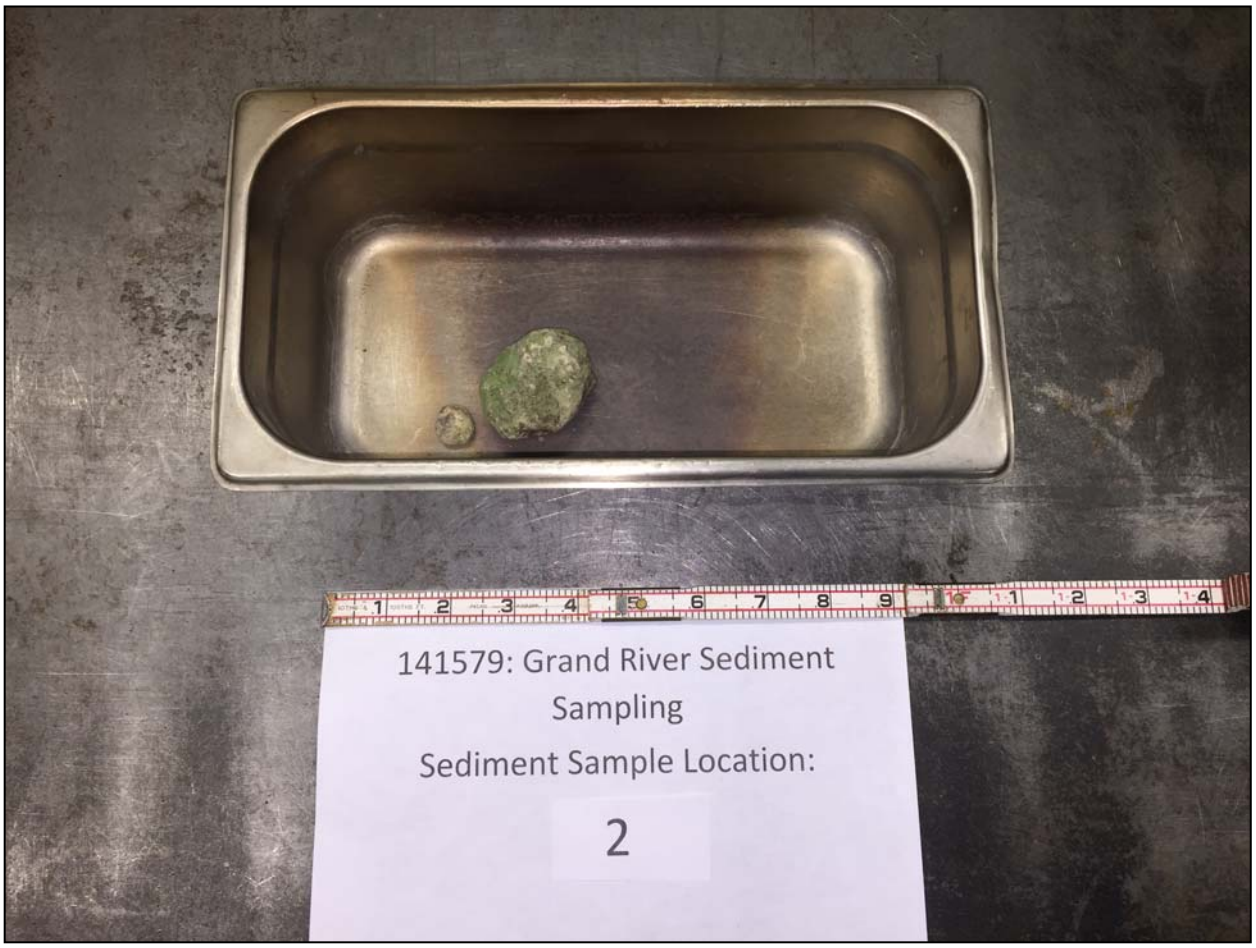
Grand Rapids, MI

Figure

Materials Testing Consultants, INC.



Materials Testing Consultants, INC.



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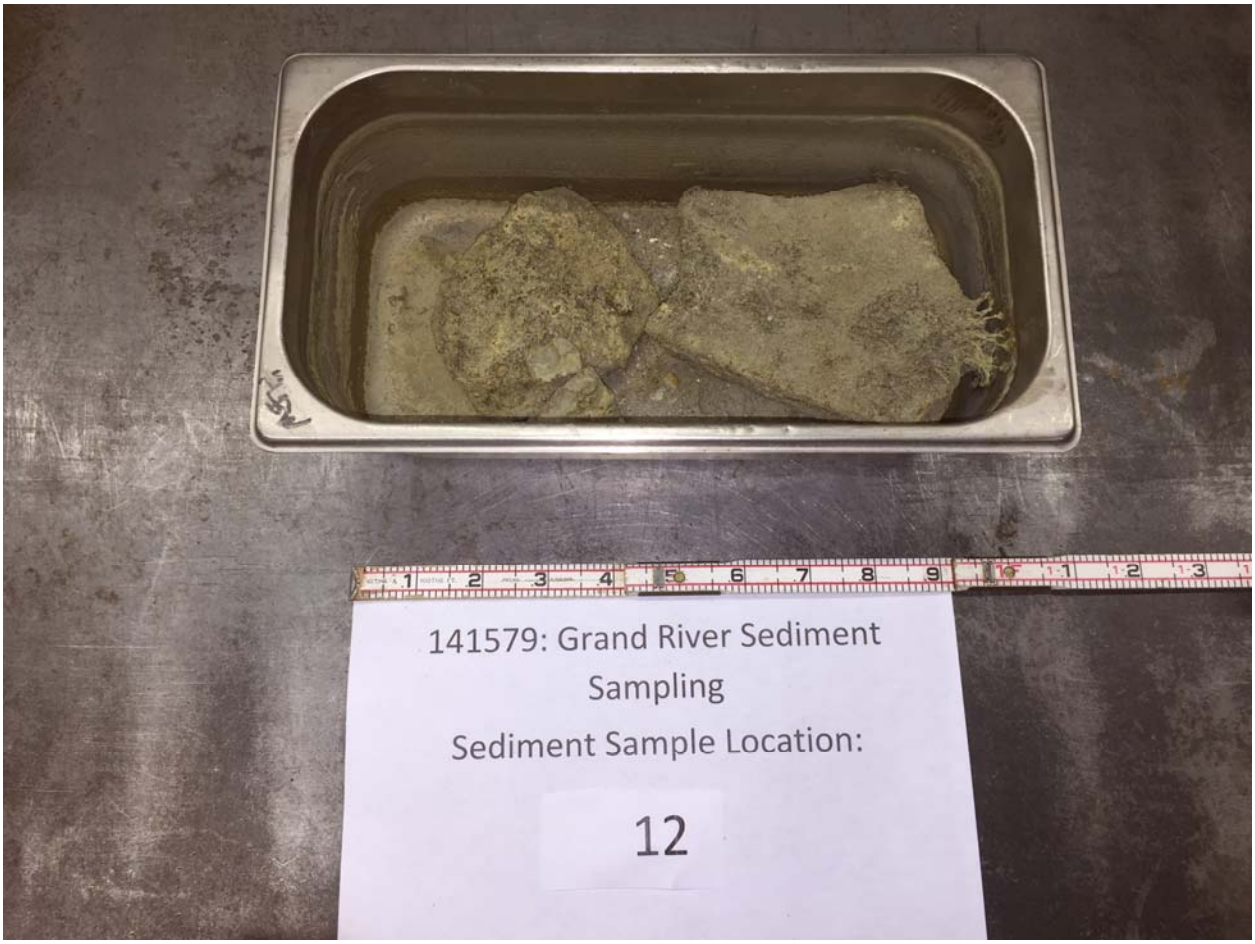

APPENDIX E

Other Supporting Information

Wetland Delineation Report Golder Associates 10/14/2014

DRAFT REPORT

WETLAND DELINEATION

Grand River Whitewater Restoration Project
City of Grand Rapids, Kent County, Michigan



Submitted To: Department of Environmental Quality
Water Resources Division
350 Ottawa NW, Unit 10
Grand Rapids, Michigan 49503
Reference No. 11-41-0105-P

Prepared For: Chris Muller
Grand Rapids Whitewater
502 2nd Street NW, Suite 300
Grand Rapids, Michigan 49503

Prepared By: Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, Colorado 80228

October 14, 2014 **1405362 001 R RevA**

Golder Associates

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EXECUTIVE SUMMARY

Grand Rapids Whitewater has proposed improvements along an urban reach of the Grand River, in the City of Grand Rapids, Kent County, Michigan. Project Engineer, River Restoration, has retained Golder Associates, Inc. (Golder) to complete a wetland delineation report that would allow the State of Michigan Department of Environmental Quality (DEQ) to determine their regulatory authority over proposed activities within the investigation area pursuant to Section 404 of the Clean Water Act and Part 303 of the Natural Resources and Environmental Protection Act. DEQ has assigned the project file number 11-41-0105-P.

A preliminary review of available information pertaining to vegetation, soils, and hydrology in the project area was implemented prior to conducting a field investigation at the site. Sources of information included the United States Geological Survey (USGS), Natural Resource Conservation Service (NRCS), the National Wetland Inventory (NWI), Federal Emergency Management Agency (FEMA), and aerial photography (aerial imagery provided by the City of Grand Rapids GIS Department). Please see these resource figures included in Appendix A. These resources indicate the possible presence of wetlands and other waters under State and Federal jurisdiction at the project site.

Golder identified twelve (12) wetland areas totaling 3.09 acres and 6,428 linear-feet of a perennial stream (Grand River) within the 13.25-acre Grand River Whitewater Restoration Project site (Appendix A). These wetland areas continue off-site and outside of the investigation area and are associated with the Grand River. From aerial photographs, these wetlands appear to be contiguous with the littoral fringe of the Grand River; however, there are breaks in the physical indicators of an ordinary high water mark, which are devoid of vegetation or separated by sea walls and other man-made structures.

Golder conducted a wetland delineation of the subject project area in accordance with regulatory standards (Section 3). This report was prepared in accordance with regulatory guidance. If any impacts to potentially jurisdictional resources are proposed, Golder recommends submitting this report to the State of Michigan Department of Environmental Quality to request a wetland boundary confirmation and jurisdictional determination.[1]

[1] Wetlands are defined and regulated under the state's assumed §404 program and Natural Resources and Environmental Protection Act (MCL 324.30301 – 324.30323).

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1.0 INTRODUCTION

Grand Rapids Whitewater is requesting confirmation of the wetland delineation conducted by Golder at the proposed project location for the Grand River Whitewater Restoration Project. The investigation areas were identified by the project engineer, RiverRestoration.Org, and include nine investigation areas encompassing 13.25 acres, located in the City of Grand Rapids, Kent County, Michigan, along the east and west banks of the Grand River (Appendix A). Collectively, the investigation areas are referred to as the "Investigation Area."

Federal wetlands and other Waters of the U.S. (WOUS) have legal protection in accordance with Section 404 of the Clean Water Act (CWA).[1] Since 1984, the State of Michigan has administered the CWA 404 permit program.[2] That is, the State of Michigan, through the Department of Environmental Quality (DEQ), has consistent but not identical authority and can provide federal authorization under the CWA. The Natural Resources and Environmental Protection Act (NREPA), Wetland Protection (Part 303) provides the regulatory authority over wetlands in Michigan.[3]

The DEQ generally requires the issuance of a permit, or coverage under an existing permit, for all actions that have the potential to degrade or modify protected resources. Per regulatory standard, the Investigation Area was surveyed for wetlands and other aquatic resources that may be regulated pursuant to DEQ authority.[4] Jurisdictional wetlands are distinguished from non-wetlands using specific criteria related to the hydrology, soil, and vegetative of an area.

For the purpose of this report, discussion of aquatic resources occurring within the project area is separated into uplands, wetlands and non-wetland waters, referred to herein as "water bodies." Water bodies refer to all waters that do not meet the wetland criteria (hydrophytic vegetation, hydric soils, and hydrology) as defined by the U.S. Army Corps of Engineers (USACE).[5] Specifically, unvegetated sections of the Grand River are categorized as water bodies. If these features (*i.e.*, wetlands or water bodies) are determined to be jurisdictional by DEQ, proposed activities within the features may be regulated.

Golder delineated twelve (12) wetland areas totaling 3.09 acres and 6,428 linear-feet of water bodies (*i.e.,* 0.64 acres of non-wetland waters) within the Investigation Area. Typically, DEQ asserts jurisdiction over contiguous wetlands, or those wetlands having a direct hydrological relationship with the water body.[6]

1 33 U.S.C. 1344.

2 40 CFR 233.1

3 Wetlands are defined and regulated under the state's assumed CWA 404 permitting program and Natural Resources and Environmental Protection Act (NREPA) Part 303 (MCL 324.30301 – 324.30323; MAC 281.921 – 281.925.).

4 33 CFR 328.3(a); NREPA 303 Section 324.30301.

5 USACE 1987.

6 Note that draft federal guidance published in April 2011 and a subsequent proposed rule change currently on public notice could supersede current regulatory guidance. Also, Michigan Legislature enacted Public Act 98, amending multiple parts of the Michigan environmental code regarding wetlands. The U.S. Environmental Protection Agency has said that changes to the administration of the CWA 404 program resulting from PA98 will not happen without federal approval.

Generally, wetlands with any permanent or intermittent surface water connection or within 500 feet of a stream are considered contiguous.[7] Activities in contiguous wetlands are regulated without regard to the size of the wetland. Therefore, it is assumed that each of the aquatic resources identified within the Investigation Area would be considered jurisdictional by DEQ.

This report represents the professional opinion of Golder regarding the presence or absence of wetlands and water bodies that may be jurisdictional and their boundaries within the Investigation Area. Resource maps depicting the Investigation Area are presented in Appendix B; photographs of the Investigation Area are included in Appendix C; and, data recorded during the investigation is included on wetland delineation forms in Appendix D.

[7] MCL 324.30301

2.0 PROJECT LOCATION AND DESCRIPTION

The Investigation Area totals 13.25 acres and is located along an urban stream corridor within the City of Grand Rapids, in Kent County, Michigan.[8] The Investigation Area is centered on the Grand River, approximately 25-miles east of Lake Michigan. The Grand River is the namesake for its parent watershed: the Lower Grand Watershed (HUC 04050006).

Ecological restoration and enhancement to the Grand River is being proposed as part of a multi-year public process involving amendments to the City of Grand Rapids' master plan. The Grand River Whitewater Project proposes to remove the Sixth Street Dam and install a new barrier, 5,500-feet upstream. A major focus of the proposal is to restore the City's namesake rapids, which were inundated and excavated more than 150-years ago. The proposal also includes plans to expand parks and tree canopy along the urban river.

Existing pedestrian trails provide access to the Investigation Area between Sixth Street and Fulton Street on both sides of the Grand River. Other access points provide access to the Investigation Area, including: from the parking lot at the northwest corner of the intersection of Monroe Avenue and Leonard Street, the parking lot of Charley's Crab Shack on Market Avenue, and from the grounds of the Gerald R. Ford Museum on Scribner Avenue.

8 Grand Rapids is the second-largest city in Michigan (after Detroit). U.S. Census Bureau. 2014. Available online at: http://www.census.gov/en.html#

3.0 METHODS

Prior to conducting field evaluations, Golder reviewed available in-office information including U.S. Geological Survey (USGS) mapping, soil survey data, aerial photography, wetland inventory mapping, and flood mapping (Appendix B).

- As depicted on the USGS Grand Rapids West Quadrangle, surface water drains toward the Grand River, which flows south through the Investigation Area. Aquatic resources within the Investigation Area are associated with the Grand River, which is identified as a Section 10 Navigable Water, downstream of the investigation area, from the Fulton Bridge to Lake Michigan.[9]
- NWI mapping depict aquatic features including:
  - A palustrine forested, broad-leaved deciduous freshwater wetlands that are temporarily flooded (PFO1A) that is contiguous with the Grand River, and
  - A riverine, lower perennial water having a substrate composed of unconsolidated materials that is permanently flooded (R2UBH).
- The Natural Resource Conservation Service's soil mapping depicts disturbed and altered soils (i.e., Urban land and Urban-Cohoctah complex). It appears that the soils have been leveled, dredged, and/or recently deposited. These soils vary greatly in important soil properties, including texture, permeability and drainage, but are primarily composed of sands and silts.
- The Federal Emergency Management Agency (FEMA) Floodplain map show that the Investigation Area is within the floodplain of the Grand Rapids River. The majority of the site is within the 100-year flood boundary; however, portions of the site exist within the 500-year floodplain.

Field investigations were conducted on June 11, 12, and 13 by Travis Morse of Golder, following and during substantial rain events. In consultation with DEQ, Golder performed a delineation of the Investigation Area in the field and using aerial photograph interpretation, due to complications with timing, access, size, and river stage.[10] Potential wetland areas were delineated and the individual acreages calculated.

Golder applied methodology specified by the 1987 *Corps of Engineers Wetlands Delineation Manual* (1987) and the 2012 *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* (Version 2.0) to perform a delineation of aquatic resources within the site.[11] Wetland determinations at sampling points were based on the (1) hydrophytic vegetation dominance, (2) presence of hydric soils, and (3) evidence or indications of wetland hydrology.

Positive indicators of wetland conditions for all three parameters are normally present in jurisdictional wetlands, as defined below.

9 List of Navigable Waters of the United States in Michigan. Available online at: https://www.michigan.gov/documents/deq/lwm-jpatm-appx-i_213469_7.pdf

10 DEQ meeting with project proponent and Golder, 6/12/14.

11 USACE 2012; USACE 1987.

1. Hydrophytic vegetation is defined as vegetation that is adapted to, and occurs in, areas where soils are frequently or permanently saturated of sufficient duration to exert a controlling influence on the plant species present. The hydrophytic vegetation parameter is met when one of the following is true: (a) the dominant vegetation (more than 50 percent of the dominant plant species) is typically adapted to areas having wetland hydrology and hydric soil conditions; (b) the prevalent vegetation is typically adapted to areas having wetland hydrology and hydric soil conditions (as determined by a formula); or (c) morphological adaptations are observed to confirm that plant species are growing in inundated or saturated conditions. Plants are assigned a Wetland Indicator Status based on their frequency of occurrence in wetland habitats.[12] Those ratings are as follows:

   A. UPL (Obligate Upland) = occur in wetlands in another region, but usually occur (estimated probability <99% in uplands in the region specified

   B. FAC (Facultative) = equally likely to occur in wetlands or non-wetlands (estimated probability 34 to 66%)

   C. FACW (Facultative Wetland) = usually occur in wetlands (estimated probability 67 to 99%), but occasionally found in non-wetlands

   D. FACU (Facultative Upland) = usually occur in non-wetlands (estimated probability 67to 99%), but occasionally found in wetlands (estimated probability 1 to 33%)

   E. OBL (Obligate Wetland) = occur usually (estimated probability >99%) in wetlands under natural conditions.

   Sampling locations are situated so that the data point best represents the vegetation present within the vegetative community at each plot. Plant species and their percent cover were recorded for each vegetative stratum generally using a 30-foot radius for trees, a 15-foot radius for shrubs, and a 5-foot radius for herbaceous plants and woody vines; however, some modification was necessary to limit sampling to the same community type.

2. Hydric soils, which are indicative of wetlands, are defined as soils that are sufficiently ponded, flooded, or saturated throughout the growing season to produce anaerobic conditions which favor the growth of hydrophytic vegetation. Hydric soils are identifiable based on observable properties that result from prolonged saturated-anaerobic conditions. Soil pits were dug at sample plot centers to 16 inches or refusal. Soil color and other characteristics were used to distinguish hydric versus non-hydric soils.[13] The Investigation Area contains fluvial deposits and sandy soils, which can be problematic hydric soils, and their proper identification requires additional information, such as landscape position, presence or absence of restrictive soil layers, and information about vegetation and hydrology.

3. Wetland hydrology refers to inundation and/or saturation of the soil by flooding or a shallow water table for a prolonged period during the growing season, such that the character of the soil and vegetation are substantially different from areas that do not experience inundation/saturation in this manner. The identification of wetland hydrology follows the USACE 1987 delineation manual. Geomorphic features associated with flooding (*e.g.*, channels, shorelines) and sediment deposits are example indicators of wetland hydrology. Wetland hydrology can be determined by documenting the presence of one primary indicator (such as watermarks on vegetation, drift deposits, sediment deposits, surface-scoured areas, algal mats, and oxidized root channels) or two secondary indicators (such as water-stained leaves, drainage patterns, geomorphic position, shallow aquitard, or a FAC-Neutral Test). The FAC-neutral test is performed by

12 Lichvar et al. 2014; USACE 2014.

13 Munsell 2009.

compiling a list of dominant plant species across all strata in the community, and dropping from the list any species with a Facultative indicator status (*i.e.*, FAC). The FAC-neutral test is met if more than 50 percent of the remaining dominant species are rated FACW and/or OBL.

Non-wetland waters were identified and delineated as water bodies based on the absence of one or more wetland criteria present below the ordinary high water mark.

4.0 RESULTS AND DISCUSSION

Based on the field investigation conducted by Golder during June of 2014, twelve (12) potentially jurisdictional wetlands were delineated within the Investigation Area (Table 1). Appendix A depicts the location of all aquatic resources noted during the survey. Photographs of the site and the vicinity of the site are included in Appendix C. Detailed notes on wetland sampling points can be found on wetland determination data forms which are included as Appendix D.

Table 1 Potentially Jurisdictional Aquatic Resources

Investigation Area	Acres	Aquatic Resource	Size (Acres)	Aquatic Resource	Length (linear-feet)
1	0.73	W12	0.12	Grand River	335.4
2	2.54	W11	0.11	Grand River	1237.29
		W10	0.02	Grand River	
3	0.65	W9	0.16	Grand River	275.11
4	3.89	W6	0.15	Grand River	2122.43
		W7	0.12	Grand River	
		W8	0.40	Grand River	
5	0.33	W4	0.10	Grand River	163.70
6	0.34	W5	0.05	Grand River	177.05
7	3.67	W3	1.66	Grand River	1493.40
8	0.25	W2	0.12	Grand River	163.08
9	0.85	W1	0.08	Grand River	460.59
Totals	**13.25**		**3.09**		**6428.05**

Note:
1. Please note that where wetland polygons are open, these resources extend outside of the project area.

Data points are located in places that adequately represent the variation in vegetation, soils, and hydrologic regimes within the Investigation Area. The presence or absence of hydrophytic vegetation, hydric soil, and wetland hydrology indicators were documented for each sample plot to justify the delineated wetland boundaries.

The local USGS stream gauge on the Grand River (04119000) recorded flows during the survey between 3500 and 4200 cubic-feet-per-second (cfs). These flows are higher than average for June; however, these flows are still below the calculated ordinary high water mark. Additionally, a significant precipitation overlapped with the dates of the field survey and certain indicators of hydrology were considered unreliable (*e.g.*, soil saturation).

4.1.1 Uplands

The upland portions of the Investigation Area are the non-wetland areas above the ordinary high water mark. These areas contain naturally problematic fluvial deposits and sandy soils. The development of

hydric soil indicators in these soil types can be inhibited due to low iron or manganese content and/or low organic-matter content. The presence or absence of indicators of wetland vegetation and wetland hydrology were used to identify the hydric soil boundary.

Old fill material and construction debris are encountered in the soil profile and provide evidence of historic impacts. These materials may be classified as Udorthents; however, soil pits were limited to no deeper than 18 inches, so classification based on collected data is not possible.[14] In areas, primarily located at the north and south ends of the Investigation area, there are homeless camps, human latrines, and evidence of heavy foot-traffic. Historic soil disturbances can also compromise positive hydric soil determinations where fill activities include red materials (e.g., crushed bricks) that can appear to be redoximorphic features in the soil profile.

Four data points were recorded within two upland communities encountered during the field survey; (a) Successional Northern Hardwoods and (b) Managed Plant Community:

4.1.1.1 Successional Northern Hardwoods (Data Points 1, 5, and 8)

A successional northern hardwood community exists; however, the number of non-native species is explained by its metropolitan location. Trees are dominated largely by Boxelder (*Acer negundo*), Eastern Cottonwood (*Populus deltoides*), American Basswood (*Tilia americana*), Black Willow (*Salix nigra*), Austrian Pine (*Pinus nigra*), Russian-Olive (*Elaeagnus angustifolia*), American Elm (*Ulmus americana*), Siberian Elm (*U. pumila*), and White Mulberry (*Morus alba*) species.

The understory contains saplings and shrubs dominated by Boxelder (*A. negundo*), Staghorn Sumac (*Rhus typhina*), Black Locust (*Robinia pseudoacacia*), Green Ash (*Fraxinus pennsylvanica*), Northern Catalpa (*Catalpa speciosa*), Siberian Elm (*Ulmus pumila*), European Buckthorn (*Rhamnus cathartica*), Sandbar Willow (*Salix interior*), Fire Cherry (*Prunus pensylvanica*), Rambler Rose (*Rosa multiflora*), Red Osier (*Cornus alba*), and Twinsisters (*Lonicera tatarica*) species.

Herbaceous dicots are relatively diverse and contain several non-native and invasive species: Lesser Burdock (*Arctium minus*), American Yellow-Rocket (*Barbarea orthoceras*), Common Motherwort (*Leonurus cardiac*), Climbing Nightshade (*Solanum dulcamara*), Prickly Lettuce (*Lactuca serriola*), Poison Ivy (*Toxicodendron radicans*), Japanese Knotweed (*Polygonum cuspidum*), Common Milkweed (*Asclepias syriaca*), Oldfield Cinquefoil (*Potentilla simplex*), Red Clover (*Trifolium pretense*), Buck-Horn Plantain (*Plantago coronopus*), Yellow Sweet-Clover (*Melilotus officinalis*), Purple Loosestrife (*Lythrum salicaria*), and Blunt-Leaf Yellowcress (*Rorippa curvipes*). The herbaceous layer also contains seedlings of Sweet Sumac (*Rhus aromatic*) and White Mulberry (*Morus alba*).

[14] Udorthents contains durable refuse to at least 3 feet.

Upland graminoids existing in this community-type include Kentucky Blue Grass (*Poa pratensis*), Orchard Grass (*Dactylis glomerata*), Pennsylvania sedge (*Carex pensylvanica*), Clustered Fescue (*Festuca paradoxa*), Reed Canary Grass (*Phalaris arundinacea*), Slender Wild Rye (*Elymus trachycaulus*), Smooth Brome (*Bromus inermis*), and Cheat Grass (*B. tectorum*). River-Bank Grape (*Vitis riparia*) is a species of vine that is locally abundant.

Vegetation was evaluated for hydrophytic dominance or other affinity to wetland conditions by calculating the prevalence index. The prevalence index ranges from one to five. A prevalence index of 3.0 or less indicates that hydrophytic vegetation is present. Vegetation data was negative for hydrophytic vegetation and the prevalence index calculation for each of the upland areas is indicative of an upland plant community.

Surface soils within this community are typically a very dark grayish brown (10YR 3/2) loamy sand over dark brown (10YR 4/3) loamy sand. However, portions of the substrate have a shallow A Horizon that is a light olive brown (2.5Y 5/3) sandy loam over a very dark grayish brown (10YR 3/2) sandy loam layer containing gravel. Shovel refusal was experienced at approximately 1-foot below the surface on what appears to be old boulder-riprap in various locations.

4.1.1.2 Managed Plant Community (Data Point 4)

A portion of this community type, located in Ah-Nab-Awen Park, exhibited indicators of hydrology, including its geomorphic position, sparsely vegetated concave surfaces, and sediment and drift deposits (e.g., silt lines on tree bark and debris piled against upstream side of rocks and trees). However, the vegetative community is dominated by non-wetland species, including White Mulberry (*Morus alba*), Black Locust (*Robinia pseudoacacia*), Eastern Cottonwood (*Populus deltoides*), Amur Maple (*Acer ginnala*), Norway Maple (*A. platanoides*), American Elm (*Ulmus americana*), Red Oak (*Quercus rubra*), and Austrian Pine (*Pinus nigra*) trees. The sapling component is largely dominated by European Buckthorn (*Rhamnus cathartica*) along the successional northern hardwood interface. Pruned shrubs appear planted and consist of Burningbush (*Euonymus alatus*) and Twinsisters (*Lonicera tatarica*). The herbaceous community is manicured Kentucky Blue Grass (*Poa pratensis*), with several ruderal colonists of Yellow Sweet Clover (*Melilotus officinalis*), Prostrate Speedwell (*Veronica prostrate*), Common Dandelion (*Taraxacum officinale*), English Plantain (*Plantago lanceolata*). Unmanaged areas at the same landscape position are dominated by successional northern hardwoods and vegetative management does not appear to compromise the integrity of a non-hydrophytic determination. The invasive Reed Canary Grass (*Phalaris arundinacea*) was identified east of Data Point 4.

Soils here are a yellowish brown (10YR 5/4) color until about 10-inches below the surface, where they become very dark gray (10YR 3/1).

4.1.2 Aquatic Resources

Aquatic resources identified in the Investigation Area are wetlands and areas below the ordinary high water mark that are absent wetland soils, wetland hydrology or wetland vegetation. The ordinary high water line is based on the mean annual flood flow of 19,000 cfs and was calculated and identified by the project engineer, RiverRestoration. This was determined by obtaining the peak flow rates for each year from USGS for the downtown gauge over the period of recorded data, which dates back to 1901 and taking the average value. This flow rate was modeled one-dimensionally in HEC-RAS using a corrective model based on the FEMA flood model. The water surface elevation at each cross-section was assigned to a polyline in AutoCAD Civil 3d representing that location, a water surface was the generated using these as break lines. The intersection of this water surface with the existing surface was extracted as a polyline and is displayed as the ordinary high water line (Appendix A).

Seven data points were recorded within two wetland communities found at the Investigation Area: (a) Floodplain Forest and (b) Emergent Marsh:

4.1.2.1 *Floodplain Forest* (Data Points 2, 3, 6, 7, and 10)

Portions of the Investigation Area exist within the active floodplain of the Grand River. These areas have a flood disturbance cycle that results in the annual deposition of new soil material. Although certain indicators of wetland hydrology (*e.g.*, soil saturation, high water table,) are compromised by concurrent precipitation events, positive indicators include sediment deposits, inundation visible on aerial imagery, sparsely vegetated concave surfaces, geomorphic position, and microtopographic relief. Additionally, the vegetation of the community type satisfies the FAC-Neutral Test.

Sediment deposits (*i.e.*, thin layers or coatings of fine-grained mineral material) are evident on tree bark, leaves, and rocks that surface waters have recently covered the data point location. Sediment deposits indicate where water has stood for sufficient time to allow suspended sediment to settle. The upper edge of the sediment deposit reflects a water-surface elevation that was extrapolated across lower elevation areas to limit the extent of the sample. Additionally, leaf litter was evaluated for indicators of hydrology by the presence of water-stained leaves, which are grayish and blackish in color due to inundation for long periods; whereas, litter is dominated by faded yellow colors outside of the wetland.

Dominant tree species include Eastern Cottonwood (*Populus deltoides*), American Elm (*Ulmus americana*), American Sycamore (*Platanus occidentalis*), Black Willow (Salix nigra), Silver Maple (Acer saccharinum), Green Ash (*Fraxinus pennsylvanica*), and River Birch (*Betula nigra*).

The understory contains shrubs and sapling species, dominated by young Boxelder (*Acer negundo*), Silver Maple (*A. saccharinum*), Green Ash (*Fraxinus pennsylvanica*), Black Willow (*Salix nigra*), American Elm (*Ulmus americana*), and European Buckthorn (*Rhamnus cathartica*).

The herbaceous layer of the floodplain forest is sparsely vegetated, but contains Purple loosestrife (*Lythrum salicaria*), Flat-Top Goldernrod (*Euthamia graminifolia*), Parasol Whitetop (*Doellingeria umbellata*), Reed Canary Grass (*Phalaris arundinacea*), Common Ninebark (*Physiocarpus opulifolius*), Virginia Creeper (*Parthenocissus quinquefolia*), Wooly Sedge (*Carex pellita*), False-Spike Hedge Nettle (*Boehmeria cylindrical*), Common Red Raspberry (*Rubus idaeus*), River-Bank Grape (*Vitis riparia*), and seedling Silver Maple (*Acer saccharinum*) species.

Soils within the floodplain forest typically exhibit a shallow surface layer that is a grayish brown (2.5Y 5/2) sandy loam with few fine distinct black (5Y 2.5/1) mottles (*i.e.*, sandy redox). Redox concentrations can sometimes be found between soil stratifications in areas where organic matter is buried. However, in portions of this community has soils that exhibit a shallow, a grayish brown (2.5Y 5/2) sandy loam surface layer. At approximately 5-inches below the surface, the soil becomes a very dark grayish brown (2.5Y 3/2) and contains few ¾" gravel. Large rock exists at approximately 14-inches below the soil surface and prevents excavation with a hand-shovel to deeper depths. At approximately 6 inches, the soils are a dark brown (10YR 4/3) fine sandy loam containing ¾" gravel. At other locations, the top 12-inches of the substrate are composed of black (7.5YR 2.5/1) mucky sand, containing prominent strong brown (7.5YR 4/6) mottles over a dark gray (10YR 4/1) sandy silt loam containing faint reddish-brown (5YR 4/4) mottles.

Problematic soils occur within this community type, on vegetated bars within the active channel and above the bankfull level of the Grand River. Hydric soils are difficult to identify in sandy soils, especially along fluvial systems, because wetland indicators may be missing due to natural processes or recent disturbances. These soils are also problematic because of its proximity and relationship to the Grand River. Fluvial deposits within floodplains occur on vegetated bars within the active channel and above the bankfull level of the Grand River. In some cases, these soils may lack hydric soil indicators due to their sandy characteristics or due to recent deposition of soil material that has not had time sufficient to develop hydric soil indicators.

These soils are a very dark grayish brown (10YR 3/2) sandy loam, frequently over old boulder riprap, and lack hydric soil indicators. These soils likely lack hydric indicators due to seasonal or annual deposition of new soil material, low iron or manganese content, and/or low organic-matter content. Soils lacking hydric soil indicators are assumed hydric because hydrology and vegetation criteria are satisfied.

4.1.2.2 *Emergent Marsh* (Data Points 9 and 11)

The emergent marsh community was largely inundated during the field survey. Certain indicators of hydrology can provide false-positives relative to precipitation events or are inappropriate due to being contiguous with the fringe of the river. Reliable indicators of hydrology within this community include inundation, saturation, a high water table, water marks, sediment deposits, drift deposits, inundation visible on aerial imagery, and water-stained leaves.

Water marks provide evidence of inundation at the data point in the form of discolorations on the bark of woody vegetation and rocks. The water marks collectively form a level plane that can be viewed from one object to another. Sediment deposits are thin coatings of silt that remain on tree bark, plant stems and leaves, and large driftwood after surface waters recede. Drift deposits consist of rafted debris (i.e., waterborne branches, stems, leaves, and man-made litter that have been deposited on the ground surface and entangled in vegetation. Drift deposits are widely distributed across the dewatered area of the data points and are piled against the upstream sides of trees and rocks.

Additionally, the vegetation of this community type pass a FAC-Neutral Test. Characteristic riparian trees that are rooted within this community include Black Willow (*Salix nigra*), Silver Maple (*Acer saccharinum*), Green Ash (*Fraxinus pennsylvanica*), and American Elm (*Ulmus americana*), with a few young willow *S. nigra*) and maple (*A. saccharinum*) saplings over Red Osier (*Cornus sericea*) shrubs. However, woody vegetation represent less than significant total cover (*i.e.,* 8%). The herbaceous community contains Duck Potato (*Sagittaria peltatum*), Broad-Leaf Cat-Tail (*Typha latifolia*), Duck Potato (Sagittaria latifolia), Pale Yellow-Iris (*Iris pseudocarus*), Creeping-Jenny (*Lysimachia nummularia*), and Crested Sedge (*Carex cristatella*).

Soils are predominately black (10YR 2/1) to a very dark gray (10YR 3/1) sandy loam, over a dark gray (10YR 4/1) sandy loam. Soils were determined to be hydric at these locations due to the presence of a layer of sandy mucky material (Indicator S1) and/or having a dark surface (Indicator S7).

5.0 CONCLUSION

Within the 13.25-acre Investigation Area, Golder identified:

- 3.09 acres of wetland
- 6428 linear-feet of a perennial stream (Grand River)
- 0.64 acres of non-wetland waters

It is Golder's professional opinion that each of these aquatic resources identified within the Investigation Area would be considered jurisdictional by DEQ.

If plans require disturbing or filling of aquatic resources, coordination with DEQ will be required. The results of the delineation should be submitted to the DEQ for concurrence prior to the development of the proposed project.

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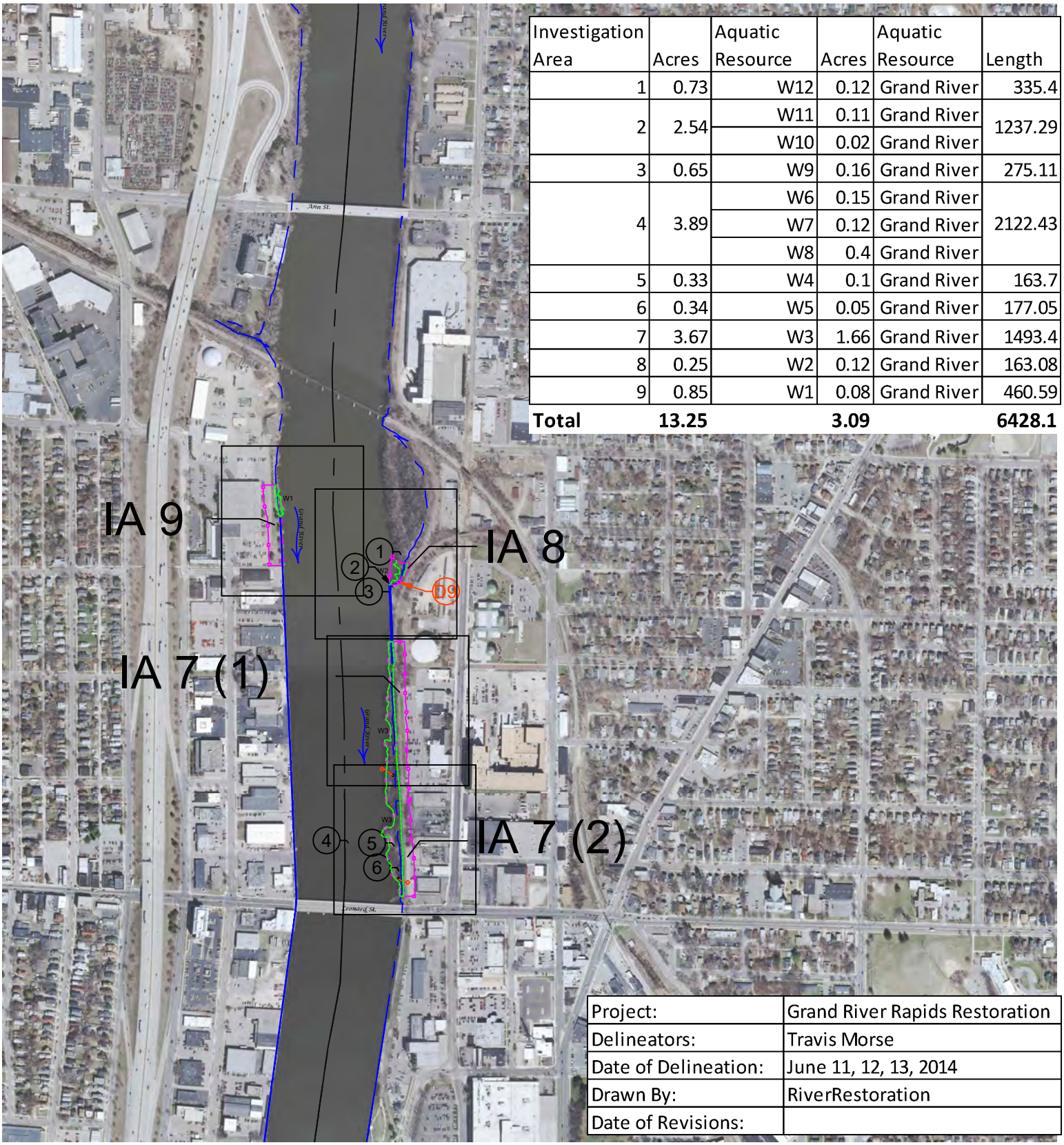
APPENDIX A
WETLAND MAP



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2	2.54	W11	0.11	Grand River	1237.29
		W10	0.02	Grand River	
3	0.65	W9	0.16	Grand River	275.11
4	3.89	W6	0.15	Grand River	2122.43
		W7	0.12	Grand River	
		W8	0.4	Grand River	
5	0.33	W4	0.1	Grand River	163.7
6	0.34	W5	0.05	Grand River	177.05
7	3.67	W3	1.66	Grand River	1493.4
8	0.25	W2	0.12	Grand River	163.08
9	0.85	W1	0.08	Grand River	460.59
Total	**13.25**		**3.09**		**6428.1**

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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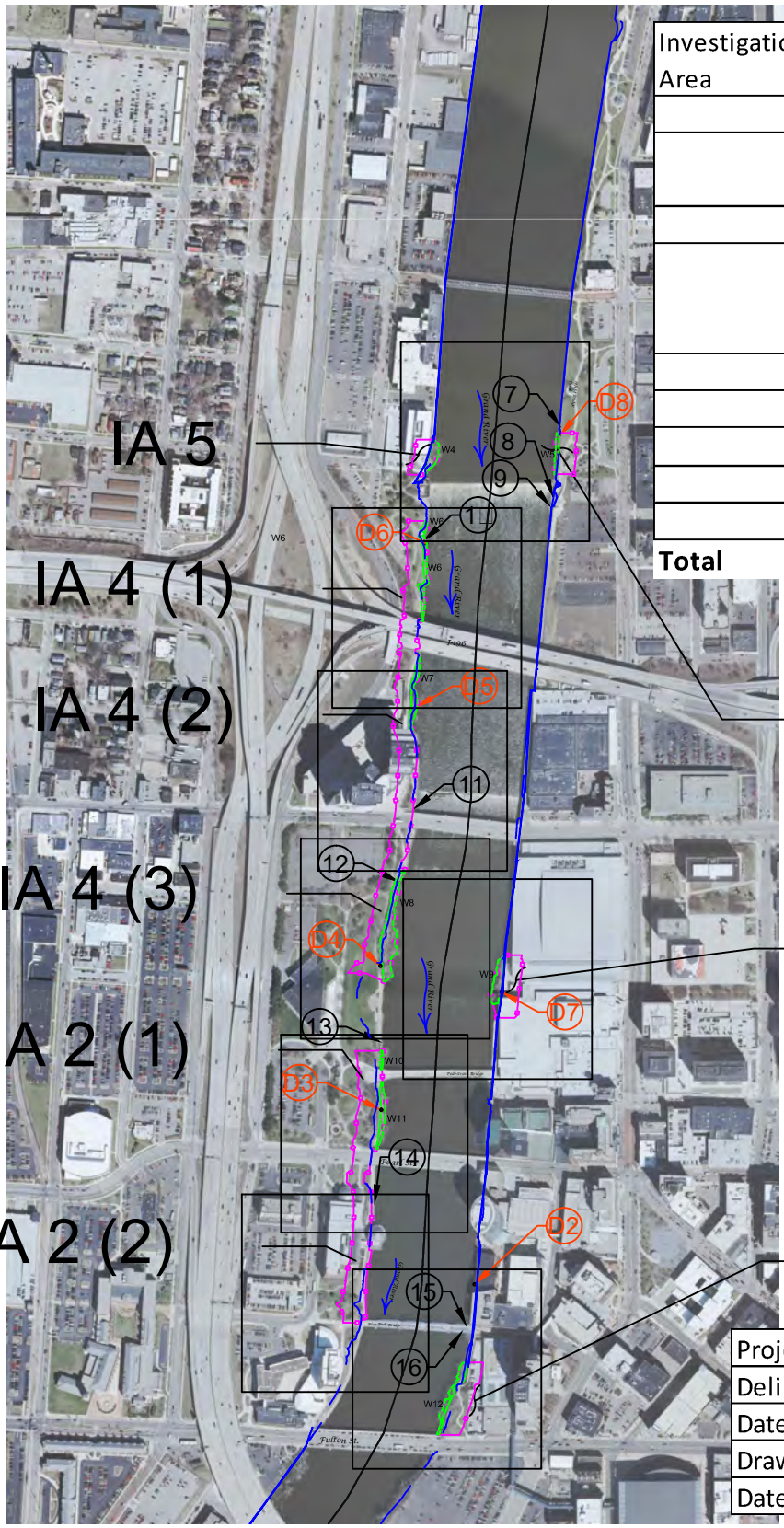

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
1	0.73	W12	0.12	Grand River	335.4
2	2.54	W11	0.11	Grand River	1237.29
		W10	0.02	Grand River	
3	0.65	W9	0.16	Grand River	275.11
4	3.89	W6	0.15	Grand River	2122.43
		W7	0.12	Grand River	
		W8	0.4	Grand River	
5	0.33	W4	0.1	Grand River	163.7
6	0.34	W5	0.05	Grand River	177.05
7	3.67	W3	1.66	Grand River	1493.4
8	0.25	W2	0.12	Grand River	163.08
9	0.85	W1	0.08	Grand River	460.59
Total	**13.25**		**3.09**		**6428.1**

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
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Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
1	0.73	W12	0.12	Grand River	335.4

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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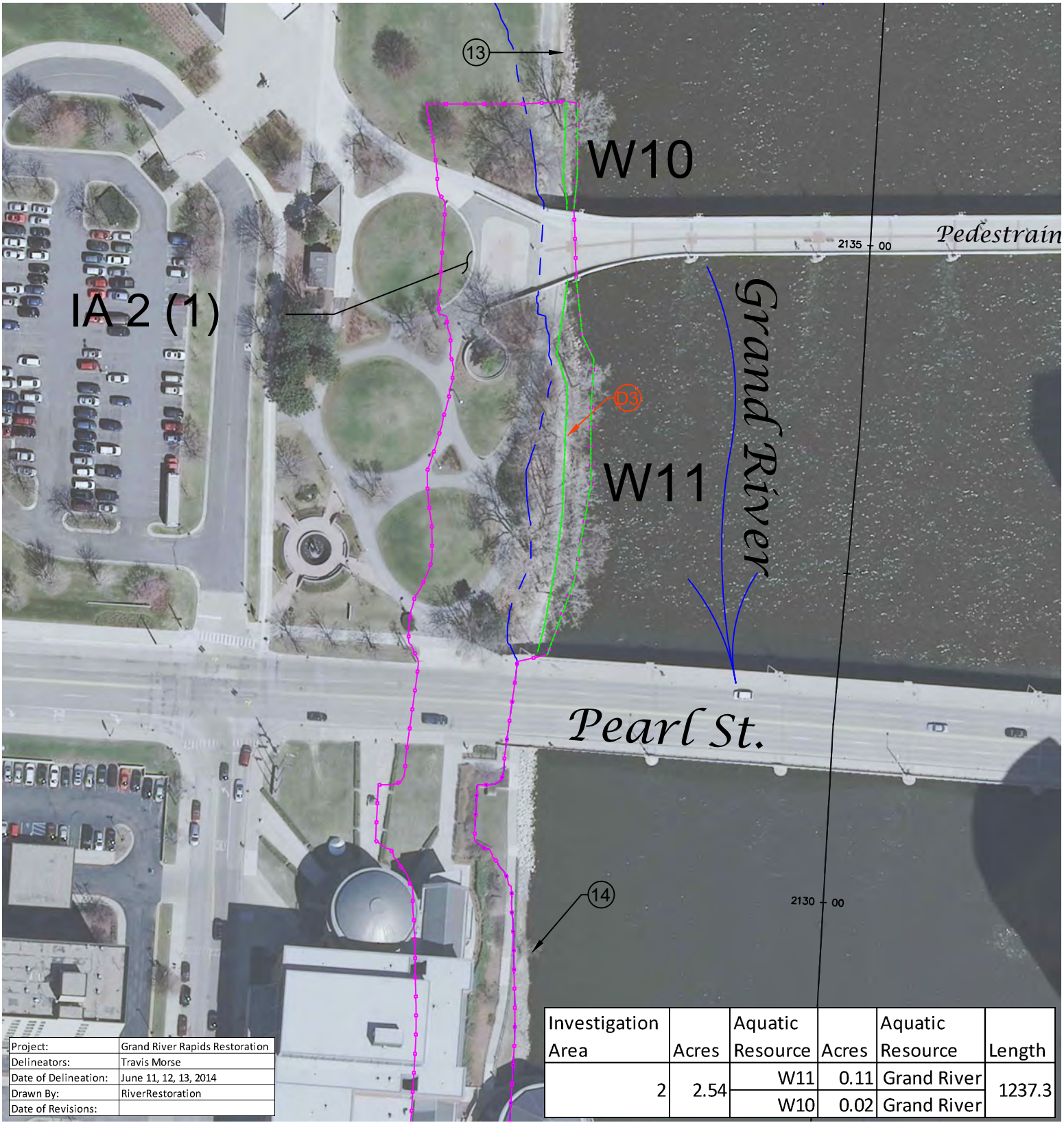

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
2	2.54	W11	0.11	Grand River	1237.3
		W10	0.02	Grand River	

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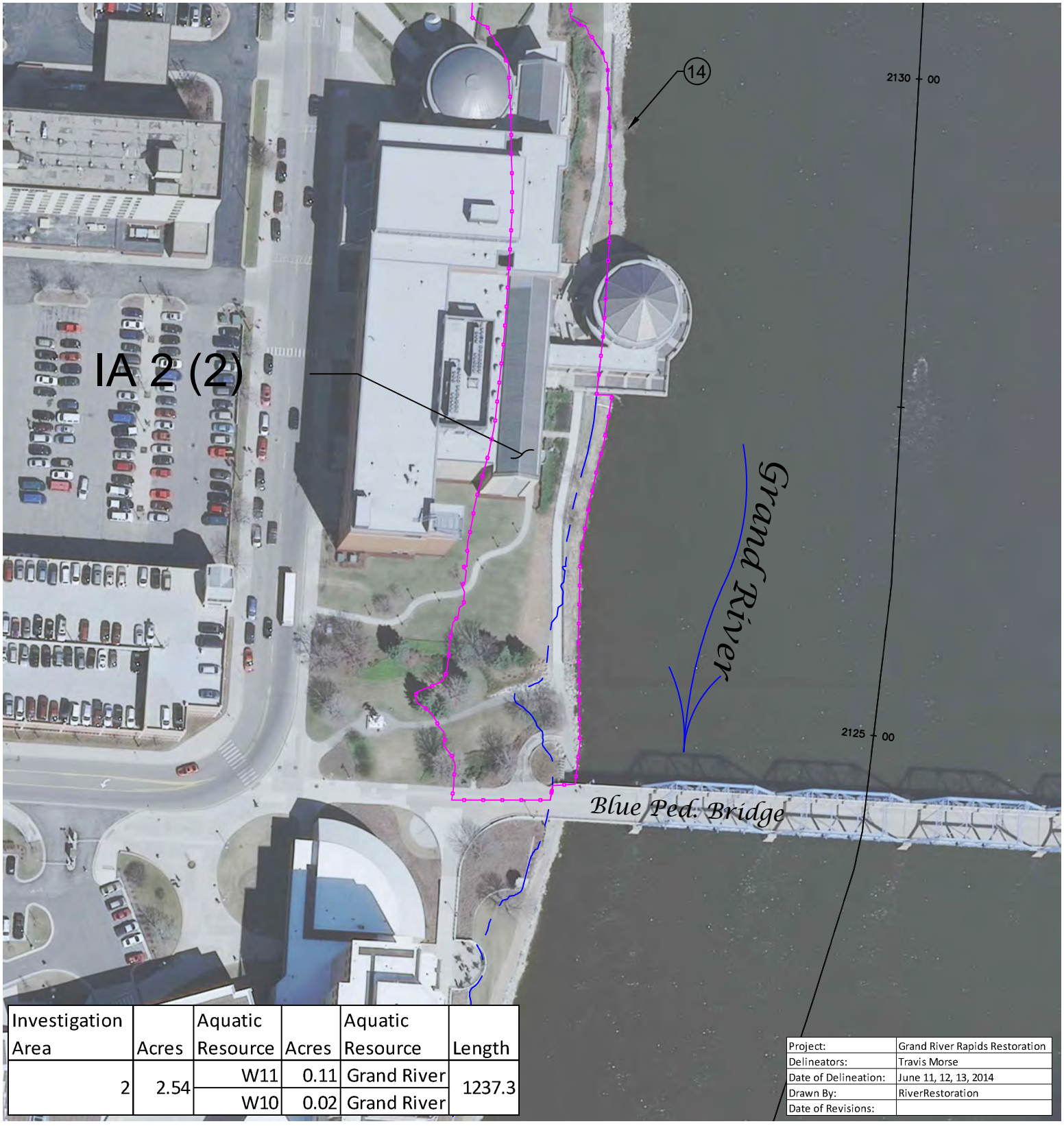

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
2	2.54	W11	0.11	Grand River	1237.3
		W10	0.02	Grand River	

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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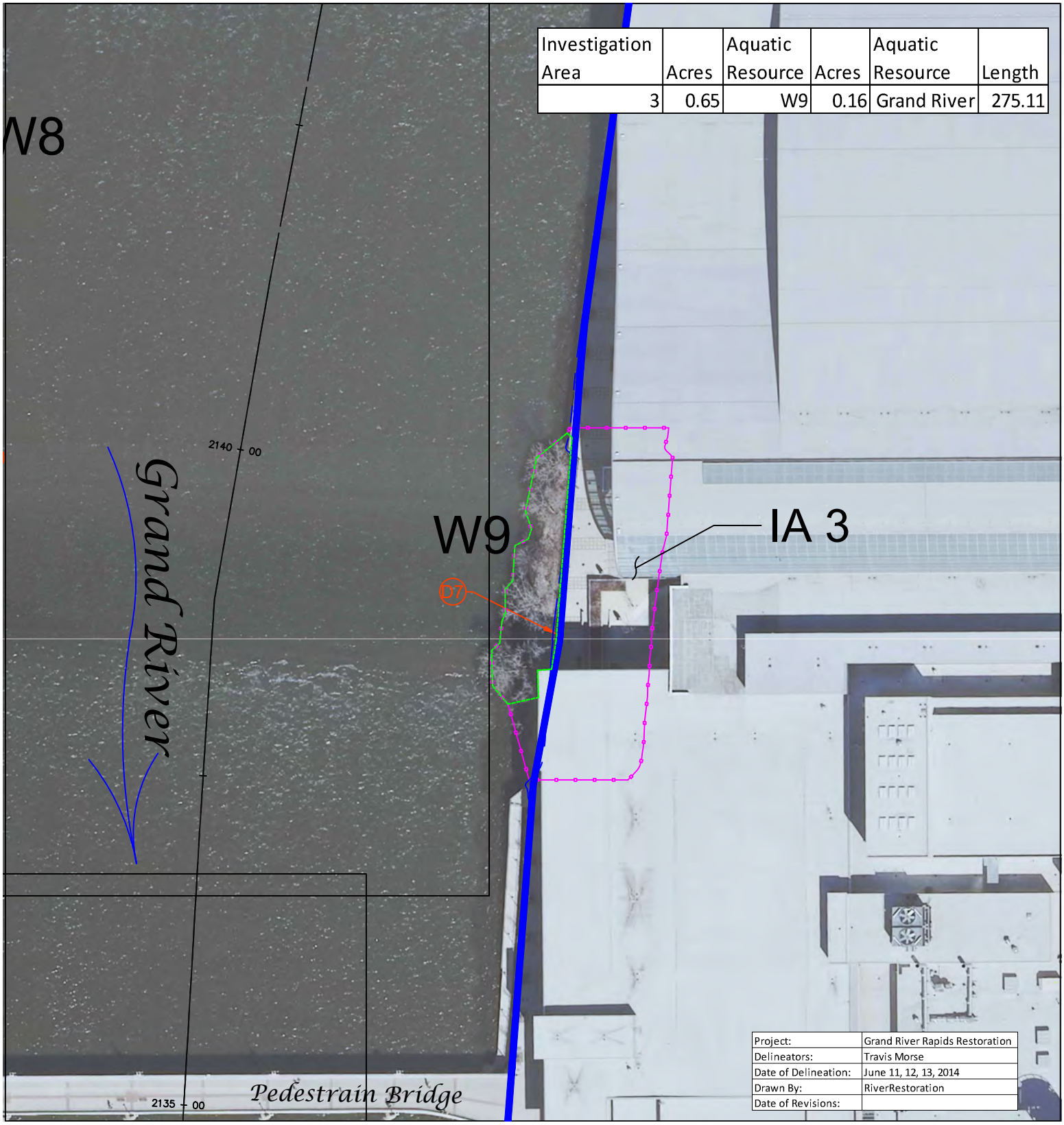

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
3	0.65	W9	0.16	Grand River	275.11

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
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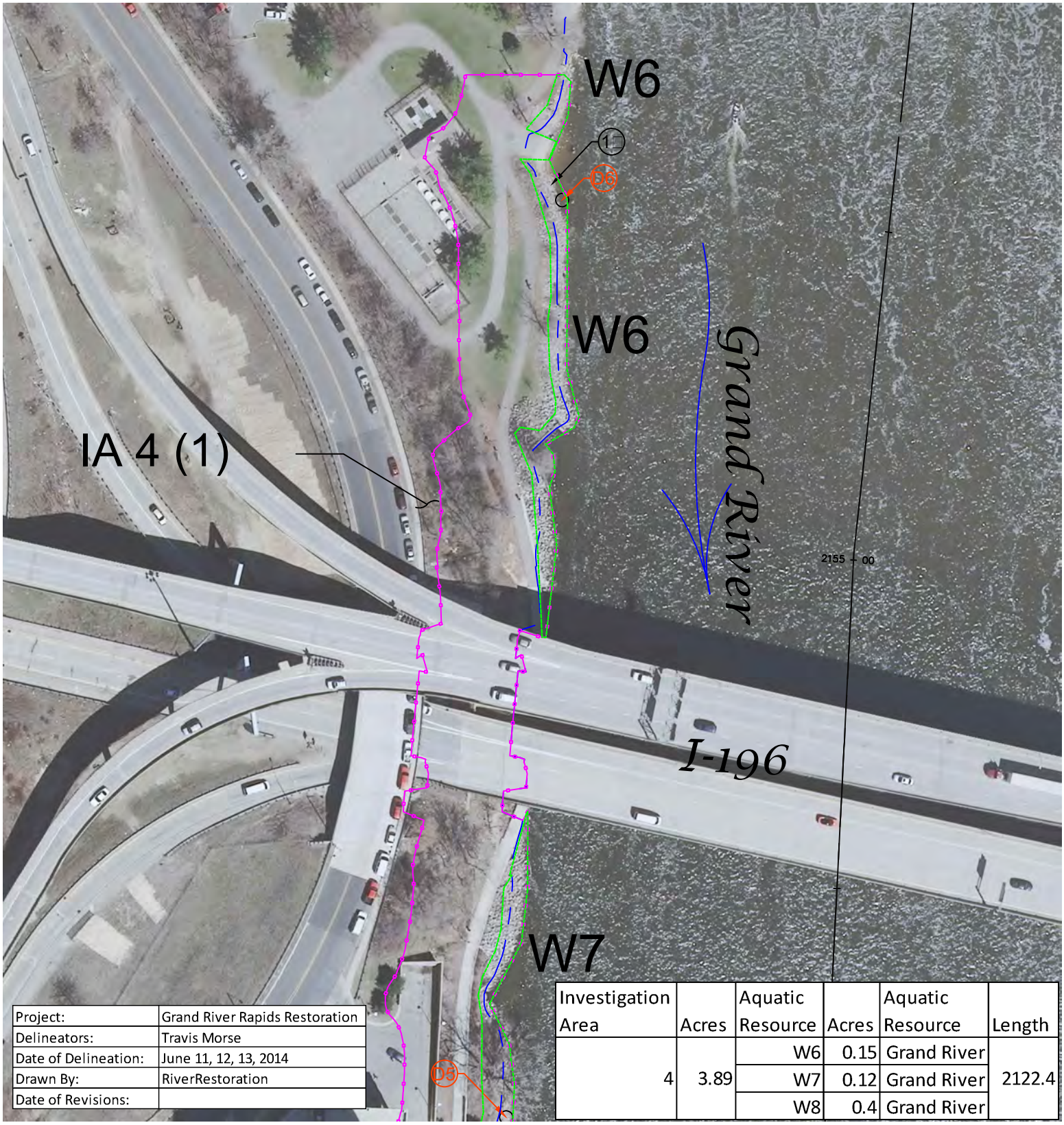

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
4	3.89	W6	0.15	Grand River	2122.4
		W7	0.12	Grand River	
		W8	0.4	Grand River	

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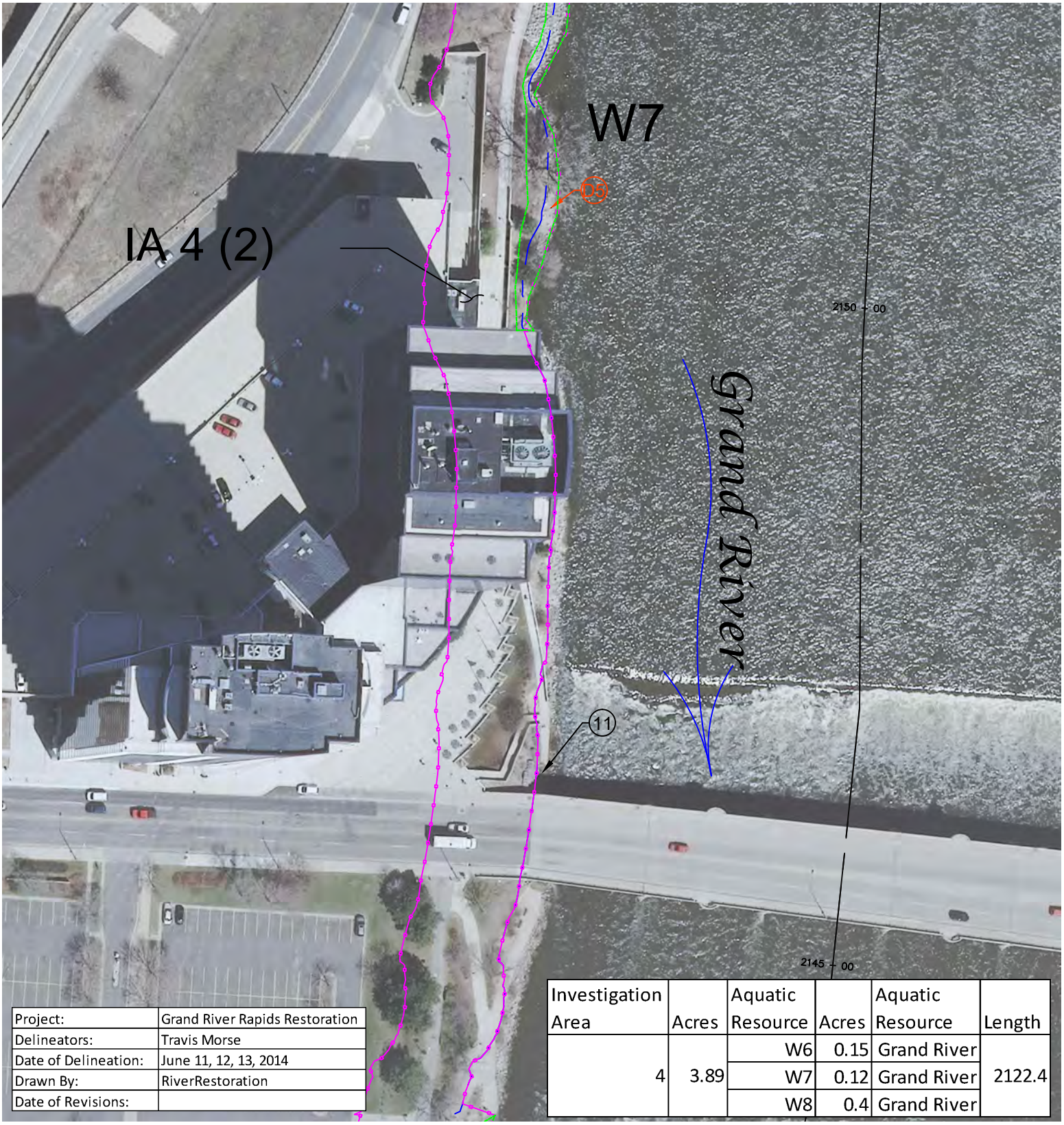

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
4	3.89	W6	0.15	Grand River	2122.4
		W7	0.12	Grand River	
		W8	0.4	Grand River	

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Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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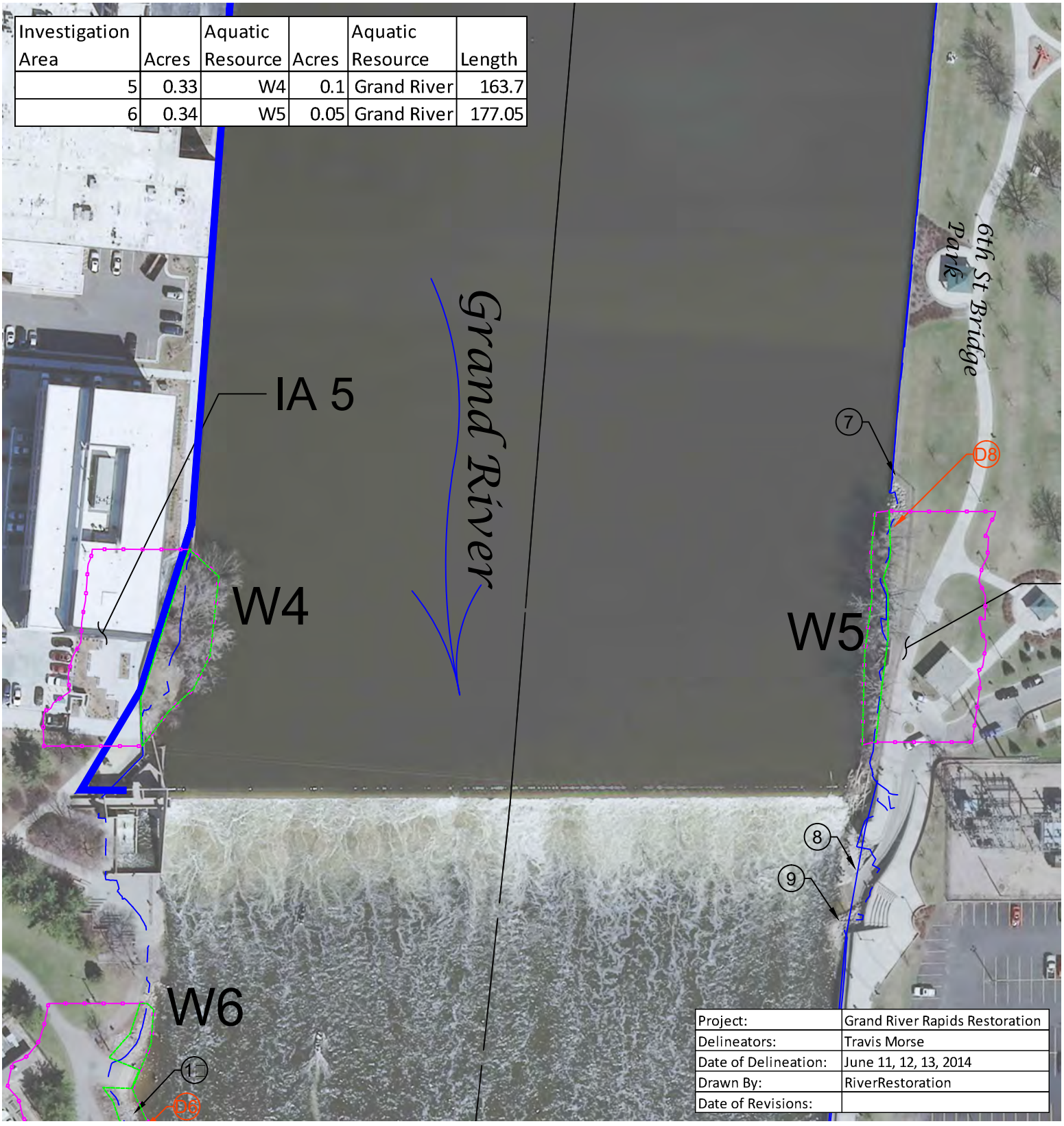
Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
5	0.33	W4	0.1	Grand River	163.7
6	0.34	W5	0.05	Grand River	177.05



Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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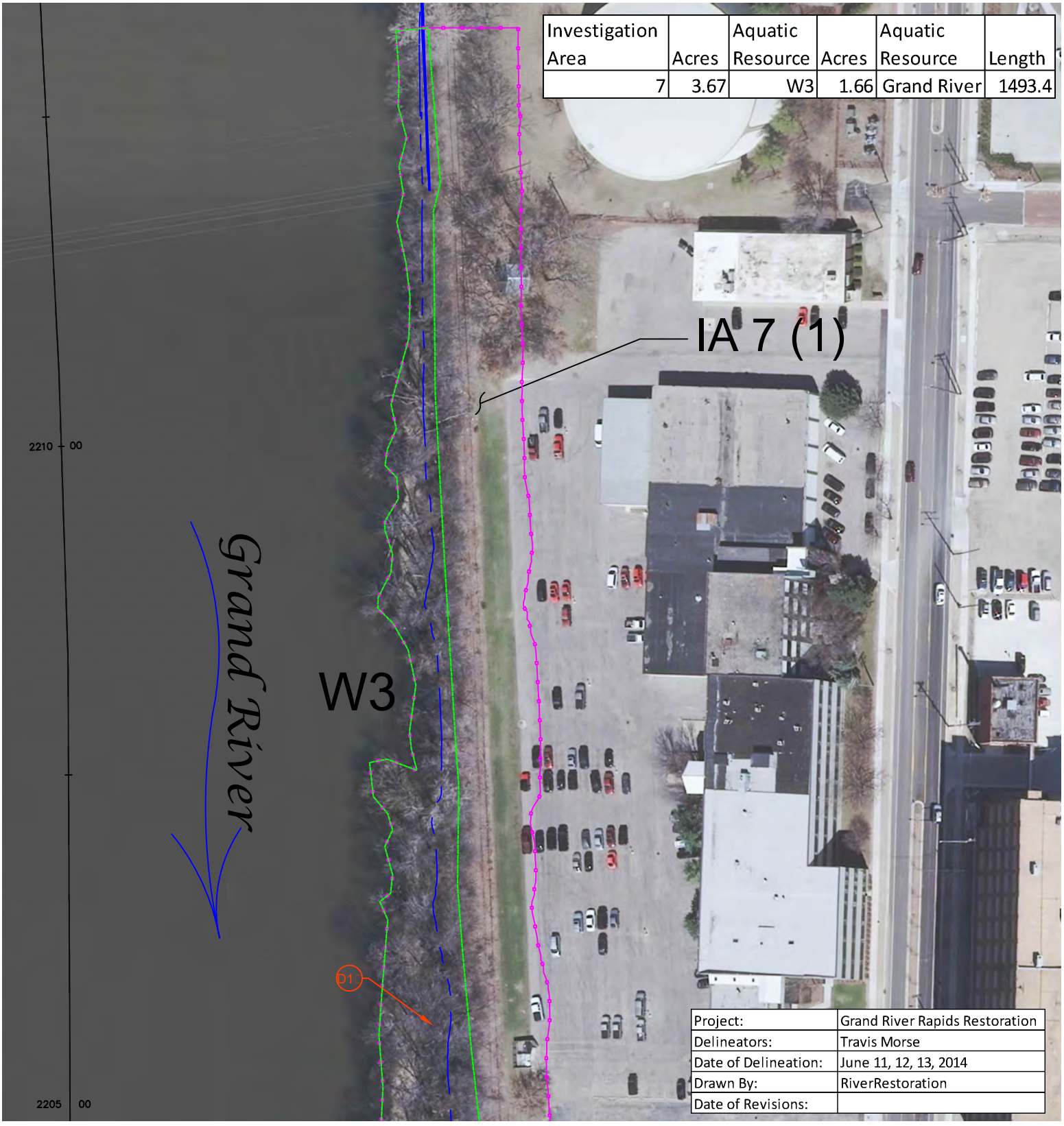
Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
7	3.67	W3	1.66	Grand River	1493.4



Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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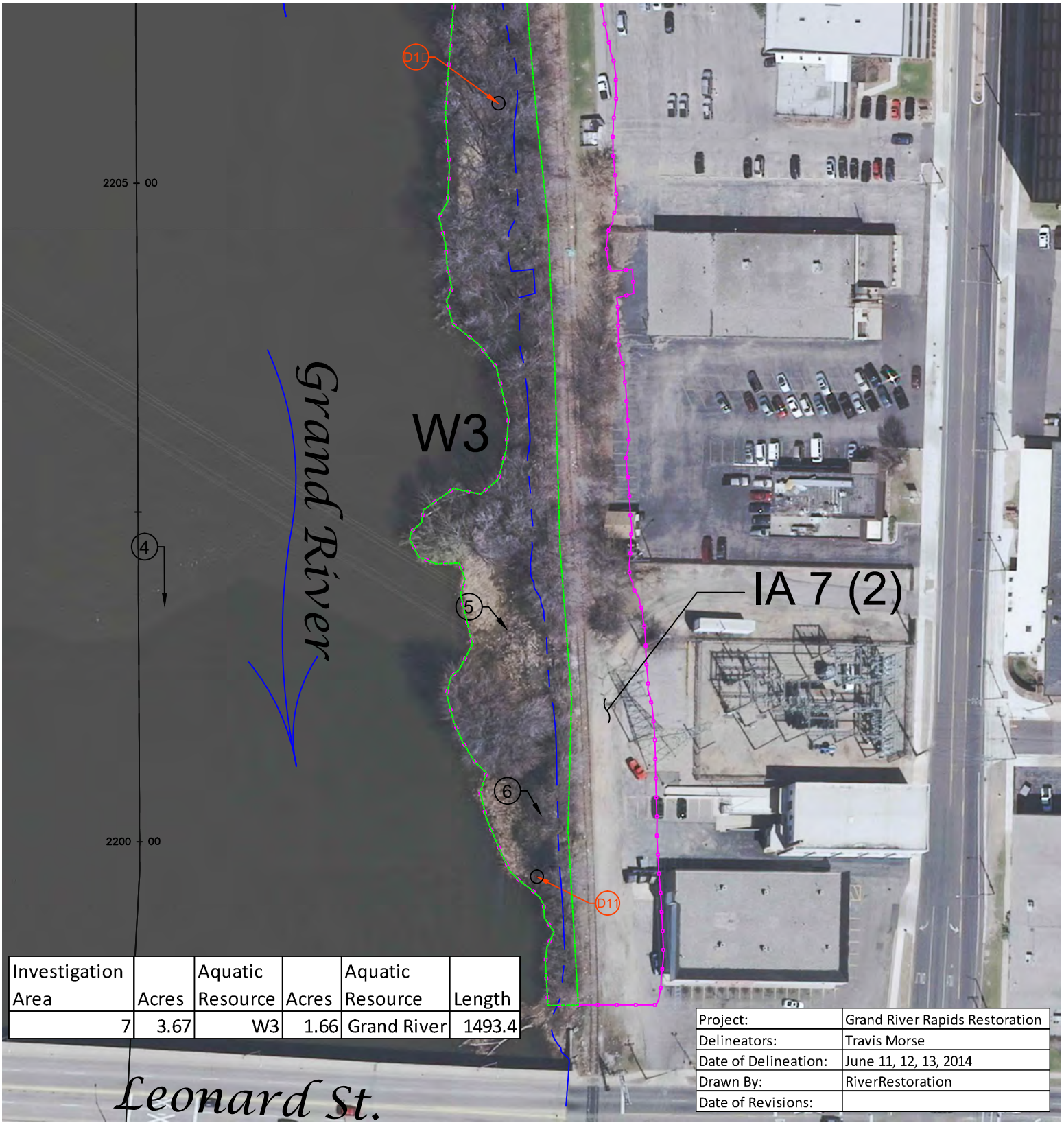

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
7	3.67	W3	1.66	Grand River	1493.4

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
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Date of Revisions:	

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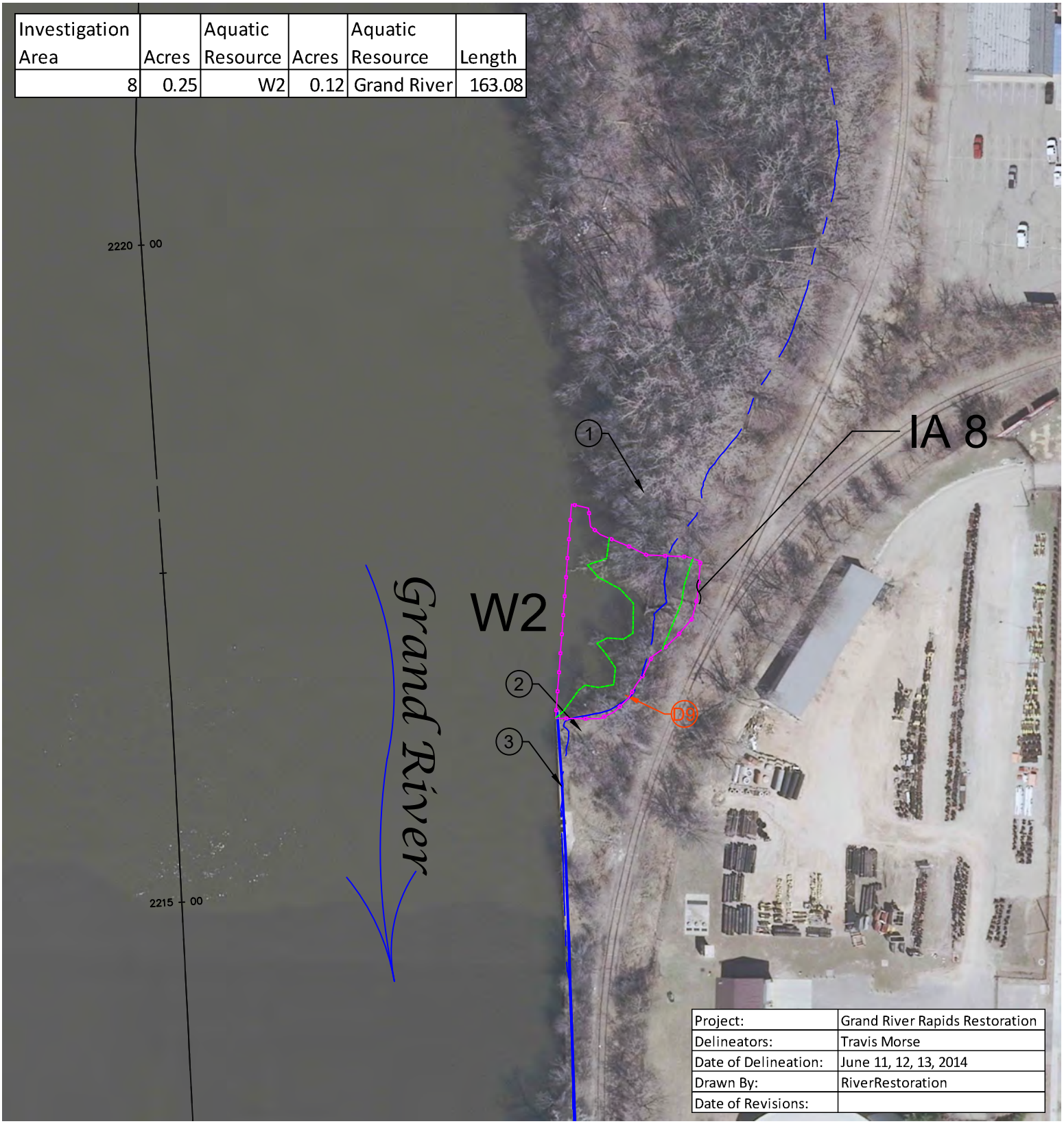

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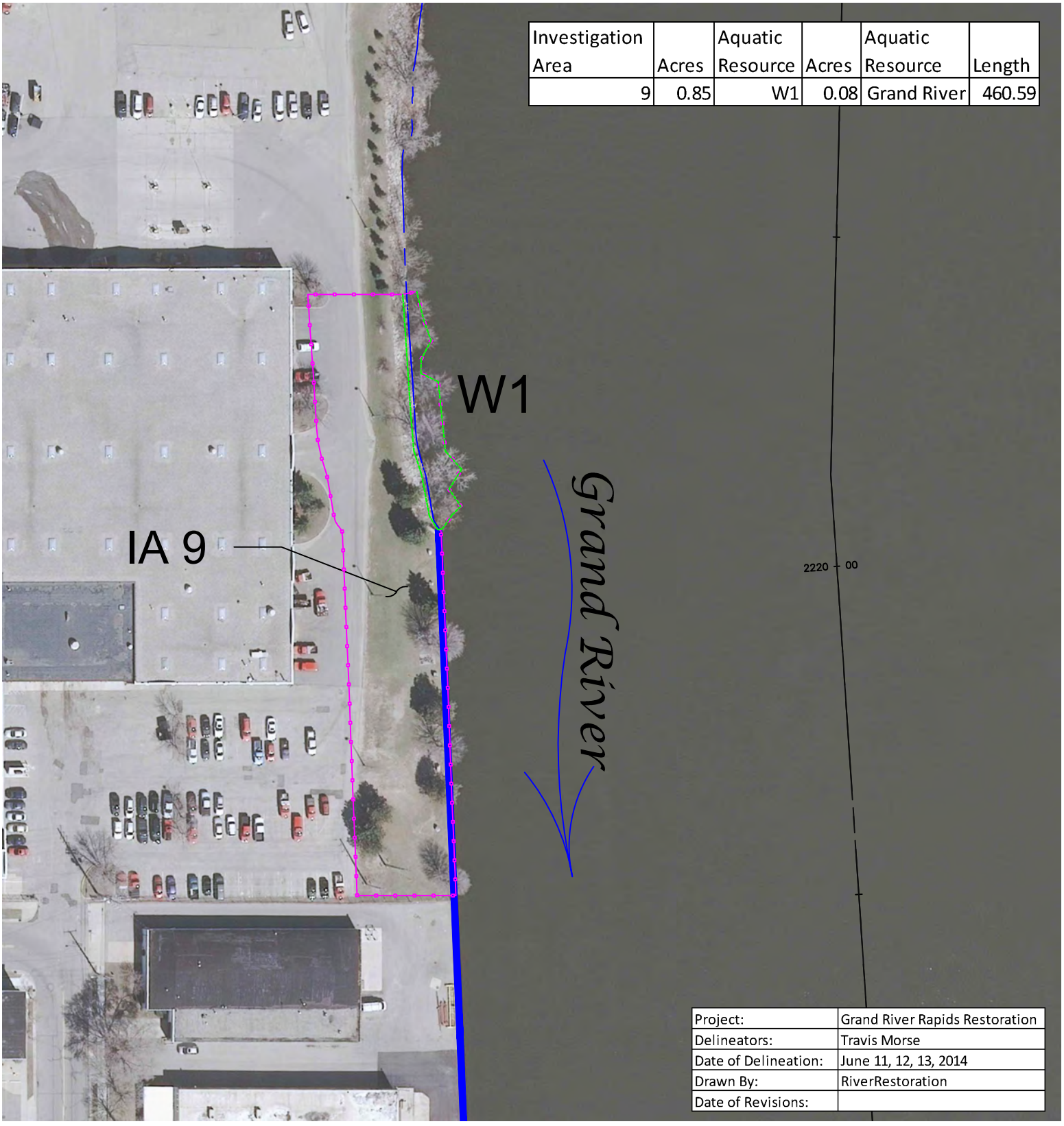

Investigation Area	Acres	Aquatic Resource	Acres	Aquatic Resource	Length
9	0.85	W1	0.08	Grand River	460.59

Project:	Grand River Rapids Restoration
Delineators:	Travis Morse
Date of Delineation:	June 11, 12, 13, 2014
Drawn By:	RiverRestoration
Date of Revisions:	

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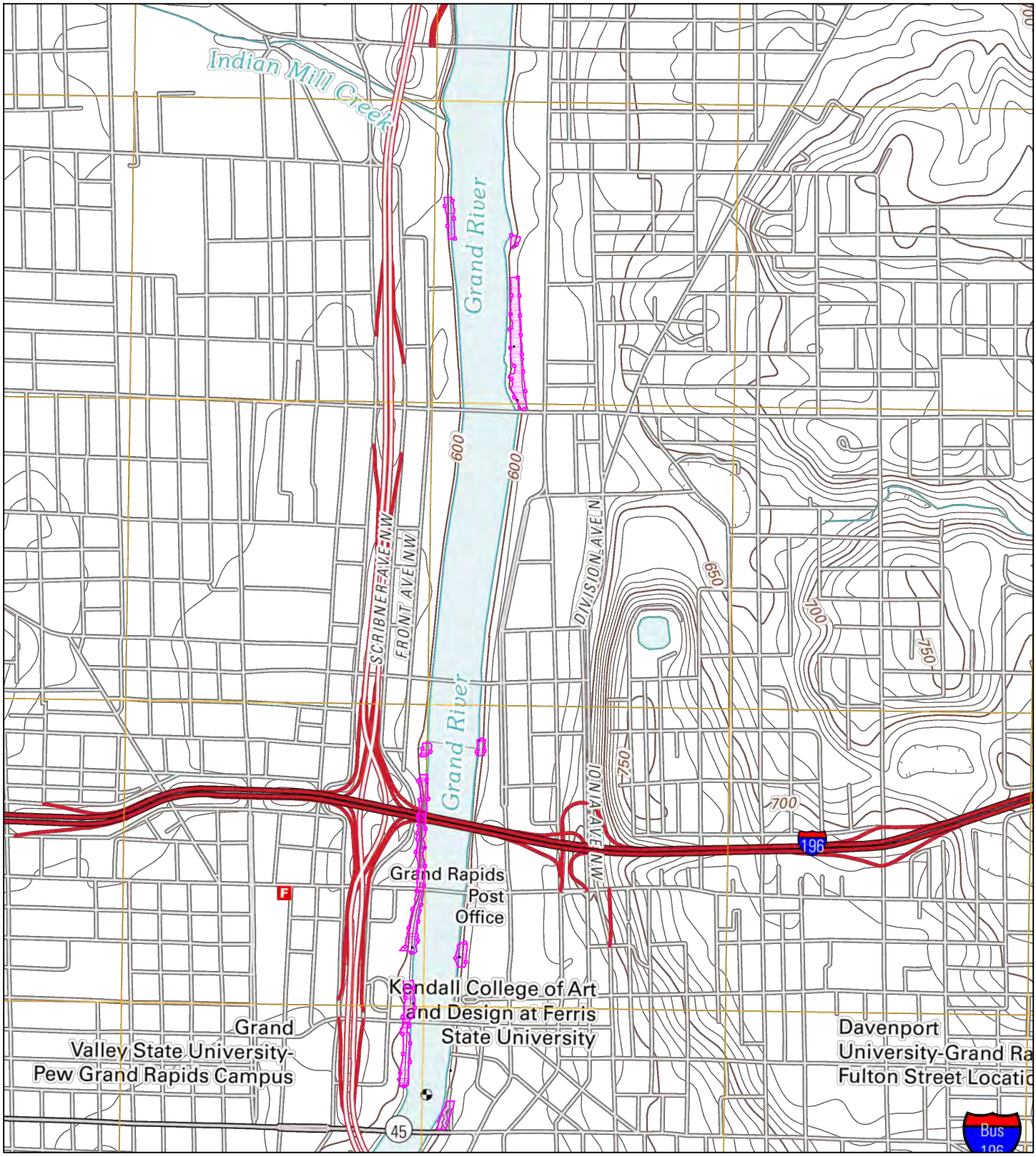
APPENDIX B
RESOURCE MAPS



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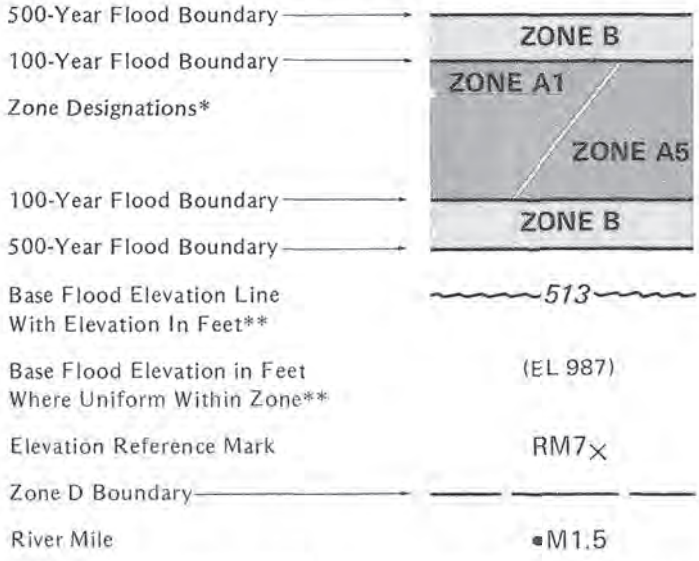
FEMA Zone Legend on Page 3 of 6 in Appendix B

KEY TO MAP



**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

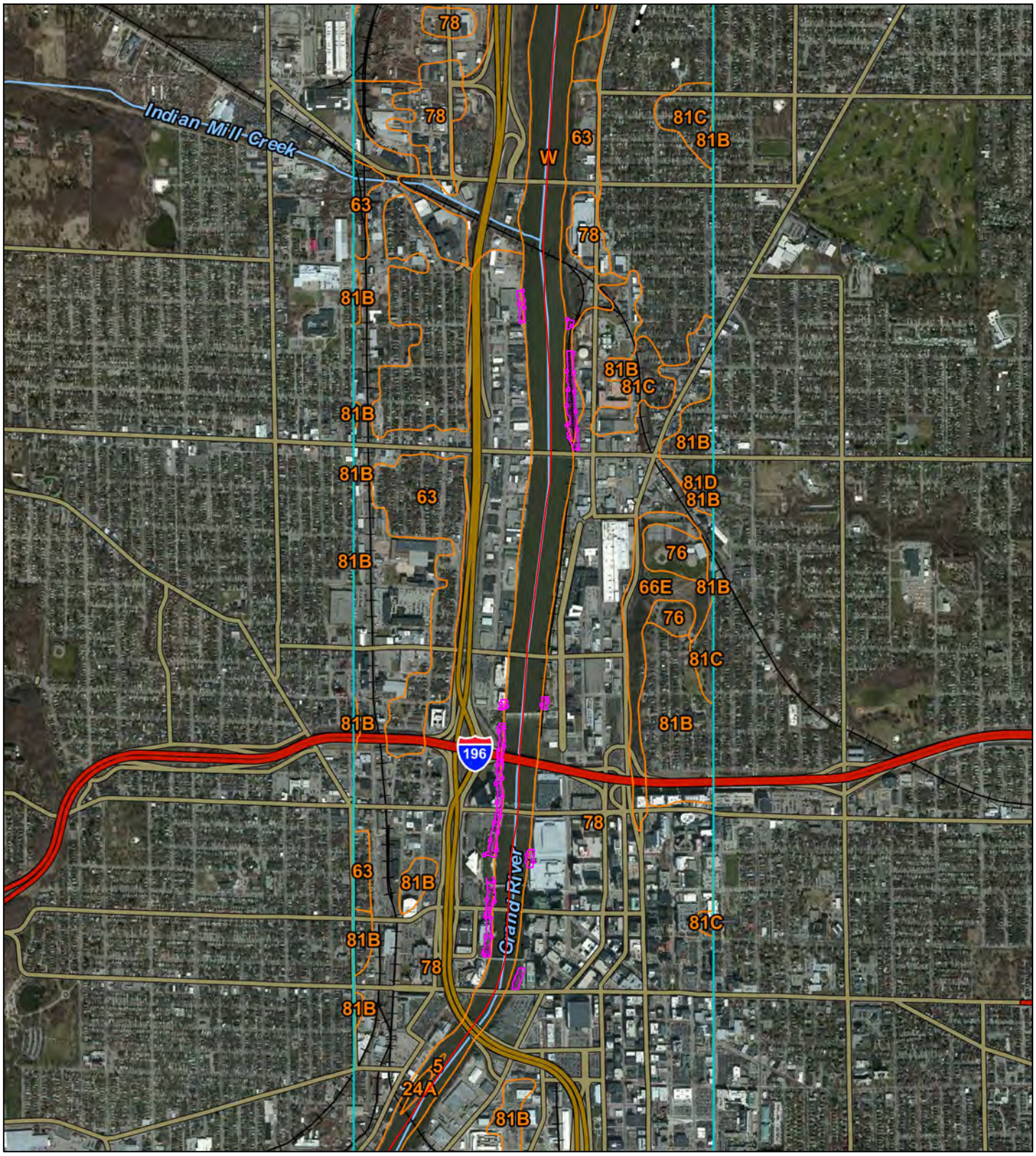
ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
A0	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flooc hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Index To Map Panels.



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Soils Described on Page 5 of 6 in Appendix B

Map Unit Legend

Kent County, Michigan (MI081)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5	Algansee loamy fine sand	130.0	4.4%
7	Cohoctah loam	35.3	1.2%
11B	Owosso-Marlette sandy loams, 2 to 6 percent slopes	25.1	0.9%
11C	Owosso-Marlette sandy loams, 6 to 12 percent slopes	30.4	1.0%
16	Ceresco loam	2.7	0.1%
17C	Chelsea loamy fine sand, 6 to 12 percent slopes	1.1	0.0%
24A	Abscota loamy sand, 0 to 3 percent slopes	2.0	0.1%
25D	Oakville fine sand, 12 to 18 percent slopes	5.5	0.2%
36C	Marlette loam, 6 to 12 percent slopes	11.7	0.4%
36D	Marlette loam, 12 to 18 percent slopes	2.6	0.1%
37B	Capac loam, 0 to 4 percent slopes	2.2	0.1%
39B	Arkport loamy very fine sand, 1 to 6 percent slopes	3.7	0.1%
48C	Metea loamy sand, 6 to 12 percent slopes	7.4	0.3%
63	Urban land-Cohoctah complex	477.2	16.1%
66B	Boyer loamy sand, 0 to 6 percent slopes	0.3	0.0%
66E	Boyer loamy sand, 18 to 40 percent slopes	35.6	1.2%
74	Dumps	136.0	4.6%
75	Udorthents, loamy	56.5	1.9%
76	Udipsamments, nearly level to steep	20.1	0.7%
78	Urban land	1,236.4	41.8%
81B	Urban land-Spinks complex, 0 to 8 percent slopes	346.5	11.7%
81C	Urban land-Spinks complex, 8 to 15 percent slopes	51.2	1.7%
81D	Urban land-Spinks complex, 15 to 25 percent slopes	1.3	0.0%
82B	Urban land-Perrinton complex, 0 to 8 percent slopes	11.9	0.4%
82D	Urban land-Perrinton complex, 15 to 25 percent slopes	0.0	0.0%
W	Water	321.7	10.9%
Totals for Area of Interest		**2,954.8**	**100.0%**

MAP LEGEND

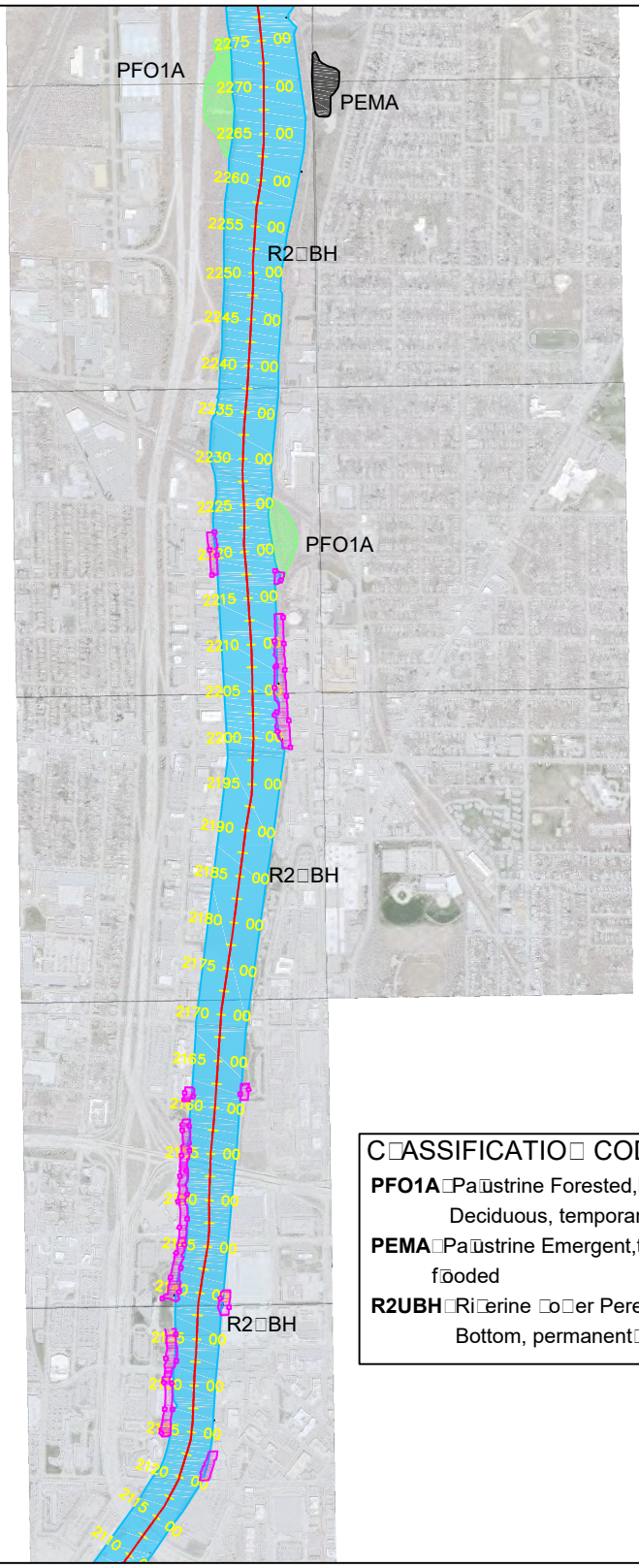
Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features



C□ASSIFICATIO□ CODES

PFO1A□Pa□ustrine Forested,Broad-□ea□ed Deciduous, temporar□ f□ooded

PEMA□Pa□ustrine Emergent,temporar□ f□ooded

R2UBH□Ri□erine □o□er Perennia□, □nconso□idated Bottom, permanent□□ f□ooded

□EGE□D

- I□□ESTIGATIO□ AREA
- FRESH□ ATER EMERGE□T
- FRESH□ ATER FORESTED□SHR□B
- RI□ERI□E

APPE□DIX B

□□ I MAP

October 13, 2□14 SCA□E□1"□2□□□□

□□ 5□□□ 1□□□□ 2□□□□ 3□□□□ 4□□□□

APPENDIX C
SITE PHOTOGRAPHS

APPENDIX C

Photo point #1



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #1
Comment	Photo depicts area just north of wetland # 2 (investigation area # 8)
Latitude	42.990
Longitude	-85.672
Photo Direction	S
Time Stamp	
Date Stamp	12-Jun-14
File Name	2011-01-01-42.jpg

Photo point #2



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #2
Comment	Photo depicts area just south of wetland # 2 (investigation area # 8)
Latitude	42.990
Longitude	-85.672
Photo Direction	N
Time Stamp	
Date Stamp	12-Jun-14
File Name	2011-01-01-35.jpg

APPENDIX C

Photo point #3



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #3
Comment	Photo depicts floodwall just south of wetland # 2 (investigation area # 8)
Latitude	42.990
Longitude	-85.672
Photo Direction	S
Time Stamp	
Date Stamp	9-Jul-12
File Name	IMGP0922.jpg

Photo point #4



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #4
Comment	Photo depicts Grand River adjacent to wetland # 3 (investigation area # 7) looking downstream towards Leonard St.
Latitude	42.986
Longitude	-85.673
Photo Direction	S
Time Stamp	
Date Stamp	28-Oct-11
File Name	359.jpg

APPENDIX C

Photo point #5



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #5
Comment	Photo depicts wetland # 3 (investigation area # 7)
Latitude	42.986
Longitude	-85.672
Photo Direction	W
Time Stamp	
Date Stamp	26-Jun-14
File Name	IMG_4212.jpg

Photo point #6



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #6
Comment	Photo depicts wetland # 3 (investigation area # 7)
Latitude	42.985
Longitude	-85.672
Photo Direction	W
Time Stamp	
Date Stamp	26-Jun-14
File Name	IMG_4211.jpg

APPENDIX C

Photo point #7



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #7
Comment	Photo depicts floodwall break in 6th St Park just north of wetland # 5 (investigation area # 6)
Latitude	42.975
Longitude	-85.673
Photo Direction	S
Time Stamp	
Date Stamp	12-Jun-14
File Name	2011-01-01-34.jpg

Photo point #8



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #8
Comment	Photo depicts 6th St Dam south of wetland # 5 (investigation area # 6)
Latitude	42.974
Longitude	-85.674
Photo Direction	W
Time Stamp	
Date Stamp	12-Jun-14
File Name	2011-01-01-24.jpg

APPENDIX C

Photo point #9



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #9
Comment	Photo depicts stormdrain outlet downstream of 6th St. Dam near wetland # 5 (investigation area # 6)
Latitude	42.974
Longitude	-85.674
Photo Direction	S
Time Stamp	
Date Stamp	12-Jun-14
File Name	2011-01-01-27.jpg

Photo point #10



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #10
Comment	Photo depicts shallow channel from Fish Passge Park boat ramp on north end of wetland # 6 (investigation area # 4)
Latitude	42.974
Longitude	-85.676
Photo Direction	E
Time Stamp	
Date Stamp	28-Oct-11
File Name	360.jpg

APPENDIX C

Photo point #11



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #11
Comment	Photo depicts path under Pearl St. near the middle of investigation area # 4
Latitude	42.971
Longitude	-85.676
Photo Direction	S
Time Stamp	
Date Stamp	26-Oct-13
File Name	IMGP1977.jpg

Photo point #12



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #12
Comment	Photo depicts rip rap bank at Ah-Nab-Awen Park in wetland # 8 (investigation area # 4)
Latitude	42.970
Longitude	-85.676
Photo Direction	N
Time Stamp	
Date Stamp	27-Oct-11
File Name	IMGP0330.jpg

APPENDIX C

Photo point #13



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #13
Comment	Photo depicts rip rap above concrete wall in Ah-Nab-Awen Park just north of wetland # 10 (investigation area # 2)
Latitude	42.968
Longitude	-85.676
Photo Direction	S
Time Stamp	
Date Stamp	27-Oct-11
File Name	IMPG0328.jpg

Photo point #14



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #14
Comment	Photo depicts carousel building in investigation area # 2
Latitude	42.966
Longitude	-85.676
Photo Direction	S
Time Stamp	
Date Stamp	24-Oct-13
File Name	IMGP1887.jpg

APPENDIX C

Photo point #15



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #15
Comment	Photo depicts bank north of pedestrian bridge, north of wetland # 12 (investigation area # 1)
Latitude	42.965
Longitude	-85.675
Photo Direction	N
Time Stamp	
Date Stamp	8-Jul-12
File Name	IMGP0900.jpg

Photo point #16



Attributes	
Subject	Grand Rapids River Restoration
Title	Photo point #16
Comment	Photo depicts bank south of pedestrian bridge, north of wetland # 12 (investigation area # 1)
Latitude	42.965
Longitude	-85.675
Photo Direction	S
Time Stamp	
Date Stamp	8-Jul-12
File Name	IMGP0886.jpg

APPENDIX D
WETLAND DETERMINATION DATA FORMS

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/11/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D1

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): hillslope Local relief (concave, convex, none): convex Slope (%): 4

Subregion (LRR or MLRA): LRR L Lat: 42.960904853 Long: -85.67723631 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil x, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No x	**Is the Sampled Area**		
Hydric Soil Present?	Yes ____	No x	**within a Wetland?**	**Yes** ____	**No** x
Wetland Hydrology Present?	Yes ____	No x	If yes, optional Wetland Site ID:		

Remarks: (Explain alternative procedures here or in a separate report.)
Naturally problematic fluvial deposits/sandy soils. Sample taken near crest of shoulder to Grand River at approximately 607 ft in elevation, near the fence behind the Public Works building.Outside of sample, C&D bricks serve as armor below OHWM.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- ____ High Water Table (A2)
- ____ Saturation (A3)
- ____ Water Marks (B1)
- ____ Sediment Deposits (B2)
- ____ Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- ____ Inundation Visible on Aerial Imagery (B7)
- ____ Sparsely Vegetated Concave Surface (B8)
- ____ Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- ____ Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- ____ Microtopographic Relief (D4)
- ____ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____
Water Table Present?	Yes ____	No x	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No x	Depth (inches): ____

Wetland Hydrology Present? **Yes** ____ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rained intermittently all afternoon.

VEGETATION – Use scientific names of plants. Sampling Point: D1

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Acer negundo*	85	Yes	FAC
2. *Morus alba*	20	No	FACU
3.			
4.			
5.			
6.			
7.			
	105	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Lonicera tatarica*	10	Yes	FACU
2. *Rhus typhina*	12	Yes	UPL
3. *Acer negundo*	15	Yes	FAC
4.			
5.			
6.			
7.			
	37	=Total Cover	
Herb Stratum (Plot size: 5' r)			
1. *Arctium minus*	30	Yes	FACU
2. *Solanum dulcamara*	5	No	FAC
3. *Leonurus cardiaca*	5	No	UPL
4. *Carex pensyvanica*	3	No	UPL
5. *Poa pratensis*	3	No	FACU
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	46	=Total Cover	
Woody Vine Stratum (Plot size:)			
1. *Vitis riparia*	15	Yes	FAC
2.			
3.			
4.			
	15	=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	120	x 3 =	360
FACU species	63	x 4 =	252
UPL species	20	x 5 =	100
Column Totals:	203 (A)		712 (B)

Prevalence Index = B/A = 3.51

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of same riparian community. Barbarea orthoceras outside of sample plot.

SOIL

Sampling Point: D1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 3/2	100					Sandy	loamy sand -old fill material
6-16	10YR 4/3	100					Sandy	loamy sand, some OM, sand grains visible

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks:

Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/11/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D2

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): river bank Local relief (concave, convex, none): convex Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.965104436 Long: -85.674604631 Datum:

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No (If no, explain in Remarks.)

Are Vegetation , Soil , or Hydrology significantly disturbed? Are "Normal Circumstances" present? Yes x No

Are Vegetation , Soil x , or Hydrology naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No	**Is the Sampled Area**	
Hydric Soil Present?	Yes X	No	**within a Wetland?**	**Yes** X **No**
Wetland Hydrology Present?	Yes X	No	If yes, optional Wetland Site ID:	

Remarks: (Explain alternative procedures here or in a separate report.)
Fluvial deposits within floodplain; soil disturbance cycle/annual deposition of new soil material limits horizon development. Area satisfies wetland criteria; sample taken below OHWM.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- Surface Water (A1)
- X High Water Table (A2)
- x Saturation (A3)
- Water Marks (B1)
- x Sediment Deposits (B2)
- Drift Deposits (B3)
- Algal Mat or Crust (B4)
- Iron Deposits (B5)
- x Inundation Visible on Aerial Imagery (B7)
- Sparsely Vegetated Concave Surface (B8)
- Water-Stained Leaves (B9)
- Aquatic Fauna (B13)
- Marl Deposits (B15)
- Hydrogen Sulfide Odor (C1)
- Oxidized Rhizospheres on Living Roots (C3)
- Presence of Reduced Iron (C4)
- Recent Iron Reduction in Tilled Soils (C6)
- Thin Muck Surface (C7)
- Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- Surface Soil Cracks (B6)
- Drainage Patterns (B10)
- Moss Trim Lines (B16)
- Dry-Season Water Table (C2)
- Crayfish Burrows (C8)
- Saturation Visible on Aerial Imagery (C9)
- Stunted or Stressed Plants (D1)
- Geomorphic Position (D2)
- Shallow Aquitard (D3)
- Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes	No x	Depth (inches):	
Water Table Present?	Yes x	No	Depth (inches):	-6
Saturation Present? (includes capillary fringe)	Yes x	No	Depth (inches):	-6

Wetland Hydrology Present? **Yes** X **No**

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:
Canopy cover on aerials. Anecdotal evidence: Client says area is frequently under water.

Remarks:
Rained intermittently all afternoon. Geomorphic Position (D2) is not applicable to the location along river and over sand and gravel substrate.

VEGETATION – Use scientific names of plants. Sampling Point: D2

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Betula nigra*	5	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
	5	=Total Cover	

Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Acer saccharinum*	5	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
	5	=Total Cover	

Herb Stratum (Plot size: 5' r)			
1. *Lythrum salicaria*	8	Yes	OBL
2. *Vitis riparia*	5	Yes	FAC
3. *Acer saccharinum*	3	No	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	16	=Total Cover	

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	8	x 1 =	8
FACW species	13	x 2 =	26
FAC species	5	x 3 =	15
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	26 (A)		49 (B)

Prevalence Index = B/A = 1.88

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of same riparian community. Photo of exposed roots.

SOIL

Sampling Point: D2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-6	2.5Y 5/2	95	5Y 2.5/1	5	C	M	Sandy	Sandy loam, few distinct Fe and Mg masses
6-16	10YR 4/3	100					Sandy	fine sandy loam; 3/4" gravel

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- X Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- x Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

Saturated soils examined for redox features after drying to a moist condition. Buried organics are evidence of active floodplain. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/12/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D3

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): river bank Local relief (concave, convex, none): convex Slope (%): 2-4

Subregion (LRR or MLRA): LRR L Lat: 42.96711621 Long: -85.67613005 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil x, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area**		
Hydric Soil Present?	Yes x	No ____	**within a Wetland?**	**Yes** X	**No** ____
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:		

Remarks: (Explain alternative procedures here or in a separate report.)
Fluvial deposits within floodplain; soil disturbance cycle/annual deposition of new soil material limits horizon development. Accessed from along foot path, approximately 100-feet south of the Interurban/Richard Gillette Bridge. Compared to similar conditions at DP2 below OHWM and on opposite bank, outside of IA.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- ____ High Water Table (A2)
- ____ Saturation (A3)
- ____ Water Marks (B1)
- x Sediment Deposits (B2)
- ____ Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- ____ Inundation Visible on Aerial Imagery (B7)
- ____ Sparsely Vegetated Concave Surface (B8)
- ____ Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- ____ Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- ____ Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____	
Water Table Present?	Yes ____	No x	Depth (inches): ____	
Saturation Present? (includes capillary fringe)	Yes ____	No x	Depth (inches): ____	**Wetland Hydrology Present?** **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain within past 24 hours. Along low-elevation fringe of river.

VEGETATION – Use scientific names of plants. Sampling Point: D3

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	30	Yes	FAC
2. *Ulmus americana*	5	No	FACW
3. *Platanus occidentalis*	40	Yes	FACW
4. *Fraxinus pennsylvanica*	20	Yes	FACW
5.			
6.			
7.			
	95	=Total Cover	

Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Fraxinus pennsylvanica*	35	Yes	FACW
2. *Acer negundo*	5	No	FAC
3. *Ulmus americana*	5	No	FACW
4.			
5.			
6.			
7.			
	45	=Total Cover	

Herb Stratum (Plot size: 5' r)			
1. *Rubus idaeus*	40	Yes	FAC
2. *Vitis riparia*	5	No	FAC
3. *Acer saccharinum*	3	No	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	48	=Total Cover	

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	108	x 2 =	216
FAC species	80	x 3 =	240
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	188 (A)		456 (B)

Prevalence Index = B/A = 2.43

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

__ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** __

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of same community. Doellingeria umbellata and Physiocarpus opulifolius outside sample.

SOIL

Sampling Point: D3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-5	2.5Y 5/2	100					Sandy	sandy loam - buried organics (twigs, bark)
5-14	2.5Y 3/2	100					Sandy	sandy loam, 3/4" gravel

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- x Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: Riprap boulders

Depth (inches): 14+

Hydric Soil Present? **Yes** x **No** ___

Remarks:

Sandy fluvial deposits are naturally problematic. Buried organics are evidence of active floodplain. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/12/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D4

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.96879305 Long: -85.67617747 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No x	**Is the Sampled Area**
Hydric Soil Present?	Yes ____	No x	**within a Wetland?** **Yes** ____ **No** x
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:

Remarks: (Explain alternative procedures here or in a separate report.)
Managed plant community (Ah-Nab-Awen Park east of Gerald R. Ford Museum)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- ____ High Water Table (A2)
- ____ Saturation (A3)
- ____ Water Marks (B1)
- x Sediment Deposits (B2)
- x Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- ____ Inundation Visible on Aerial Imagery (B7)
- x Sparsely Vegetated Concave Surface (B8)
- ____ Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- x Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- ____ Microtopographic Relief (D4)
- ____ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____
Water Table Present?	Yes ____	No x	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No x	Depth (inches): ____

Wetland Hydrology Present? **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain within past 24 hours. Concave position of floodplain. Silt lines on tree bark. Debris piled against upstream side of rocks and trees.

VEGETATION – Use scientific names of plants. Sampling Point: D4

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Morus alba*	20	Yes	FACU
2. *Robinia pseudoacacia*	30	Yes	FACU
3. *Populus deltoides*	10	No	FAC
4. *Acer ginnala*	5	No	UPL
5. *Ulmus americana*	5	No	FACW
6.			
7.			
	70	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Euonymus alatus*	20	Yes	UPL
2. *Lonicera tatarica*	3	No	FACU
3.			
4.			
5.			
6.			
7.			
	23	=Total Cover	
Herb Stratum (Plot size: 5' r)			
1. *Poa pratensis*	55	Yes	FACU
2. *Melilotus officinalis*	10	No	FACU
3. *Veronica prostrata*	8	No	FAC
4. *Taraxacum officinale*	5	No	FACU
5. *Phalaris arundinacea*	2	No	FACW
6. *Plantago lanceolata*	2	No	FACU
7.			
8.			
9.			
10.			
11.			
12.			
	82	=Total Cover	
Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	7	x 2 =	14
FAC species	18	x 3 =	54
FACU species	125	x 4 =	500
UPL species	25	x 5 =	125
Column Totals:	175 (A)		693 (B)

Prevalence Index = B/A = 3.96

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of same community. Just outside of sample there are mature Rhamnus cathartica, Acer platanoides, Quercus rubra, and Pinus nigra. Mowing, seeding, and planting of community does not make the hydrophytic vegetation determination unreliable. Unmanaged reference site (within treeline ~25 north, similar soils and hydrologic conditions) contains upland vegetation.

SOIL

Sampling Point: D4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 5/4	100					Sandy	loamy sand
10-16	10YR 3/1	100					Sandy	loamy sand

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks:

Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/12/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D5

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): terrace Local relief (concave, convex, none): convex Slope (%): 3-5

Subregion (LRR or MLRA): LRR L Lat: 42.97180933 Long: -85.67567642 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No x	**Is the Sampled Area**
Hydric Soil Present?	Yes ____	No x	**within a Wetland?** **Yes** ____ **No** x
Wetland Hydrology Present?	Yes ____	No x	If yes, optional Wetland Site ID: ____

Remarks: (Explain alternative procedures here or in a separate report.)
along foot-path, ~450-feet north of River House at Bridgewater

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____
Water Table Present?	Yes ____	No x	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No x	Depth (inches): ____

Wetland Hydrology Present? **Yes** ____ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain within past 24 hours.

VEGETATION – Use scientific names of plants. Sampling Point: D5

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	20	Yes	FAC
2. *Salix nigra*	10	No	OBL
3. *Pinus nigra*	20	Yes	UPL
4. *Elaeagnus angustifolia*	10	No	FACU
5. *Ulmus pumila*	15	Yes	FACU
6.			
7.			
	75	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Robinia pseudoacacia*	35	Yes	FACU
2. *Fraxinus pennsylvanica*	10	No	FACW
3. *Catalpa speciosa*	10	No	FACU
4. *Cornus alba*	10	No	FACW
5.			
6.			
7.			
	65	=Total Cover	
Herb Stratum (Plot size: 5' r)			
1. *Rhus aromatica*	25	Yes	UPL
2. *Phalaris arundinacea*	10	Yes	FACW
3. *Lactuca serriola*	10	Yes	FACU
4. *Toxicodendron radicans*	10	Yes	FAC
5. *Asclepias syriaca*	5	No	UPL
6. *Elymus trachycaulus*	5	No	FACU
7. *Bromus inermis*	5	No	UPL
8. *Potentilla simplex*	5	No	FACU
9. *Trifolium repens*	3	No	FACU
10. *Morus alba*	2	No	FACU
11. *Vitis riparia*	2	No	FAC
12.			
	82	=Total Cover	
Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 37.5% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	10	x 1 =	10
FACW species	30	x 2 =	60
FAC species	32	x 3 =	96
FACU species	95	x 4 =	380
UPL species	55	x 5 =	275
Column Totals:	222 (A)		821 (B)

Prevalence Index = B/A = 3.70

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of same community. Herbacious community is relatively diverse. If sample sizes were doubled, community composition would also include Tilia americana, Bromus tectorum, Dactylis glomerata, and Polygonum cuspidum (invasive).

SOIL

Sampling Point: D5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2	2.5Y 5/3	100					Sandy	
2-12	10YR 3/2	100					Sandy	gravel throughout/boulder refusal

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: cobbles. Boulders

Depth (inches): 12+

Hydric Soil Present? **Yes** ___ **No** x

Remarks:

Old riprap prevents deep sampling. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/12/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D6

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.97372178 Long: -85.67555809 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil X, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area**
Hydric Soil Present?	Yes x	No ____	**within a Wetland?** **Yes** x **No** ____
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:

Remarks: (Explain alternative procedures here or in a separate report.)
Sandy fluvial deposits are naturally problematic.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

____ Surface Water (A1)	____ Water-Stained Leaves (B9)	____ Surface Soil Cracks (B6)
X High Water Table (A2)	____ Aquatic Fauna (B13)	____ Drainage Patterns (B10)
x Saturation (A3)	____ Marl Deposits (B15)	____ Moss Trim Lines (B16)
____ Water Marks (B1)	____ Hydrogen Sulfide Odor (C1)	____ Dry-Season Water Table (C2)
x Sediment Deposits (B2)	____ Oxidized Rhizospheres on Living Roots (C3)	____ Crayfish Burrows (C8)
x Drift Deposits (B3)	____ Presence of Reduced Iron (C4)	____ Saturation Visible on Aerial Imagery (C9)
____ Algal Mat or Crust (B4)	____ Recent Iron Reduction in Tilled Soils (C6)	____ Stunted or Stressed Plants (D1)
____ Iron Deposits (B5)	____ Thin Muck Surface (C7)	x Geomorphic Position (D2)
____ Inundation Visible on Aerial Imagery (B7)	____ Other (Explain in Remarks)	____ Shallow Aquitard (D3)
x Sparsely Vegetated Concave Surface (B8)		x Microtopographic Relief (D4)
		X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____	
Water Table Present?	Yes x	No ____	Depth (inches): 5	
Saturation Present? (includes capillary fringe)	Yes x	No ____	Depth (inches): 5	**Wetland Hydrology Present?** **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain within past 24 hours. Silt lines on tree bark. Debris piled against upstream side of rocks and trees. Concave position of floodplain.

VEGETATION – Use scientific names of plants. Sampling Point: D6

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	5	Yes	FAC
2.			
3.			
4.			
5.			
6.			
7.			
	5	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Salix interior*	80	Yes	FACW
2. *Ulmus americana*	5	No	FACW
3. *Fraxinus americana*	5	No	FACU
4. *Acer saccharinum*	3	No	FACW
5.			
6.			
7.			
	93	=Total Cover	
Herb Stratum (Plot size: 5' r)			
1. *Lythrum salicaria*	20	Yes	OBL
2. *Parthenocissus quinquefolia*	10	Yes	FACU
3. *Carex pellita*	5	No	OBL
4. *Boehmeria cylindrica*	3	No	OBL
5. *Vitis riparia*	2	No	FAC
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	40	=Total Cover	
Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
		=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 75.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	28	x 1 =	28
FACW species	88	x 2 =	176
FAC species	7	x 3 =	21
FACU species	15	x 4 =	60
UPL species	0	x 5 =	0
Column Totals:	138	(A)	285 (B)

Prevalence Index = B/A = 2.07

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- X 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of same community. Lythrum salicoria defoliated (Galerucella beetles?). Chrysemys picta basking outside sample in river.

SOIL

Sampling Point: D6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-8	10YR 3/2	100					Sandy	sandy loam; refusal - old boulder riprap

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- X Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: old riprap (boulders/cobbles)

Depth (inches): 8+

Hydric Soil Present? **Yes** X **No** ___

Remarks:

Soil sample allowed to dry to moist condition for inspection of redox features. No redox features were identified; however, soils are naturally problematic and assumed hydric because hydrology and vegetation criteria are satified. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/12/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D7

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.96851359 Long: -85.6742455 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area**	
Hydric Soil Present?	Yes x	No ____	**within a Wetland?**	**Yes** X **No** ____
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:	

Remarks: (Explain alternative procedures here or in a separate report.)

The community is located ~20' below the walkway/seawall. No access to ground level except for from river. Soil is assumed hydric based on position below OHWM. Soils were evaluated against data recorded at similar landscape postiion (e.g., D2)..

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- ____ High Water Table (A2)
- ____ Saturation (A3)
- ____ Water Marks (B1)
- x Sediment Deposits (B2)
- x Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- ____ Inundation Visible on Aerial Imagery (B7)
- x Sparsely Vegetated Concave Surface (B8)
- ____ Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- ____ Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- x Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____ No x	Depth (inches):	
Water Table Present?	Yes ____ No ____	Depth (inches):	?
Saturation Present? (includes capillary fringe)	Yes ____ No ____	Depth (inches):	?

Wetland Hydrology Present? **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Canopy cover on aerials. Anecdotal evidence: Client says area is frequently under water.

Remarks:

Rain within past 24 hours. Silt lines on tree bark. Debris piled against upstream side of rocks and trees. No access to dig soil pit. Geomorphic Position is an inappropriate indicator due to the rapidly permeable substrate and association to active drainageway.

VEGETATION – Use scientific names of plants. Sampling Point: D7

Tree Stratum (Plot size: 30' r modified)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	65	Yes	FAC
2. *Morus alba*	10	No	FACU
3. *Ulmus americana*	8	No	FACW
4.			
5.			
6.			
7.			
	83	=Total Cover	

Sapling/Shrub Stratum (Plot size: 15' r modified)			
1. *Acer negundo*	35	Yes	FAC
2. *Rhamnus cathartica*	10	Yes	FAC
3. *Acer saccharinum*	5	No	FACW
4.			
5.			
6.			
7.			
	50	=Total Cover	

Herb Stratum (Plot size: 5' r)			
1. *Euthamia graminifolia*	5	Yes	FAC
2. *Phalaris arundinacea*	5	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	10	=Total Cover	

Woody Vine Stratum (Plot size: 30' r modified)			
1. *Vitis riparia*	5	Yes	FAC
2.			
3.			
4.			
	5	=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	18	x 2 =	36
FAC species	120	x 3 =	360
FACU species	10	x 4 =	40
UPL species	0	x 5 =	0
Column Totals:	148 (A)		436 (B)

Prevalence Index = B/A = 2.95

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

X 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)
Modified width of sample plot to limited extent of same community.

SOIL

Sampling Point: D7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
	***							no access for sample

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- X Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** X **No** ___

Remarks:

No access to ground level. Soils were not sampled but are assumed to be hydric based on examination of reference sites with the same landscape position below OHWM. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/12/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D8

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): terrace Local relief (concave, convex, none): convex Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.97500115 Long: -85.67345894 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: PFO1A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil x, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No x	**Is the Sampled Area**
Hydric Soil Present?	Yes ____	No x	**within a Wetland?** **Yes** ____ **No** x
Wetland Hydrology Present?	Yes ____	No x	If yes, optional Wetland Site ID:

Remarks: (Explain alternative procedures here or in a separate report.)
sandy soils, fluvial deposits, Elevation ~609 ft (msl). Access from 6th Street Bridge Park, between managed landscape and seawall.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____
Water Table Present?	Yes ____	No x	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No x	Depth (inches): ____

Wetland Hydrology Present? **Yes** ____ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain within past 24 hours. Microtopographic relief over ~30% of the surface area (relief 8 inches above the base soil level). Uneven topography resulting from rocks, logs, and other debris and really not indicative of hydrology. Therefore, D4 is inappropriate indicator at this location.

VEGETATION – Use scientific names of plants. Sampling Point: D7

Tree Stratum (Plot size: 30' r)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Acer saccharinum*	10	No	FACW
2. *Populus deltoides*	35	Yes	FAC
3. *Ulmus americana*	10	No	FACW
4. *Ulmus pumila*	5	No	FACU
5.			
6.			
7.			
	60	=Total Cover	

Sapling/Shrub Stratum (Plot size: 15' r)			
1. *Ulmus pumila*	8	Yes	FACU
2. *Rhamnus cathartica*	10	Yes	FAC
3. *Salix interior*	5	No	FACW
4. *Prunus pensylvanica*	5	No	FACU
5. *Rosa multiflora*	3	No	FACU
6.			
7.			
	31	=Total Cover	

Herb Stratum (Plot size: 5' r)			
1. *Poa pratensis*	60	Yes	FACU
2. *Dactylis glomerata*	10	No	FACU
3. *Trifolium pratense*	10	No	FACU
4. *Plantago coronopus*	5	No	FACU
5. *Festuca paradoxa*	5	No	FAC
6. *Melilotus officinalis*	5	No	FACU
7. *Lythrum salicaria*	2	No	OBL
8. *Rorippa curvipes*	2	No	FACW
9.			
10.			
11.			
12.			
	99	=Total Cover	

Woody Vine Stratum (Plot size: 30' r modified)			
1. *Vitis riparia*	3	No	FAC
2.			
3.			
4.			
	3	=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	2	x 1 =	2
FACW species	27	x 2 =	54
FAC species	53	x 3 =	159
FACU species	111	x 4 =	444
UPL species	0	x 5 =	0
Column Totals:	193 (A)		659 (B)

Prevalence Index = B/A = 3.41

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks: (Include photo numbers here or on a separate sheet.)

Polygonum cuspidum immediately outside of sample and locally abundant. Also from same community but outside of the sample are Potentilla fruticosa and an unkown groundsel (Senecio sp.).

SOIL

Sampling Point: D8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 3/2	100					Sandy	Sandy loam - gravel through out, some organics; sand grains visible

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- x Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks:

Sandy fluvial deposits are a naturally problematic condition; however, the vegetation and hydrology criteria are not met. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/13/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D9

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): river bank Local relief (concave, convex, none): convex Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.98981028 Long: -85.67196484 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil x, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area**	
Hydric Soil Present?	Yes X	No ____	**within a Wetland?**	**Yes** X **No** ____
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:	

Remarks: (Explain alternative procedures here or in a separate report.)
sandy soils, fluvial deposits

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- ____ High Water Table (A2)
- ____ Saturation (A3)
- x Water Marks (B1)
- x Sediment Deposits (B2)
- x Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- ____ Inundation Visible on Aerial Imagery (B7)
- ____ Sparsely Vegetated Concave Surface (B8)
- x Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- ____ Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- ____ Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____
Water Table Present?	Yes ____	No x	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No x	Depth (inches): ____

Wetland Hydrology Present? **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain again; within past 24 hours. Near fringe of river. Otter midden in hollow log; several discarded mussel shales (unkown spp.).

VEGETATION – Use scientific names of plants. Sampling Point: D9

Tree Stratum (Plot size: 30' r)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Salix nigra*	40	Yes	OBL
2. *Acer saccharinum*	20	Yes	FACW
3. *Fraxinus pennsylvanica*	20	Yes	FACW
4. *Ulmus americana*	10	No	FACW
5.			
6.			
7.			
	90	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r)			
1. *Salix nigra*	10	Yes	OBL
2.			
3.			
4.			
5.			
6.			
7.			
	10	=Total Cover	
Herb Stratum (Plot size: 5' r)			
1. *Lysimachia nummularia*	25	Yes	FACW
2. *Carex cristatella*	20	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	45	=Total Cover	
Woody Vine Stratum (Plot size: 30' r modified)			
1. *Vitis riparia*	3	No	FAC
2.			
3.			
4.			
	3	=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	50	x 1 =	50
FACW species	95	x 2 =	190
FAC species	3	x 3 =	9
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	148 (A)		249 (B)

Prevalence Index = B/A = 1.68

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

x 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

Sagittaria peltatum immediately outside of sample. Bark abrasion evident on willows - perhaps boat encounter or ice scour.

SOIL

Sampling Point: D9

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-6	10YR 2/1	100					Sandy	~90% masked, many fine roots, sandy loam
6-16	10YR 2/1	100					Sandy	sandy loam few OM. Sand grains visible

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- x Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

OM = Organic Matter. Sandy fluvial deposits are a naturally problematic condition. Organic masking estimated without handlens. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/13/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D10

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): terrace Local relief (concave, convex, none): convex Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.98680284 Long: -85.67201948 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil x, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area**
Hydric Soil Present?	Yes x	No ____	**within a Wetland?** **Yes** x **No** ____
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:

Remarks: (Explain alternative procedures here or in a separate report.)
sandy soils, fluvial deposits

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- x High Water Table (A2)
- ____ Saturation (A3)
- x Water Marks (B1)
- x Sediment Deposits (B2)
- x Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- ____ Inundation Visible on Aerial Imagery (B7)
- ____ Sparsely Vegetated Concave Surface (B8)
- x Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- ____ Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- ____ Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No x	Depth (inches): ____
Water Table Present?	Yes x	No ____	Depth (inches): 9
Saturation Present? (includes capillary fringe)	Yes x	No ____	Depth (inches): 6

Wetland Hydrology Present? **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Rain within past 24 hours.

VEGETATION – Use scientific names of plants. Sampling Point: D10

Tree Stratum (Plot size: 30' r)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Salix nigra*	40	Yes	OBL
2. *Acer saccharinum*	40	Yes	FACW
3. *Fraxinus pennsylvanica*	15	No	FACW
4.			
5.			
6.			
7.			
	95	=Total Cover	
Sapling/Shrub Stratum (Plot size: 15' r)			
1. *Fraxinus pennsylvanica*	20	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
	20	=Total Cover	
Herb Stratum (Plot size: 5' r)			
1. *Phalaris arundinacea*	5	Yes	FACW
2. *Acer saccharinum*	2	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	7	=Total Cover	
Woody Vine Stratum (Plot size: 30' r modified)			
1. *Vitis riparia*	2	No	FAC
2.			
3.			
4.			
	2	=Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	40	x 1 =	40
FACW species	82	x 2 =	164
FAC species	2	x 3 =	6
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	124	(A)	210 (B)

Prevalence Index = B/A = 1.69

Hydrophytic Vegetation Indicators:

_ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

x 3 - Prevalence Index is ≤3.0[1]

_ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

_ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** _

Remarks: (Include photo numbers here or on a separate sheet.)
Iris versicolor immediately outside of sample and locally abundant.

SOIL

Sampling Point: D10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-12	7.5YR 2.5/1	95	7.5YR 4/6	5	C	M	Mucky Sand	greasy
12-16	10YR 4/1	98	5YR 4/4				Sandy	sandy silt loam

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- X Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- X Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- x Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ___

Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

Texture greasy and no grit/no plastic. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Grand River Whitewater Restoration Project City/County: Kent Sampling Date: 6/13/14

Applicant/Owner: City of Grand Rapids State: MI Sampling Point: D11

Investigator(s): Travis Morse Section, Township, Range:

Landform (hillside, terrace, etc.): river bank Local relief (concave, convex, none): convex Slope (%): 0-2

Subregion (LRR or MLRA): LRR L Lat: 42.98519301 Long: -85.6718763 Datum: NAD 83

Soil Map Unit Name: Urban Land NWI classification: R2UBH

Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes x No ____

Are Vegetation ____, Soil x, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area**	
Hydric Soil Present?	Yes x	No ____	**within a Wetland?**	**Yes** x **No** ____
Wetland Hydrology Present?	Yes X	No ____	If yes, optional Wetland Site ID:	

Remarks: (Explain alternative procedures here or in a separate report.)
sandy soils, fluvial deposits

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ____ Surface Water (A1)
- x High Water Table (A2)
- ____ Saturation (A3)
- x Water Marks (B1)
- x Sediment Deposits (B2)
- x Drift Deposits (B3)
- ____ Algal Mat or Crust (B4)
- ____ Iron Deposits (B5)
- x Inundation Visible on Aerial Imagery (B7)
- ____ Sparsely Vegetated Concave Surface (B8)
- x Water-Stained Leaves (B9)
- ____ Aquatic Fauna (B13)
- ____ Marl Deposits (B15)
- ____ Hydrogen Sulfide Odor (C1)
- ____ Oxidized Rhizospheres on Living Roots (C3)
- ____ Presence of Reduced Iron (C4)
- ____ Recent Iron Reduction in Tilled Soils (C6)
- ____ Thin Muck Surface (C7)
- ____ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ____ Surface Soil Cracks (B6)
- ____ Drainage Patterns (B10)
- ____ Moss Trim Lines (B16)
- ____ Dry-Season Water Table (C2)
- ____ Crayfish Burrows (C8)
- ____ Saturation Visible on Aerial Imagery (C9)
- ____ Stunted or Stressed Plants (D1)
- ____ Geomorphic Position (D2)
- ____ Shallow Aquitard (D3)
- ____ Microtopographic Relief (D4)
- X FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes x	No ____	Depth (inches):	0-2
Water Table Present?	Yes x	No ____	Depth (inches):	0
Saturation Present? (includes capillary fringe)	Yes x	No ____	Depth (inches):	0

Wetland Hydrology Present? **Yes** X **No** ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Several positive indicators are inappropriate due to recent rainfall and being contiguous with fringe of river.

VEGETATION – Use scientific names of plants. Sampling Point: D11

Tree Stratum (Plot size:)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
	=Total Cover		
Sapling/Shrub Stratum (Plot size: 15' r)			
1. *Cornus alba*	5	Yes	FACW
2. *Acer saccharinum*	3	Yes	FACW
3.			
4.			
5.			
6.			
7.			
	8 =Total Cover		
Herb Stratum (Plot size: 5' r)			
1. *Typha latifolia*	15	Yes	OBL
2. *Sagittaria latifolia*	12	Yes	OBL
3. *Iris pseudacorus*	3	No	OBL
4. *Phalaris arundinacea*	3	No	FACW
5. *Lythrum salicaria*	2	No	OBL
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	35 =Total Cover		
Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
	=Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	32	x 1 =	32
FACW species	11	x 2 =	22
FAC species	0	x 3 =	0
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	43 (A)		54 (B)

Prevalence Index = B/A = 1.26

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

x 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)
Freshwater marsh community. Sample limited to same community type.

SOIL

Sampling Point: D11

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 3/1	100					Sandy	sandy loam, particles >90% masked by organics
4-16	10YR 4/1	100					Sandy	sand grains visible

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- x Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
- ___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**)
- ___ High Chroma Sands (S11) (**LRR K, L)**
- ___ Loamy Mucky Mineral (F1) (**LRR K, L**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) (**LRR K, L**)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**)
- ___ Coast Prairie Redox (A16) (**LRR K, L, R**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
- ___ Polyvalue Below Surface (S8) (**LRR K, L**)
- ___ Thin Dark Surface (S9) (**LRR K, L**)
- ___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
- ___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
- ___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- x Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

Sandy, fluvial deposits. Observed without handlens. Data form is revised from Northcentral and Northeast Regional Supplement Version 2.0 to reflect the NRCS Field Indicators of Hydric Soils version 7.0 March 2013 Errata. (http://soils.usda.gov/use/hydric)

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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Golder Associates

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APPENDIX E

Other Supporting Information

Updated Wetland Delineation Report Fishbeck 2/2019

TRANSMITTAL

Mr. Jason Carey
River Restoration
PO Box 248
Carbondale, CO 81623

February 26, 2019

Re: Updated Wetland Delineation

Project No. 181779

☒ **FOR REVIEW**
☒ **FOR YOUR USE**
☐ **AS REQUESTED**

Sent By: Elise Hansen Tripp, PWS/lkj

COPIES	DATE	DESCRIPTION
1	2/2019	Updated Wetland Delineation, Grand River Whitewater Restoration Project, City of Grand Rapids, Kent County, Michigan

COMMENTS

If you have any questions or require additional information, please contact me at 616.464.3738 or email ehtripp@ftch.com.

By email
cc: Mr. Richard Bishop – Grand Rapids Whitewater
Mr. James E. Smalligan, PE – FTCH
Ms. Cheryl L. Pitchford – FTCH

Z:\2018\181779\WORK\REPT\TR_WTLND_DEL_RESTORATIONPROJECT_2019_0226.DOCX

Updated Wetland Delineation

Grand River Whitewater Restoration Project
City of Grand Rapids, Kent County
Michigan

Project No. 181779
February 2019






Fishbeck, Thompson, Carr & Huber, Inc.
engineers | scientists | architects | constructors

Updated Wetland Delineation

Grand River Whitewater Restoration Project
City of Grand Rapids, Kent County, Michigan

Prepared For:
River Restoration
Carbondale, Colorado

February 26, 2019
Project No. 181779

1515 Arboretum Drive, SE
Grand Rapids, Michigan 49546

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Fishbeck, Thompson, Carr & Huber, Inc.
engineers I scientists I architects I constructors

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List of Abbreviations/Acronyms

FAC	Facultative
FACU	Facultative Upland
FACW	Facultative Wetland
FTCH	Fishbeck, Thompson, Carr & Huber, Inc.
Golder	Golder Associates, Inc.
GPS	Global Positioning System
MDEQ	Michigan Department of Environmental Quality
NREPA	Natural Resources and Environmental Protection Act
OBL	Obligate
OHWM	ordinary high-water mark
UPL	Upland
USACE	U.S. Army of Corps of Engineers
USEPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit

1.0 Introduction

Grand Rapids Whitewater has proposed improvements along an urban reach of the Grand River in the City of Grand Rapids, Kent County, Michigan. In 2014, the project engineer, River Restoration, retained Golder Associates, Inc. (Golder) to delineate wetlands within the project area to determine project impacts to regulated wetlands under Section 404 of the federal Clean Water Act and Part 303 of Michigan's Natural Resources and Environmental Protection Act (NREPA). River Restoration has engaged the Michigan Department of Environmental Quality (MDEQ) regarding the proposed project, and the MDEQ has assigned a project file number of 11-41-0105-P.

Golder completed a draft wetland delineation report in 2014 that identified twelve wetland areas totaling 3.09 acres within the 13.25-acre Grand River Whitewater Restoration Project site (Golder, 2014). The twelve wetlands were located within nine areas of investigation (IA 1 through IA 9), extending from the Fulton Street bridge north to approximately 0.45 mile north of the Leonard Street bridge. On December 11, 2014, MDEQ staff inspected the flagged wetland boundaries and discussed the draft report with Golder staff. In a letter dated January 14, 2015 (Appendix 1), MDEQ staff confirmed the delineated wetland boundaries located above the river's ordinary high-water mark (OHWM). The letter also states most of the delineated wetlands are located below the OHWM.

Redelineation of site wetlands is required to obtain an MDEQ/U.S. Environmental Protection Agency (USEPA) Joint Permit for proposed river and wetland impacts, because Golder's wetland delineation occurred more than three years previously. River Restoration requested Fishbeck, Thompson, Carr & Huber, Inc. (FTCH) to complete wetland delineation of the first phase of the proposed river restoration project. The area impacted by Phase 1 extends from the Fulton Street bridge north to approximately 100 feet north of westbound Interstate I-196. This area of investigation corresponds to Golder's Investigation Areas IA 1 through IA 4. FTCH surveyed both sides of the Grand River within this area and evaluated the wetland status at seven of Golder's identified wetlands (W6 through W12).

This report summarizes the results of FTCH's wetland investigation. It is intended to be a supplement to Golder's 2014 report, which contained resource maps and in-office information not replicated in this report. The intent of this report is to provide current wetland boundaries to accurately determine wetland impacts resulting from the river restoration project and assist in making design choices that avoid and minimize wetland impacts.

2.0 Project Location and Description

The area of investigation extends approximately 0.7 mile along the Grand River, as indicated on Figure 1. Within this area, river frontage contained seawalls, armored banks, and vegetated buffer (both natural and managed). The area of investigation is located within the heart of downtown Grand Rapids; the surrounding landscape is highly developed and urbanized. Sidewalks, pedestrian pathways, and boardwalks were located within close proximity of the river edge throughout most of the area of investigation. Riverbanks were steep in some areas and contained evidence of historic fill (i.e., bricks, concrete slabs, and boulders).

3.0 Methods

FTCH conducted the field investigation on December 18, 2018. The river was not at flood stage and water levels were approximately 2 feet below a boardwalk extending over the east edge of the river.

The investigation was conducted in a manner consistent with the 1987 *Corps of Engineers Wetlands Delineation Manual* and 2012 *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* (Version 2). The wetlands identification and delineation procedures outlined in these manuals require evaluation of site vegetation, soils, and hydrologic characteristics. Dominant wetland vegetation, hydric soil, and wetland hydrology must all be present for an area to be classified as a wetland. Hydrophytic vegetation decisions are based on the wetland indicator status of species that are dominant in the plant community. Wetland indicator statuses were obtained from the *State of Michigan 2016 Wetland Plant List* (Lichvar et.al.). Species with indicator statuses of obligate wetland (OBL), facultative wetland (FACW), and facultative (FAC) are considered wetland species, while species with indicator statuses of facultative upland (FACU) and upland (UPL) are considered upland species. FAC species are also commonly present in upland plant communities.

A U.S. Army Corps of Engineers Wetland Determination Data Form was completed to describe site vegetation, soil, and hydrology at each sampling location (Appendix 2). FTCH flagged wetland boundaries with pink ribbon and surveyed the flags with a handheld GPS unit with submeter accuracy. The wetland boundaries are noted as solid fuchsia-colored lines on Figure 1. The approximate outer wetland boundary along the river's edge was estimated based upon the aerial photograph and is noted as a dashed purple line on Figure 1.

4.0 Results and Discussion

The field investigation was conducted on a sunny day with air temperatures ranging from 20°F to 38°F. The investigation was conducted weeks after a killing frost, which impaired identification of vegetation. The ground was not covered in snow, but it was frozen at some locations, which impeded examination of soil at sampling point SP-8.

Identified wetlands were numbered in a manner consistent with the Golder investigation and are discussed below. Photographs of each area are included in Appendix 3.

Wetland 6

The Golder report indicated Wetland W6 extended north, approximately 400 feet from Interstate I-196 on the west side of the Grand River, and it encompassed 0.15 acre of scrub-shrub wetland. FTCH investigated approximately 100 feet north from the highway, in accordance with the northern limit of Phase 1. No wetlands were observed along the river's edge in this area. The bank contained boulders and riprap (see the photograph in Appendix 3). Google Earth® aerial photographs indicate a partial dam was present halfway across the river in this area in September 2017. It was constructed to facilitate work on I-196. The dam was removed by September 2018. The boulders currently present at the south end of former Wetland W6 corresponds to the northern limit of the embankment.

Wetland 7

Wetland 7 is located on the west bank on the Grand River, between Interstate I-196 and Bridge Street. The associated steep bank contained an array of seawalls and hard armoring consisting of boulders and slabs of broken concrete. In some areas, boulders extend to the water's edge, with wetland vegetation growing around them. Wetland sampling point SP-7 was evaluated at the north end of Wetland 7 on a flood bench relatively free

of boulders. A test pit excavated to a depth of 17 inches verified the presence of wetland hydrology (soil saturation and the water table was within the surface foot) and wetland soil (prominent redox features). The dominant vegetation observed in the vicinity of SP-7 was reed canarygrass (*Phalaris arundinacea*, FACW). Other common species observed in Wetland 7 were purple loosestrife (*Lythrum salicaria*, OBL), riverbank grape (*Vitis riparia*, FAC), and red-osier dogwood (*Cornus alba*, FACW). FTCH flagged Wetland 7's boundaries with pink ribbons labelled 7-1 through 7-12.

Wetland 8

Wetland 8 consisted of floodplain forest on the west side of the Grand River, north and northeast of Ah-Nab-Awen Park. Golder's 2014 wetland delineation placed the eastern wetland boundary into the Grand River in some areas, thus overestimating the extent of this wetland. A flood bench containing forested wetland dominated with eastern cottonwood trees (*Populus deltoides*, FAC) was present along the river edge. Fluvial deposits of sand and gravel were observed on the ground surface throughout the flood bench. The adjacent slope steeply graded up 10 to 15 feet to the top-of-bank. The bank contained boulders and large blocks of concrete.

Sampling point SP-8 was evaluated on the flood bench near the south end of Wetland 8. Soil excavation was impeded by frozen ground at a depth of one inch. Surface soil consisted of a shallow layer of fluvial sand and gravel over darker topsoil consisting of sandy loam. The USACE recognizes fluvial deposits within a floodplain as a problematic hydric soil because they often lack hydric soil indicators. FTCH assumed the frozen soil indicated the presence of groundwater. This depth was consistent with the corresponding level of water in the adjacent river.

FTCH flagged the wetland boundary with pink ribbons labelled 8-1 through 8-10. A short seawall constructed from rocks and/or concrete chunks was located between flags 8-5 and 8-6.

Wetland 9

Wetland 9 is located on the east side of the river, directly west of the DeVos Place Convention Center and Performance Hall. An approximately 20-foot-high seawall is present along the river's edge throughout this area. The wall curves to the east, forming a cove. The only access to this area is from the river.

Sediment has accumulated within the cove, resulting in two distinct plant communities: floodplain forest in a relatively flat area along the river's edge, and a scrub-shrub plant community on an embankment next to the seawall (see photograph of Wetland 9 view from the west). The top-of-bank was approximately 5 feet above the floodplain elevation; no wetland hydrology indicators were observed on the embankment. The wetland boundary appeared to be at the toe of the embankment, which corresponded to the easternmost location of mature floodplain trees. The north and south limits of Wetland 9 were surveyed from a walkway overlooking the wetland. These points also correlated to the approximate wetland boundary. Wetland occupied approximately the western half of the area filled with sediment within the cove.

Sampling point SP-9 was located within the floodplain forest, approximately 25 feet west of the pedestrian pathway guardrail, as noted on Figure 1. Data included on the wetland determination data form was obtained visually from the pathway directly east of SP-9.

Wetland 10

Wetland 10 is located on the west side of the river, north of the Gillett Bridge and east of the Gerald R. Ford Presidential Museum. Two scrub-shrub wetlands were identified at the toe of a heavy riprap, armored bank in this area. The wetlands were separated by a concrete culvert with wing walls. The dominant species in the wetland were sandbar willow (*Salix exigua*, OBL) and reed canarygrass. FTCH was unable to excavate a soil pit at

sampling point SP-10 due to the presence of rock associated with the armored bank. Surface soil saturation was visible at SP-10, verifying wetland hydrology. This wetland has expanded to the north since Golder's 2014 wetland delineation.

FTCH flagged the wetland boundaries with pink ribbons labelled 10-1 through 10-3 for the southern wetland and 10-4 through 10-9 for the northern wetland.

Wetland 11

The Golder report indicated Wetland W11 was located on the west side of the Grand River, between the Gillett and Pearl Street Bridges, and consisted of 0.11 acre of floodplain forest. In this area, FTCH observed new sidewalk, concrete steps to the river's edge, and an armored bank containing heavy riprap (see photographs in Appendix 3). No wetlands were observed in this area. Google Earth® aerial photographs indicate site modifications were implemented between September 9, 2017, and September 22, 2018.

Wetland 12

Wetland 12 was located on the east side of the river, just north of the Fulton Street bridge. The wetland was confined to the toe of a steep, armored bank and primarily consisted of eastern cottonwood trees (*Populus deltoides*, FAC). The wetland was typically 2 to 3 feet wide along the river's edge. FTCH was unable to dig a test pit at sampling point SP-12 due to the presence of concrete and rocks associated with the embankment. The presence of hydric soil was assumed because SP-12 was located below the OHWM. Wetland hydrology was confirmed because surface water was at a similar elevation as SP-12 and within two feet of the sample plot. FTCH flagged the wetland boundaries with pink ribbons labelled 12-1 through 12-6.

5.0 Conclusions

According to Michigan's NREPA, Act 451, Section 30301(d), wetlands "contiguous to the Great Lakes or Lake St. Clair, an inland lake or pond, or a river or stream" or "more than 5 acres in size" are regulated by the State of Michigan. FTCH has delineated wetland boundaries for four wetlands contiguous to the Grand River within the area of investigation (Wetlands 7, 8, 10, and 12). FTCH verified the presence of a fifth wetland (Wetland 9) and, due to access restrictions, approximated its wetland boundaries based on remote field observation. Table 1 below summarizes the area and linear length of the identified wetlands. All the identified wetlands are regulated by the federal Clean Water Act and Part 303 of the NREPA because they are contiguous to the Grand River.

Table 1 – Summary of Delineated Wetlands
Rapids Restoration Project - Phase 1
Grand Rapids, Michigan

Wetland	Wetland Type	Size (square feet)	Size (acre)	Length (linear feet)
7	Emergent/scrub-shrub	5308	0.122	469
8	Floodplain forest	2170	0.050	385
9	Floodplain forest	2316	0.053	256
10	Scrub-shrub wetland	705	0.016	127
12	Floodplain forest	1503	0.035	200

FTCH verified that two wetlands identified by Golder in 2014 are no longer present (the south end of Wetland 6 and Wetland 11). These wetlands were removed during construction activities occurring along the river in 2017 or early 2018.

6.0 References

Golder Associates, Inc. October 14, 2014. *Wetland Delineation, Grand River Whitewater Restoration Project, City of Grand Rapids, Kent County, Michigan, Draft Report*.

Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *State of Michigan 2016 Wetland Plant List, The National Wetland Plant List: 2016 wetland ratings*. Phytoneuron 2016-30:1-17. Published 28 April 2016. ISSN 2153 733X

USACE. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. USACE Environmental Laboratory, Waterways Experiment Station, Vicksburg, MS.

USACE. 2012. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region. Version 2.0. ERDC/EL TR-12-1. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Figures

PLOT INFO: Z:\2018\181779\CAD\GIS\mapdoc\FIG01_SITE PLAN.mxd Date: 2/18/2019 9:20:08 AM User: ACS

Wetland Sampling Point

Delineated Wetland Boundary

Approximate Wetland Boundary

Area of Investigation

Former Wet and 6

See Inset

Wet and 7

SP-07

Wet and 8

SP-08

See Inset

Wet and 9

SP-09

See Inset

Wet and 10

SP-10

Former Wet and 11

See Inset

Wet and 12

SP-12

1 inch 100 feet

Gerald R Ford Fwy

I-196 E

I-196 W

US-131 S

US-131 N

Scribner Ave NW

Turner Ave NW

Mt Vernon Ave NW

Monroe Ave NW

Bond Ave NW

Ottawa Ave NW

Hastings St NW

Bridge St NW

Michigan St NW

Lyon St NW

Pearl St NW

Fulton St W

W Fulton St

Front Ave NW

Campau Ave NW

Market Ave SW

Louis St NW

Michigan Dr NW

River House Condominiums

Ah-Nab-Awen Park

Gerald R Ford Presidential Museum

Devos Place-1

Devos Place

Amway Grand Plaza

Amway Grand Plaza Hotel

Grand Rapids

Plaza Towers Apartments

Gillett Bridge

Blue Bridge

Esri, HERE, Garmin, © OpenStreetMap contributors, Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

SITE PLAN

NORTH

0 150 300 FEET

Grand River Restoration

Grand Rapids, Michigan

Wetland Delineation

FIGURE NO. 1

PROJECT NO. 181779

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Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

fishbeck, thompson, carr & huber, inc.

engineers
scientists
architects
constructors

fteh

Appendix 1

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

RICK SNYDER
GOVERNOR

DAN WYANT
DIRECTOR

January 14, 2015

VIA E-MAIL

Ms. Hattie Johnson
RiverRestoration
P.O. Box 245
Carbondale, Colorado 81623

Dear Ms. Johnson:

In follow-up to our previous discussion, the Department of Environmental Quality (DEQ), Water Resources Division (WRD) has reviewed the draft wetland delineation you provided. On December 11, 2014, Ms. Amanda Whitscell, Grand Rapids District Office, WRD, and I reviewed on-site the delineated wetlands that were mapped and discussed in the Golder Associates, Inc. draft wetland delineation report (October 2014).

According to the draft report and our on-site review, the majority of the total mapped wetland area indicated in the report appears to occur below the ordinary high water line of the Grand River. Because of this, we focused on the landward (outside the river) boundaries of the wetlands delineation within the project area and concur that this landward boundary is accurate.

If you have any questions, please contact me at 517-284-5534; gyekisk@michigan.gov; or DEQ, P.O. Box 30458, Lansing, Michigan 48909-7958.

Sincerely,

Keto Gyekis
Wetlands, Lakes, and Streams Unit
Surface Water Assessment Section
Water Resources Division

cc: Mr. Luis Saldivia, DEQ
Ms. Amanda Whitscell, DEQ

Appendix 2

WETLAND DETERMINATION DATA FORM - Northcentral and Northeast Region

Project/Site: Grand River Restoration **City/County:** Grand Rapids/Kent **Sampling Date:** 18-Dec-18

Applicant/Owner: River Restoration **State:** Michigan **Sampling Point:** SP-7

Investigator(s): Elise Tripp **Section, Township, Range:** S. 24 T. 7N R. 12W

Landform (hillslope, terrace, etc.): Floodplain **Local relief (concave, convex, none):** convex **Slope:** 29.0 % / 16.1 °

Subregion (LRR or MLRA): LRR L **Lat.:** 42.972019 **Long.:** -85.675653 **Datum:** WGS84

Soil Map Unit Name: Urban land **NWI classification:** R2UBH

Are climatic/hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ **(If no, explain in Remarks.)**

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **significantly disturbed?** **Are "Normal Circumstances" present?** Yes ◉ No ○

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **naturally problematic?** **(If needed, explain any answers in Remarks.)**

Summary of Findings - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	**Is the Sampled Area within a Wetland?**	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks: (Explain alternative procedures here or in a separate report.)

Hydrology

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☑ High Water Table (A2)
- ☑ Saturation (A3)
- ☐ Water Marks (B1)
- ☑ Sediment Deposits (B2)
- ☐ Drift deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of 2 required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☑ FAC-neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○ No ◉	Depth (inches):	0	
Water Table Present?	Yes ◉ No ○	Depth (inches):	9	
Saturation Present? (includes capillary fringe)	Yes ◉ No ○	Depth (inches):	6	**Wetland Hydrology Present?** Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Depositional sand and gravel observed in spots within Wetland 7. Boulders have been placed to the edge of water to stabilize this area. Wetland boundary was flagged with pink ribbon labelled 7-1 through 7-12.

VEGETATION - Use scientific names of plants

Sampling Point: SP-7

Tree Stratum (Plot size: 30' radius modi)	Absolute % Cover	Dominant Species?	Indicator Status
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15' modified ra)			
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	0	= Total Cover	
Herb Stratum (Plot size: 5' modified rad)			
1. *Phalaris arundinacea*	45	☑	FACW
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
8.	0	☐	
9.	0	☐	
10.	0	☐	
11.	0	☐	
12.	0	☐	
	45	= Total Cover	
Woody Vine Stratum (Plot size: 30' modified ra)			
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
	0	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

	Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0	
FACW species	45	x 2 =	90	
FAC species	0	x 3 =	0	
FACU species	0	x 4 =	0	
UPL species	0	x 5 =	0	
Column Totals:	45	(A)	90	(B)

Prevalence Index = B/A = 2.000

Hydrophytic Vegetation Indicators:

- ☑ **Rapid Test for Hydrophytic Vegetation**
- ☑ **Dominance Test is > 50%**
- ☑ **Prevalence Index is ≤3.0** [1]
- ☐ **Morphological Adaptations** [1] **(Provide supporting data in Remarks or on a separate sheet)**
- ☐ **Problematic Hydrophytic Vegetation** [1] **(Explain)**

[1] **Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.**

Definitions of Vegetation Strata:

Tree - Woody plants, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub - Woody plants less than 3 in. DBH and greater than 3.28 ft (1m) tall..

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine - All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ◉ **No** ○

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of the same plant community. Plot observed after a killing frost.

*Indicator suffix = National status or professional decision assigned because Regional status not defined by FWS.

Soil

Sampling Point: SP-7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)		%	Redox Features Color (moist)		%	Type [1]	Loc²	Texture	Remarks
0-17	10YR	3/2	90	7.5YR	4/6	10	RM	M	Loamy Sand	

[1] Type: C=Concentration. D=Depletion. RM=Reduced Matrix, CS=Covered or Coated Sand Grains ²Location: PL=Pore Lining. M=Matrix

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Muck Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☑ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) (LRR R, MLRA 149B)
- ☐ Polyvalue Below Surface (S8) (LRR R, MLRA 149B)
- ☐ Thin Dark Surface (S9) (LRR R, MLRA 149B)
- ☐ Loamy Mucky Mineral (F1) LRR K, L)
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils : [3]

- ☐ 2 cm Muck (A10) (LRR K, L, MLRA 149B)
- ☐ Coast Prairie Redox (A16) (LRR K, L, R)
- ☐ 5 cm Mucky Peat or Peat (S3) (LRR K, L, R)
- ☐ Dark Surface (S7) (LRR K, L, M)
- ☐ Polyvalue Below Surface (S8) (LRR K, L)
- ☐ Thin Dark Surface (S9) (LRR K, L)
- ☐ Iron-Manganese Masses (F12) (LRR K, L, R)
- ☐ Piedmont Floodplain Soils (F19) (MLRA 149B)
- ☐ Mesic Spodic (TA6) (MLRA 144A, 145, 149B)
- ☐ Red Parent Material (F21)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ◉ No ○

Remarks:

WETLAND DETERMINATION DATA FORM - Northcentral and Northeast Region

Project/Site: Grand River Restoration **City/County:** Grand Rapids/Kent **Sampling Date:** 18-Dec-18

Applicant/Owner: River Restoration **State:** Michigan **Sampling Point:** SP-8

Investigator(s): Elise Tripp **Section, Township, Range:** S. 25 T. 7N R. 12W

Landform (hillslope, terrace, etc.): Floodplain **Local relief (concave, convex, none):** concave **Slope:** 5.0 % / 2.9 °

Subregion (LRR or MLRA): LRR L **Lat.:** 42.969061 **Long.:** -85.676020 **Datum:** WGS84

Soil Map Unit Name: Urban land **NWI classification:** R2UBH

Are climatic/hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ **(If no, explain in Remarks.)**

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **significantly disturbed?** **Are "Normal Circumstances" present?** Yes ◉ No ○

Are Vegetation ☐ **, Soil** ☑ **, or Hydrology** ☐ **naturally problematic?** **(If needed, explain any answers in Remarks.)**

Summary of Findings - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	**Is the Sampled Area within a Wetland?**	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks: (Explain alternative procedures here or in a separate report.)

Fluvial deposits wtihin a floodplain are a problematic hydric soil. Hydric soil is assumed because groundwater was encountered at a depth of 1 inch. The wetland boundary was flagged with flags 8-1 through 8-10.

Hydrology

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☑ High Water Table (A2)
- ☑ Saturation (A3)
- ☐ Water Marks (B1)
- ☑ Sediment Deposits (B2)
- ☐ Drift deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☑ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of 2 required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☑ FAC-neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches):	
Water Table Present?	Yes ◉	No ○	Depth (inches): 1	**Wetland Hydrology Present?** Yes ◉ No ○
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): 0	

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Silt lines on tree bark. Concave relief on floodplain, next to steep bank 10 to 15 feet high.

VEGETATION - Use scientific names of plants

Sampling Point: SP-8

Tree Stratum (Plot size: 30' radius modi)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	85	☑	FAC
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	85	= Total Cover	

Sapling/Shrub Stratum (Plot size:)			
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	0	= Total Cover	

Herb Stratum (Plot size: 5' modified rad)			
1. *Phalaris arundinacea*	35	☑	FACW
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
8.	0	☐	
9.	0	☐	
10.	0	☐	
11.	0	☐	
12.	0	☐	
	35	= Total Cover	

Woody Vine Stratum (Plot size: 30' modified ra)			
1. *Vitis riparia*	5	☑	FAC
2.	0	☐	
3.	0	☐	
4.	0	☐	
	5	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:		
OBL species	0	x 1 =	0	
FACW species	35	x 2 =	70	
FAC species	90	x 3 =	270	
FACU species	0	x 4 =	0	
UPL species	0	x 5 =	0	
Column Totals:	125	(A)	340	(B)

Prevalence Index = B/A = 2.720

Hydrophytic Vegetation Indicators:

- ☐ **Rapid Test for Hydrophytic Vegetation**
- ☑ **Dominance Test is > 50%**
- ☑ **Prevalence Index is ≤3.0** [1]
- ☐ **Morphological Adaptations** [1] **(Provide supporting data in Remarks or on a separate sheet)**
- ☐ **Problematic Hydrophytic Vegetation** [1] **(Explain)**

[1] **Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.**

Definitions of Vegetation Strata:

Tree - Woody plants, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub - Woody plants less than 3 in. DBH and greater than 3.28 ft (1m) tall..

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine - All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ◉ **No** ○

Remarks: (Include photo numbers here or on a separate sheet.)

*Indicator suffix = National status or professional decision assigned because Regional status not defined by FWS.

Soil

Sampling Point: SP-8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type [1]	Loc²	Texture	Remarks
0-1	10YR 7/1						Sand	Gravelly
1+	10YR 2/1						Sandy Loam	

[1] Type: C=Concentration. D=Depletion. RM=Reduced Matrix, CS=Covered or Coated Sand Grains ²Location: PL=Pore Lining. M=Matrix

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Muck Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) (LRR R, MLRA 149B)
- ☐ Polyvalue Below Surface (S8) (LRR R, MLRA 149B)
- ☐ Thin Dark Surface (S9) (LRR R, MLRA 149B)
- ☐ Loamy Mucky Mineral (F1) LRR K, L)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils : [3]

- ☐ 2 cm Muck (A10) (LRR K, L, MLRA 149B)
- ☐ Coast Prairie Redox (A16) (LRR K, L, R)
- ☐ 5 cm Mucky Peat or Peat (S3) (LRR K, L, R)
- ☐ Dark Surface (S7) (LRR K, L, M)
- ☐ Polyvalue Below Surface (S8) (LRR K, L)
- ☐ Thin Dark Surface (S9) (LRR K, L)
- ☐ Iron-Manganese Masses (F12) (LRR K, L, R)
- ☐ Piedmont Floodplain Soils (F19) (MLRA 149B)
- ☐ Mesic Spodic (TA6) (MLRA 144A, 145, 149B)
- ☐ Red Parent Material (F21)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: Frozen

Depth (inches): 1

Hydric Soil Present? Yes ◉ No ○

Remarks:

Surface fluvial deposits of sand and gravel.Hydric soil is assumed because groundwater was encountered at a depth of 1 inch.

WETLAND DETERMINATION DATA FORM - Northcentral and Northeast Region

Project/Site: Grand River Restoration **City/County:** Grand Rapids/Kent **Sampling Date:** 18-Dec-18

Applicant/Owner: River Restoration **State:** Michigan **Sampling Point:** SP-9

Investigator(s): Elise Tripp **Section, Township, Range:** **S.** 25 **T.** 7N **R.** 12W

Landform (hillslope, terrace, etc.): Floodplain **Local relief (concave, convex, none):** convex **Slope:** 20.0 % / 11.3 °

Subregion (LRR or MLRA): LRR L **Lat.:** 42.9687.24 **Long.:** -85.674252 **Datum:** WGS84

Soil Map Unit Name: Urban land **NWI classification:** R2UBH

Are climatic/hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ **(If no, explain in Remarks.)**

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **significantly disturbed?** **Are "Normal Circumstances" present?** Yes ◉ No ○

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **naturally problematic?** **(If needed, explain any answers in Remarks.)**

Summary of Findings - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	**Is the Sampled Area within a Wetland?**	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks: (Explain alternative procedures here or in a separate report.)

Wetland was not accessible except from river. The plant community is approximately 20 feet below the walkway/seawall. Soil is assumed hydric based on position below the OHWM. Grade sloped down from seawall to the edge of water. Wetland boundary is approximately halfway between the seawall and the river's edge.

Hydrology

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☑ Drift deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☑ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☑ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of 2 required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☑ FAC-neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○ No ◉	Depth (inches):	0	
Water Table Present?	Yes ○ No ◉	Depth (inches):		**Wetland Hydrology Present?** Yes ◉ No ○
Saturation Present? (includes capillary fringe)	Yes ○ No ◉	Depth (inches):		

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Anecdotal evidence: client says area is frequently under water.

Remarks:

No access to dig soil pit.

VEGETATION - Use scientific names of plants

Sampling Point: SP-9

Tree Stratum (Plot size: 30' radius modi)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	50	☑	FAC
2. *Acer rubrum*	25	☑	FAC
3. *Ulmus americana*	10	☐	FACW
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	85	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15' modified ra)			
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	0	= Total Cover	
Herb Stratum (Plot size: 5' modified rad)			
1. *Phalaris arundinacea*	5	☑	FACW
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
8.	0	☐	
9.	0	☐	
10.	0	☐	
11.	0	☐	
12.	0	☐	
	5	= Total Cover	
Woody Vine Stratum (Plot size: 30' modified ra)			
1. *Vitis riparia*	5	☑	FAC
2.	0	☐	
3.	0	☐	
4.	0	☐	
	5	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

	Total % Cover of:	Multiply by:	
OBL species	0	x 1 =	0
FACW species	15	x 2 =	30
FAC species	80	x 3 =	240
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	95 (A)		270 (B)

Prevalence Index = B/A = 2.842

Hydrophytic Vegetation Indicators:

- ☐ **Rapid Test for Hydrophytic Vegetation**
- ☑ **Dominance Test is > 50%**
- ☑ **Prevalence Index is ≤3.0** [1]
- ☐ **Morphological Adaptations** [1] **(Provide supporting data in Remarks or on a separate sheet)**
- ☐ **Problematic Hydrophytic Vegetation** [1] **(Explain)**

[1] **Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.**

Definitions of Vegetation Strata:

Tree - Woody plants, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub - Woody plants less than 3 in. DBH and greater than 3.28 ft (1m) tall..

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine - All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ◉ **No** ○

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of sample plot to limited extent of the same plant community. Plot observed after a killing frost.

*Indicator suffix = National status or professional decision assigned because Regional status not defined by FWS.

Soil

Sampling Point: SP-9

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type [1]	Loc²	Texture	Remarks

[1] Type: C=Concentration. D=Depletion. RM=Reduced Matrix, CS=Covered or Coated Sand Grains ²Location: PL=Pore Lining. M=Matrix

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Muck Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) (LRR R, MLRA 149B)
- ☐ Polyvalue Below Surface (S8) (LRR R, MLRA 149B)
- ☐ Thin Dark Surface (S9) (LRR R, MLRA 149B)
- ☐ Loamy Mucky Mineral (F1) LRR K, L)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils : [3]

- ☐ 2 cm Muck (A10) (LRR K, L, MLRA 149B)
- ☐ Coast Prairie Redox (A16) (LRR K, L, R)
- ☐ 5 cm Mucky Peat or Peat (S3) (LRR K, L, R)
- ☐ Dark Surface (S7) (LRR K, L, M)
- ☐ Polyvalue Below Surface (S8) (LRR K, L)
- ☐ Thin Dark Surface (S9) (LRR K, L)
- ☐ Iron-Manganese Masses (F12) (LRR K, L, R)
- ☐ Piedmont Floodplain Soils (F19) (MLRA 149B)
- ☐ Mesic Spodic (TA6) (MLRA 144A, 145, 149B)
- ☐ Red Parent Material (F21)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ◉ No ○

Remarks:

No access to dig a soil pit. Assume hydric soil is present due to position below the OHWM.

WETLAND DETERMINATION DATA FORM - Northcentral and Northeast Region

Project/Site: Grand River Restoration **City/County:** Grand Rapids/Kent **Sampling Date:** 18-Dec-18

Applicant/Owner: River Restoration **State:** Michigan **Sampling Point:** **SP-10**

Investigator(s): Elise Tripp **Section, Township, Range:** **S.** 25 **T.** 7N **R.** 12W

Landform (hillslope, terrace, etc.): Floodplain **Local relief (concave, convex, none):** convex **Slope:** 20.0 % / 11.3 °

Subregion (LRR or MLRA): LRR L **Lat.:** 42.967926 **Long.:** -85.676123 **Datum:** WGS84

Soil Map Unit Name: Urban land **NWI classification:** R2UBH

Are climatic/hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ **(If no, explain in Remarks.)**

Are Vegetation ☐ **, Soil** ☑ **, or Hydrology** ☐ **significantly disturbed?** **Are "Normal Circumstances" present?** Yes ○ No ◉

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **naturally problematic?** **(If needed, explain any answers in Remarks.)**

Summary of Findings - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	**Is the Sampled Area within a Wetland?**	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks: (Explain alternative procedures here or in a separate report.)

Soil could not be evaluated due to the prevalence of rock and boulders on the ground surface. Rock was 1 to 3 feet in diameter. Wetland determination was based on observed vegetation and hydrology indicators.Wetland 10 consisted to two segments. The southern segment consisted of wetland flags 10-1 to 10-3. The northern segment consisted of wetland flags 10-4 through 10-9.

Hydrology

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☑ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of 2 required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☑ FAC-neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○ No ◉	Depth (inches):		
Water Table Present?	Yes ○ No ◉	Depth (inches):		
Saturation Present? (includes capillary fringe)	Yes ◉ No ○	Depth (inches):	0	**Wetland Hydrology Present?** Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION - Use scientific names of plants

Sampling Point: SP-10

Tree Stratum (Plot size: 30' radius modi)	Absolute % Cover	Dominant Species?	Indicator Status
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15' modified ra)			
1. *Salix exigua*	70	☑	OBL
2. *Fraxinus pennsylvanica*	5	☐	FACW
3. *Cornus alba*	5	☐	FACW
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	80	= Total Cover	
Herb Stratum (Plot size: 5' modified rad)			
1. *Phalaris arundinacea*	50	☑	FACW
2. *Lythrum salicaria*	5	☐	OBL
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
8.	0	☐	
9.	0	☐	
10.	0	☐	
11.	0	☐	
12.	0	☐	
	55	= Total Cover	
Woody Vine Stratum (Plot size: 30' modified ra)			
1. *Vitis riparia*	5	☑	FAC
2.	0	☐	
3.	0	☐	
4.	0	☐	
	5	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

	Total % Cover of:	Multiply by:		
OBL species	75	x 1 =	75	
FACW species	60	x 2 =	120	
FAC species	5	x 3 =	15	
FACU species	0	x 4 =	0	
UPL species	0	x 5 =	0	
Column Totals:	140	(A)	210	(B)

Prevalence Index = B/A = 1.500

Hydrophytic Vegetation Indicators:

- ☐ **Rapid Test for Hydrophytic Vegetation**
- ☑ **Dominance Test is > 50%**
- ☑ **Prevalence Index is ≤3.0** [1]
- ☐ **Morphological Adaptations** [1] **(Provide supporting data in Remarks or on a separate sheet)**
- ☐ **Problematic Hydrophytic Vegetation** [1] **(Explain)**

[1] **Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.**

Definitions of Vegetation Strata:

Tree - Woody plants, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub - Woody plants less than 3 in. DBH and greater than 3.28 ft (1m) tall..

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine - All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ◉ **No** ○

Remarks: (Include photo numbers here or on a separate sheet.)

Modified width of the sample plot to limited extent of the same plant community. Plot observed after a killing frost.

*Indicator suffix = National status or professional decision assigned because Regional status not defined by FWS.

Soil

Sampling Point: SP-10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type [1]	Loc²	Texture	Remarks

[1] Type: C=Concentration. D=Depletion. RM=Reduced Matrix, CS=Covered or Coated Sand Grains ²Location: PL=Pore Lining. M=Matrix

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Muck Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) (LRR R, MLRA 149B)
- ☐ Polyvalue Below Surface (S8) (LRR R, MLRA 149B)
- ☐ Thin Dark Surface (S9) (LRR R, MLRA 149B)
- ☐ Loamy Mucky Mineral (F1) LRR K, L)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils : [3]

- ☐ 2 cm Muck (A10) (LRR K, L, MLRA 149B)
- ☐ Coast Prairie Redox (A16) (LRR K, L, R)
- ☐ 5 cm Mucky Peat or Peat (S3) (LRR K, L, R)
- ☐ Dark Surface (S7) (LRR K, L, M)
- ☐ Polyvalue Below Surface (S8) (LRR K, L)
- ☐ Thin Dark Surface (S9) (LRR K, L)
- ☐ Iron-Manganese Masses (F12) (LRR K, L, R)
- ☐ Piedmont Floodplain Soils (F19) (MLRA 149B)
- ☐ Mesic Spodic (TA6) (MLRA 144A, 145, 149B)
- ☐ Red Parent Material (F21)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: Rock

Depth (inches): 0

Hydric Soil Present? Yes ◉ No ○

Remarks:

Soil refusal due to rock and boulders at ground surface. Assume hydric soil is present due to location below the OHWM.

WETLAND DETERMINATION DATA FORM - Northcentral and Northeast Region

Project/Site: Grand River Restoration **City/County:** Grand Rapids/Kent **Sampling Date:** 18-Dec-18

Applicant/Owner: River Restoration **State:** Michigan **Sampling Point:** SP-12

Investigator(s): Elise Tripp **Section, Township, Range:** S. 25 T. 7N R. 12W

Landform (hillslope, terrace, etc.): Hillside **Local relief (concave, convex, none):** convex **Slope:** 20.0 % / 11.3 °

Subregion (LRR or MLRA): LRR L **Lat.:** 42.963821 **Long.:** -85.674937 **Datum:** WGS84

Soil Map Unit Name: Urban land **NWI classification:** R2UBH

Are climatic/hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ **(If no, explain in Remarks.)**

Are Vegetation ☐ **, Soil** ☑ **, or Hydrology** ☐ **significantly disturbed?** **Are "Normal Circumstances" present?** Yes ○ No ◉

Are Vegetation ☐ **, Soil** ☐ **, or Hydrology** ☐ **naturally problematic?** **(If needed, explain any answers in Remarks.)**

Summary of Findings - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	**Is the Sampled Area within a Wetland?**	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks: (Explain alternative procedures here or in a separate report.)

Hillside is armored with a concrete/rock wall. Wetland is confined to the toe of slope at the edge of the river and is generally 2 to 3 feet wide. Could not excavate a test pit due to rock and concrete.Wetland boundary flagged with flags numbered 12-1 through 12-6.

Hydrology

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☑ Surface Water (A1)
- ☑ High Water Table (A2)
- ☑ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of 2 required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☐ FAC-neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ◉ No ○	Depth (inches):	5
Water Table Present?	Yes ◉ No ○	Depth (inches):	0
Saturation Present? (includes capillary fringe)	Yes ◉ No ○	Depth (inches):	0

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION - Use scientific names of plants

Sampling Point: SP-12

Tree Stratum (Plot size: 30' radius modi)	Absolute % Cover	Dominant Species?	Indicator Status
1. *Populus deltoides*	90	☑	FAC
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	90	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15' modified ra)			
1. *Rhamnus cathartica*	5	☑	FAC
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
	5	= Total Cover	
Herb Stratum (Plot size: 5' modified rad)			
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
5.	0	☐	
6.	0	☐	
7.	0	☐	
8.	0	☐	
9.	0	☐	
10.	0	☐	
11.	0	☐	
12.	0	☐	
	0	= Total Cover	
Woody Vine Stratum (Plot size: 30' modified ra)			
1.	0	☐	
2.	0	☐	
3.	0	☐	
4.	0	☐	
	0	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

	Total % Cover of:	Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	95	x 3 =	285
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	95 (A)		285 (B)

Prevalence Index = B/A = 3.000

Hydrophytic Vegetation Indicators:

- ☐ **Rapid Test for Hydrophytic Vegetation**
- ☑ **Dominance Test is > 50%**
- ☑ **Prevalence Index is ≤3.0** [1]
- ☐ **Morphological Adaptations** [1] **(Provide supporting data in Remarks or on a separate sheet)**
- ☐ **Problematic Hydrophytic Vegetation** [1] **(Explain)**

[1] **Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.**

Definitions of Vegetation Strata:

Tree - Woody plants, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub - Woody plants less than 3 in. DBH and greater than 3.28 ft (1m) tall..

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine - All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ◉ **No** ○

Remarks: (Include photo numbers here or on a separate sheet.)

Modified radius of sample plot to limited extent of the same community. Plot was observed after a killing frost. Rock and concrete inhibit plant growth.

*Indicator suffix = National status or professional decision assigned because Regional status not defined by FWS.

Soil

Sampling Point: SP-12

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type [1]	Loc²	Texture	Remarks

[1] Type: C=Concentration. D=Depletion. RM=Reduced Matrix, CS=Covered or Coated Sand Grains ²Location: PL=Pore Lining. M=Matrix

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Muck Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) (LRR R, MLRA 149B)
- ☐ Polyvalue Below Surface (S8) (LRR R, MLRA 149B)
- ☐ Thin Dark Surface (S9) (LRR R, MLRA 149B)
- ☐ Loamy Mucky Mineral (F1) LRR K, L)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils : [3]

- ☐ 2 cm Muck (A10) (LRR K, L, MLRA 149B)
- ☐ Coast Prairie Redox (A16) (LRR K, L, R)
- ☐ 5 cm Mucky Peat or Peat (S3) (LRR K, L, R)
- ☐ Dark Surface (S7) (LRR K, L, M)
- ☐ Polyvalue Below Surface (S8) (LRR K, L)
- ☐ Thin Dark Surface (S9) (LRR K, L)
- ☐ Iron-Manganese Masses (F12) (LRR K, L, R)
- ☐ Piedmont Floodplain Soils (F19) (MLRA 149B)
- ☐ Mesic Spodic (TA6) (MLRA 144A, 145, 149B)
- ☐ Red Parent Material (F21)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: Rock and concrete fill

Depth (inches): 0

Hydric Soil Present? Yes ◉ No ○

Remarks:

Could not excavate a test pit due to rock and concrete. Soil was not examined. Assumed hydric soil because location is below the OHWM.

Appendix 3

Fishbeck, Thompson, Carr & Huber, Inc.

Photographs
Wetland Delineation
Grand River Restoration
Grand Rapids, Michigan

fTC&h

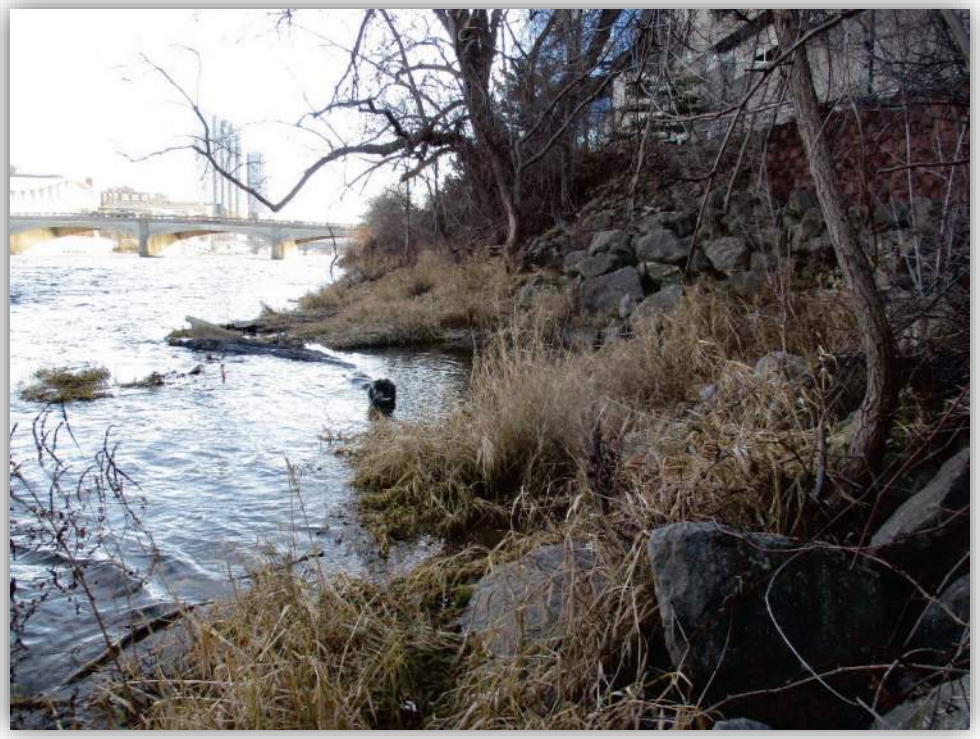
Project No. 181779

Former Wetland 6



Viewed from the South

Wetland 7

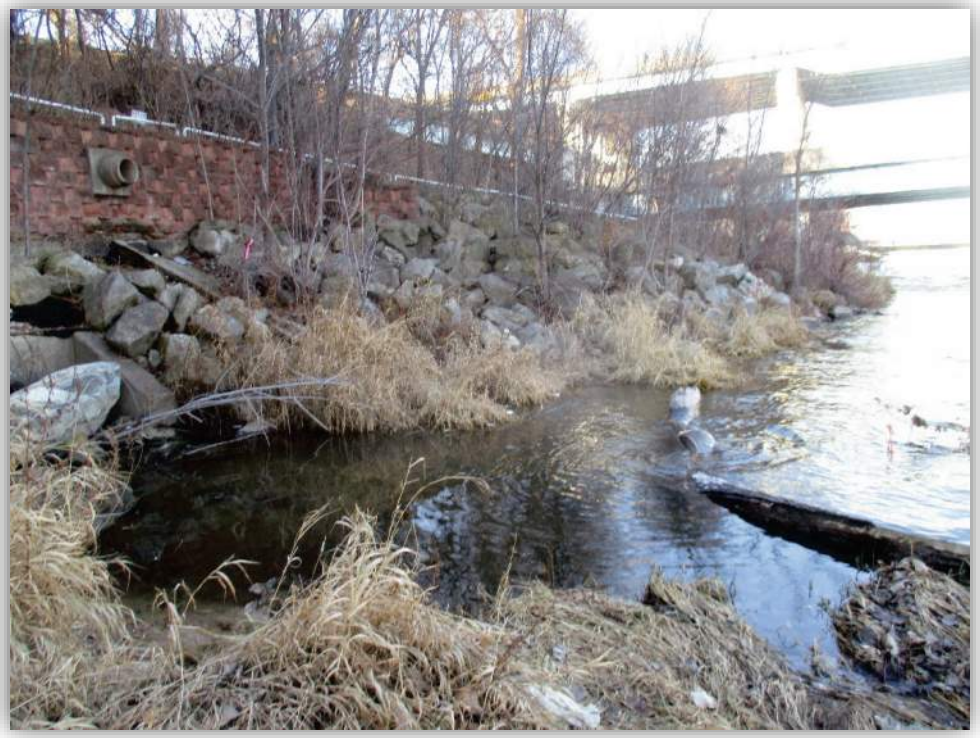


Viewed from the North



Viewed from the South

Wetland 7



Looking North from SP-7



Looking South from SP-7



Sampling Point SP-7

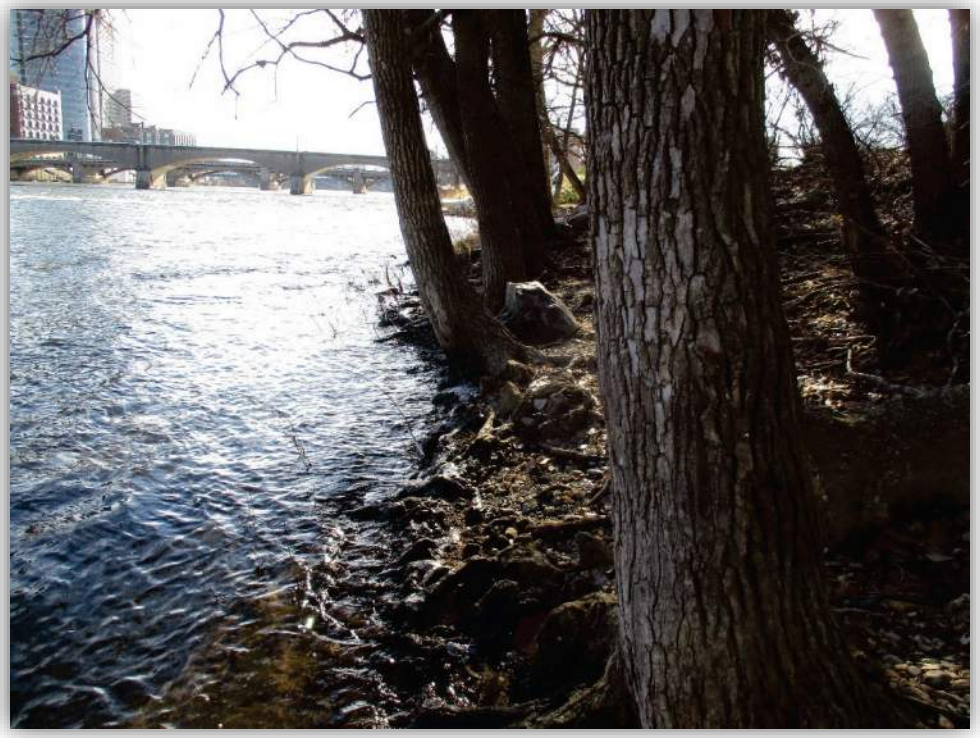


Sampling Point SP-8

Wetland 8



Looking North from SP-8

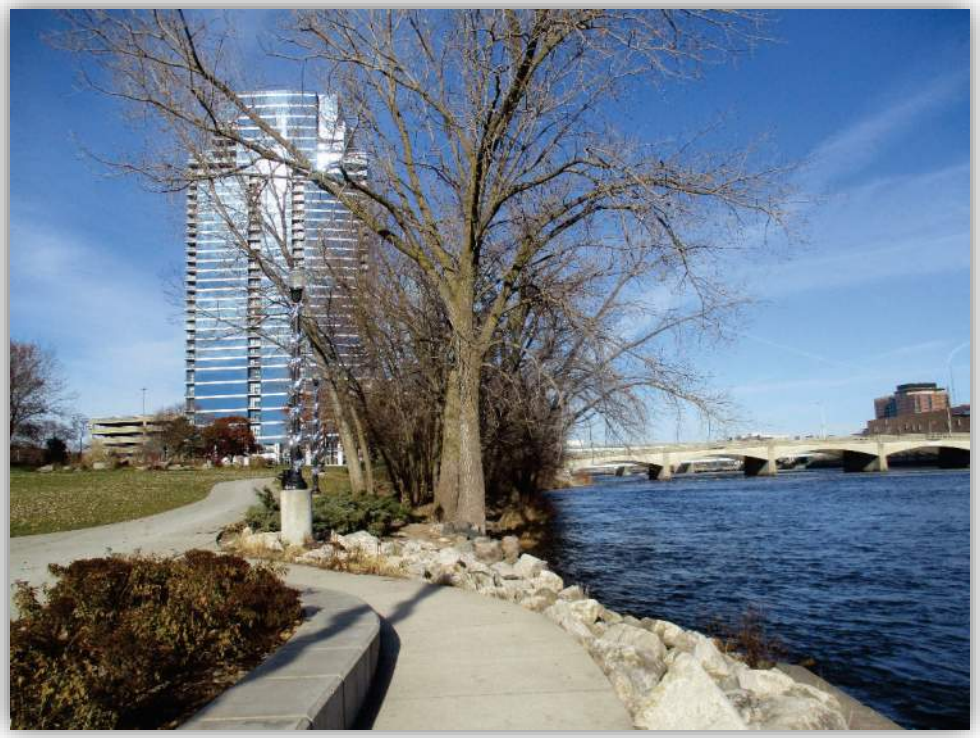


Looking South from SP-8

Wetland 8



Viewed from the North



Viewed from the South

Wetland 8



Floodwall Viewed from the North



Floodwall Viewed from the South

Wetland 9



Viewed from the South



Viewed from the North

Wetland 9



Viewed from the West



Sampling Point SP-9
(Viewed from Eastern Walkway)

Wetland 9



Looking North from SP-9



Looking South from SP-9

Wetland 10



Sampling Point SP-10



Looking North from SP-10

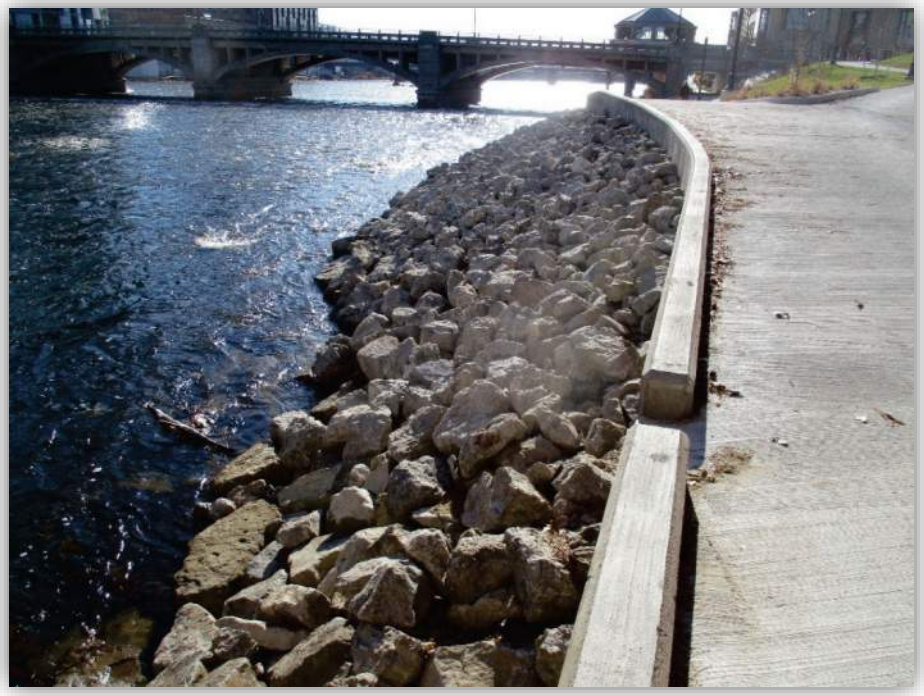


Looking South from SP-10

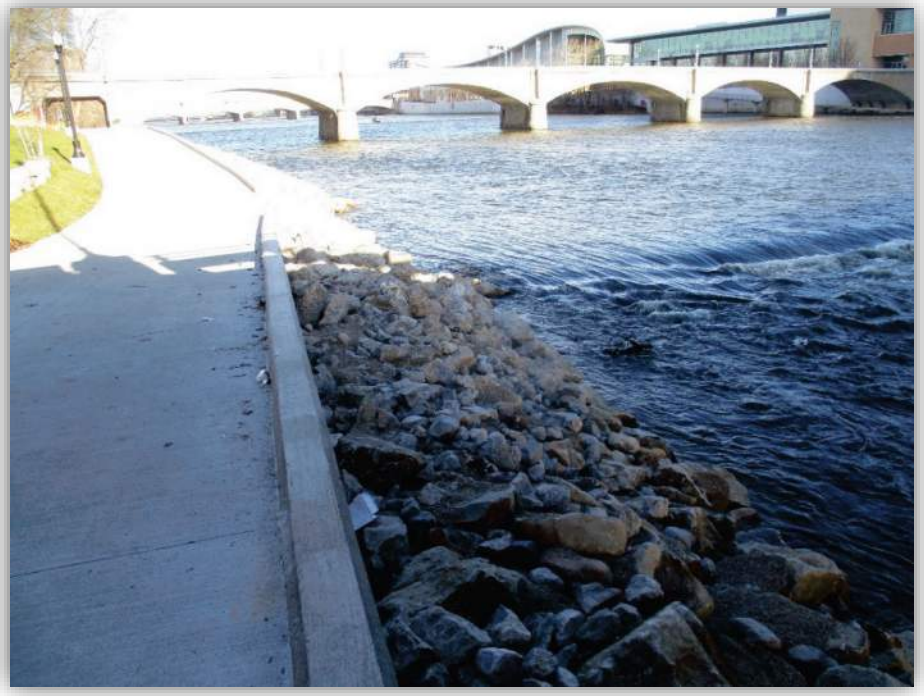
Former Wetland 11



Viewed from the East



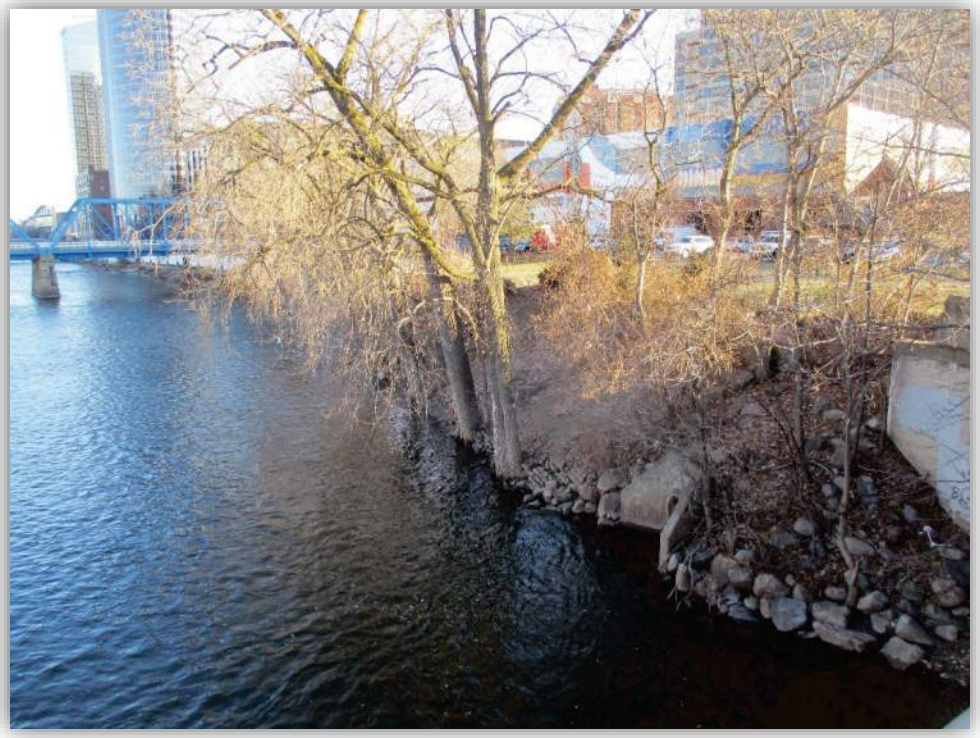
Viewed from the North



Viewed from the South

Project No.:	181779	**Date:**	12/18/2018	**Project Name:**	River Restoration/Grand River Wetland Delineation

Wetland 12



Viewed from the South



Looking North from SP-12

Wetland 12



View of SP-12 from South



Sampling Point SP-12

Boardwalks and Pathways



View North from Pearl Street Bridge



View South from Pearl Street Bridge



View North toward Pearl Street

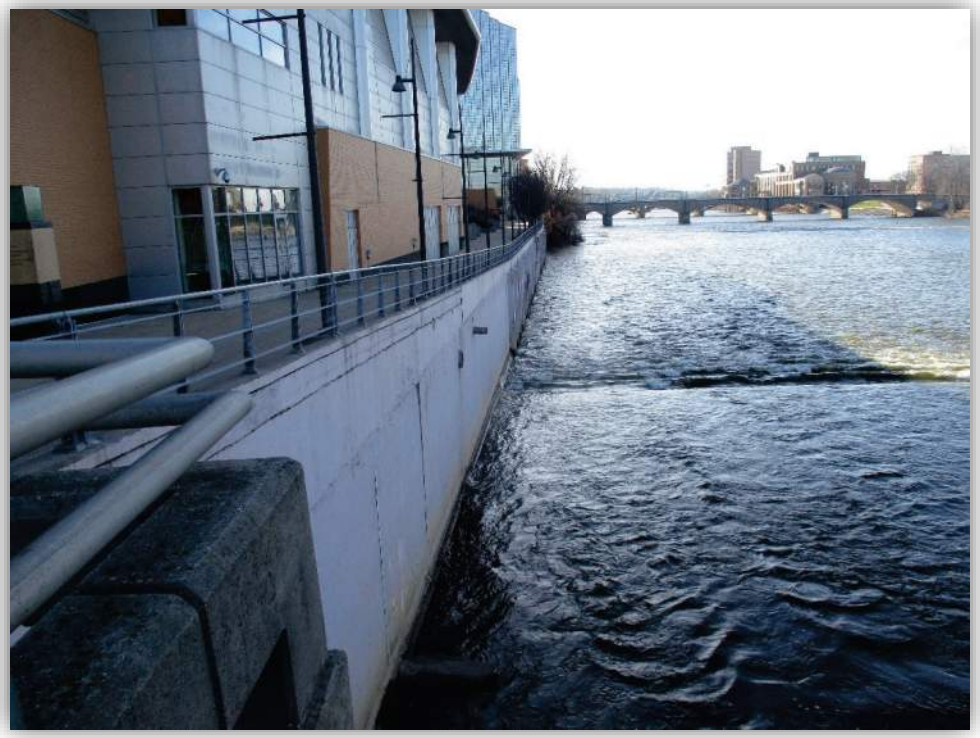


View South to Blue Bridge

Typical Seawall, at Michigan Street Bridge



Looking North



Looking South

APPENDIX E

Other Supporting Information

Wetland Boundary Verification Fishbeck 10/18/2023

fishbeck
Engineers | Architects | Scientists | Constructors

1515 Arboretum Drive, SE
Grand Rapids, Michigan 49546

616.575.3824 | fishbeck.com

Memo

TO: Tim Burkman, P.E. – City of Grand Rapids Engineer

FROM: Elise Hansen Tripp, PWS

DATE: October 18, 2023 PROJECT NO.: 180419

SUBJECT: Wetland Boundary Verification
Lower Reach of the Grand River, City of Grand Rapids, Michigan

On December 18, 2018, Fishbeck delineated wetlands along the banks of the Grand River from the Fulton Street bridge north to approximately 100 feet north of westbound Interstate I-196. The results of this investigation are summarized in Fishbeck's report titled, *Updated Wetland Delineation, Grand River Whitewater Restoration Project, City of Grand Rapids, Kent County, Michigan*, dated February 26, 2019. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) considers wetland delineations valid for a period of three years. Amy Lounds of EGLE has requested that Fishbeck inspect wetlands within the area of investigation, verify the previously delineated wetland boundaries, and update the wetland boundaries, if needed.

Site wetlands were initially delineated by Golder Associates, Inc. (Golder) in 2014. Golder's wetland naming conventions were retained in Fishbeck's 2018 and 2023 investigations. Wetlands 6 through 12 are located within the area of investigation.

Fishbeck staff conducted the wetland verification on October 10, 2023, before a killing frost. Wetland boundaries surveyed in 2018 were located using Global Positioning System technology with submeter accuracy (Trimble R1 GNSS receiver). Site observations are summarized below. Figure 1 notes the area of investigation, verified wetland boundaries, and new delineated wetland boundaries. Photographs of site wetlands are located in Attachment 1.

Wetland 6 (Former)

The Golder report indicated Wetland 6 extended north, approximately 400 feet from Interstate I-196 on the west side of the Grand River, and it encompassed 0.15 acre of scrub-shrub wetland. No wetland was present in this area in 2018 due to prior construction and placement of boulders and riprap. Additionally, no wetland was observed in this area on October 10, 2023.

Wetland 7

Wetland 7 is located on the west bank on the Grand River, between Interstate I-196 and Bridge Street. Fishbeck made one adjustment to the wetland boundary on October 10, 2023: two wetland boundary flags labelled 7-1 and 7-2 were placed west of the 2018 wetland boundary at the south end of the wetland. The adjusted boundary is noted as a cyan line on Figure 1.

Wetland 8

Wetland 8 consisted of floodplain forest on the west side of the Grand River, north and northeast of Ah-Nab-Awen Park. Fishbeck verified the 2018 wetland boundary correlates to the current wetland boundary. This boundary is defined by rock embankments and low seawalls. No adjustments to the wetland boundary were made.

Wetland 9

Wetland 9 is located on the east side of the river, directly west of the DeVos Place Convention Center and Performance Hall. An approximately 20-foot-high seawall is present along the river's edge throughout this area. The wall curves to the east, forming a cove. The only access to this area is from the river. The north and south limits of Wetland 9 were surveyed from a walkway overlooking the wetland. These points also correlated to the approximate wetland boundary. Wetland occupied approximately the western half of the area filled with sediment within the cove. Fishbeck did not make any adjustments to the 2018 wetland boundary.

Wetland 10

Wetland 10 is located on the west side of the river, north of the Gillett Bridge and east of the Gerald R. Ford Presidential Museum. In 2018, this wetland consisted of two segments of scrub-shrub wetland separated by concrete culvert with wingwalls. By 2023, the gap between the wetland segments had filled with sandbar willow (*Salix exigua*), a wetland-ranked species. Therefore, Fishbeck extended the delineated wetland boundary across the gap, as indicated on Figure 1.

Wetland 11 (Former)

The Golder report indicated Wetland 11 was located on the west side of the Grand River, between the Gillett and Pearl Street Bridges, and consisted of 0.11 acre of floodplain forest. Fishbeck observed sidewalk, concrete steps to the river's edge, and an armored bank containing heavy riprap in 2018 and 2023. Saplings of woody species were established between the embankment's rocks by 2023. These plants consisted of both upland-ranked [northern catalpa (*Catalpa speciosa*, FACU) and staghorn sumac (*Rhus typhina*, FACU)] and wetland-ranked [silver maple (*Acer saccharinum*, FACW)] species. No distinct wetland edge was observed along the river in this area.

Wetland 12

Wetland 12 was located on the east side of the river, just north of the Fulton Street bridge. The wetland was confined to the toe of a steep, armored bank and primarily consisted of eastern cottonwood trees (*Populus deltoides*, FAC). In 2023, wetland continued north of the 2018 Wetland 12 limit as a narrow band of emergent and scrub-shrub wetland along the river's edge south of the Blue Bridge and west of the River's Edge Environmental Sculpture. The shoreline was armored with rock in this area. The shoreline was not armored with riprap, boulders, or seawall north of the Blue Bridge, and the ground in this area appeared unstable with extensive bare areas and varying amounts of emergent and scrub-shrub wetland. In some areas, wetland was confined to the water's edge and in other areas it extended east to the adjacent riverwalk sidewalk.

Wetland was not observed in this area during the 2014 and 2018 wetland delineations. Comparing topographic surveys conducted in 1990 and 2021 confirmed the ground surface has lowered approximately 2 to 3 feet due to erosion and river scour, creating a flood bench that supports wetland vegetation. Extensive bank destabilization has undercut the adjacent riverwalk sidewalk in some areas. In January 2023, EGLE issued permit number WRP036258 to the City of Grand Rapids to reconstruct the riverwalk and stabilize the shoreline with boulders and plugs of native species. Wetland 12 did not extend into the project reach during the 2018 delineation, which was submitted as part of the permit application for the recently permitted sidewalk repairs. The East River Edge Sidewalk Repair will involve the placement of fill in the newly delineated wetland. The River Restoration project will have no impacts in the expanded wetland footprint.

Fishbeck staff flagged the boundary of the recently developed wetland with pink survey ribbons labelled 12A-1 through 12A-14. The northern extent of this wetland ended at wetland flag 12A-14 at a rock embankment. Table 1 summarizes plant species observed within Wetland 12's emergent and scrub-shrub wetland. The expanded wetland boundary is noted on Figure 1.

Conclusions

According to Michigan's NREPA, Act 451, Section 30301(d), wetlands "contiguous to the Great Lakes or Lake St. Clair, an inland lake or pond, or a river or stream" or "more than 5 acres in size" are regulated by the State of Michigan. Fishbeck staff verified and delineated wetland boundaries for four wetlands contiguous to the Grand River within the area of investigation (Wetlands 7, 8, 10, and 12). Fishbeck staff verified the presence of a fifth wetland (Wetland 9) and, due to access restrictions, approximated its wetland boundaries based on remote field observation. Table 2 summarizes the updated area and linear length of the identified wetlands. All the identified wetlands are regulated by the federal Clean Water Act and Part 303 of the NREPA because they are contiguous to the Grand River.

Table 1. Plant Species Observed at Wetland 12 on October 10, 2023
Grand River Restoration, Phase 1, Grand Rapids, Michigan

Scientific Name	Common Name	Native?	W	Physiognomy
Acer saccharinum	Silver maple	Native	FACW	Tree
Apocynum cannabinum	Indian-Hemp	Native	FAC	Forb
Cephalanthus occidentalis	Buttonbush	Native	OBL	Shrub
Cornus sericea; c. stolonifera	Red-Osier	Native	FACW	Shrub
Eupatorium perfoliatum	Boneset	Native	FACW	Forb
Eutrochium maculatum	Joe-Pye-weed	Native	OBL	Forb
Iris virginica	Southern blue flag	Native	OBL	Forb
Lythrum salicaria	Purple loosestrife	Non-native	OBL	Forb
Populus deltoides	Cottonwood	Native	FAC	Tree
Salix exigua	Sandbar willow	Native	FACW	Shrub
Salix nigra	Black willow	Native	OBL	Tree
Symphyotrichum lateriflorum	Calico aster	Native	FAC	Forb
Verbena hastata	Blue vervain	Native	FACW	Forb
Vitis riparia	Riverbank grape	Native	FAC	Vine
Xanthium strumarium	Common cocklebur	Non-native	FAC	Forb

Notes: W=Wetland indicator status
OBL=Obligate, FACW=facultative wetland, FAC=facultative

Table 2 – Summary of Delineated Wetlands
Grand River Restoration Project, Phase 1, Grand Rapids, Michigan

Wetland	Wetland Type	Size (square feet)	Size (acre)	Length (linear feet)
7	Emergent/scrub-shrub	5567	0.128	465
8	Floodplain forest	2170	0.050	385
9	Floodplain forest	2316	0.053	256
10	Scrub-shrub wetland	959	0.022	148
12	Forest/emergent/scrub-shrub	7938	0.182	697

Attachments
By email

Figures

PLOT INFO: Z:\2018\180419\CAD\GIS\ProProj\WetlandDelineation\Wetland Delineation.aprx Layout: FIG01_Site Plan Date: 10/12/2023 10:25 AM User: ahavens

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LEGEND

- Wetland Sampling Point
- Delineated Wetland Boundary (10/10/2023)
- Verified Wetland Boundary (10/10/2023)
- Approximate Waterward Wetland Boundary
- Area of Investigation

Former Wetland 6

See Inset

SP-07

Wetland 7

1:1,200

SP-07

See Inset

Wetland 8

SP-08

See Inset

SP-09

Wetland 9

1:1,200

SP-09

See Inset

SP-10

Wetland 10

Gillett Bridge

Former Wetland 11

1:1,200

SP-08

1:1,200

SP-10

See Inset

Wetland 12

Blue Bridge

SP-12

1:1,800

SP-12

NORTH

SITE PLAN

0 150 300 FEET

DATA SOURCES: 7/30/2017 AERIAL.

FIGURE NO. 1

PROJECT NO. 180419

Grand River Restoration

Grand Rapids, Michigan

Wetland Boundary Verification

Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

fishbeck

Engineers | Architects | Scientists | Constructors

Attachment 1

Former Wetland 6



Wetland 7



At South End, Looking North



At North End, Looking South

Wetland 8



At South End, Looking North



At North End, Looking South

Wetland 9





At North End, Looking South



At South End, Looking North

Wetland 10



At North End, Looking South



Looking North at Former Wetland Gap



Looking South at Former Wetland Gap

Former Wetland 11



At South End, Looking North

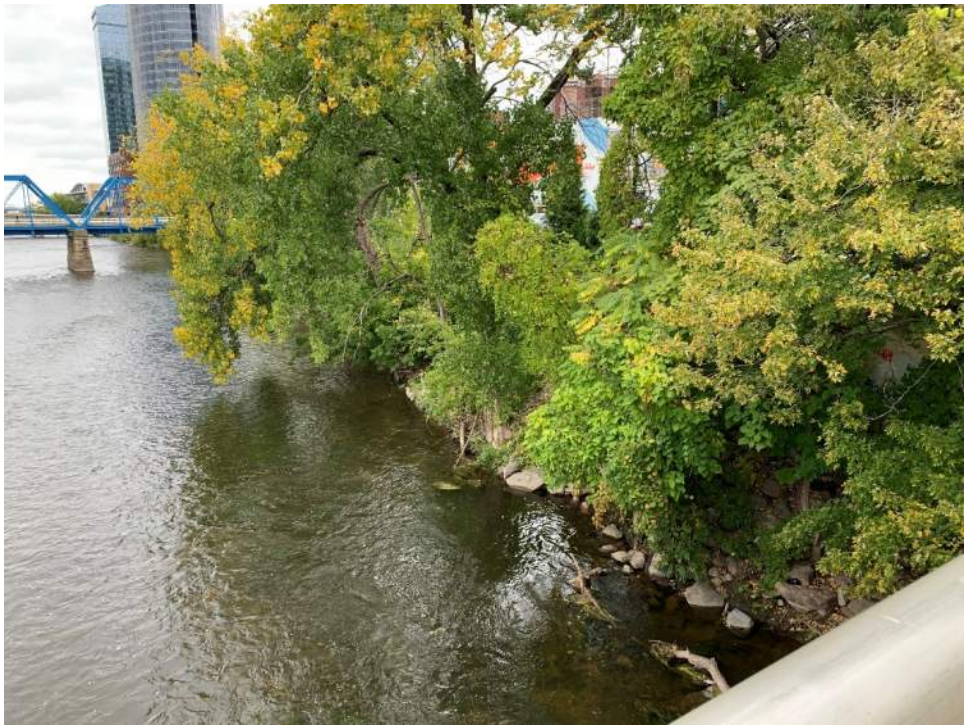


At North End, Looking South

Wetland 12



At North End of the 2018 Wetland Boundary, Looking South



At South End, Looking North

Wetland 12, Emergent and Scrub-Shrub Wetland



At North End, Looking South



At South End, Looking North

APPENDIX E

Other Supporting Information

Letter from Grand Rapids Fire Department; March 2021

FIRE DEPARTMENT

JOHN LEHMAN
FIRE CHIEF

RONALD TENNANT
DEPUTY FIRE CHIEF

TODD VANDERWALL
DEPUTY FIRE CHIEF

March 18, 2021

Subject: Public Safety for a Restored River

To Whom It May Concern:

I have had the great pleasure of working alongside the team of City of Grand Rapids staff, Grand Rapids Whitewater and their cadre of river engineers to provide input into the design of a revitalized Grand River.

As the design has progressed, the Grand Rapids Fire Department River Rescue Team has been at the table providing input on the design and emergency response access needs (both during construction and after construction), and we have been actively planning for future river rescue needs.

Over several years, we have trained many of our team in advanced swift water rescue. We have trained 22 firefighters as Public Safety divers to support immediate rescue needs above and below the river surface. We are excited about the prospect of more people using the Grand River for recreation and are ready for any emergency rescue needs that may arise.

Sincerely,



John Lehman
Grand Rapids Fire Chief
City of Grand Rapids Fire Department
38 LaGrave Av. SE
Grand Rapids, Michigan 49503
616-456-3900
jlehman@grcity.us

APPENDIX E

Other Supporting Information

Ottawa County Letter 5/7/2021

Ottawa County
Administrator's Office

Alan G. Vanderberg
County Administrator

John E. Shay
Deputy County Administrator

Regina L. MacMillan
Administrative Assistant

May 7, 2021

Mr. Steve Heacock
President and CEO
Grand Rapids Whitewater
120 Lyon Street NW
Grand Rapids, MI 49503

Dear Steve,

We are writing to comment upon your requirement to show that at least twenty percent of the benefits of the Grand Rapids Whitewater project accrue to agricultural land and communities.

As you know, Ottawa County is located immediately West of Kent County, downstream of the Grand River Restoration project in Grand Rapids and includes the mouth of the Grand River where it empties into Lake Michigan.

Ottawa County is composed of 17 townships, six cities and one village, with an area of 565 square miles. Only one of cities and six of the townships have a population of substantially more than 10,000. Thirty-eight (38%) percent of the County's land mass is farmland. Ottawa County leads all other Michigan counties in the production of turkeys, ornamental nursery crops, blueberries, and perennials.

Besides Lake Michigan beaches, there are 307 miles of rivers and streams, two state parks, and over 7,000 acres of county parks and open space lands for visitors to enjoy. Tourism is an important part of the Ottawa County economy. Each year this area welcomes millions of visitors to its vacation playground.

We are aware of the GRWW Project and have considered its potential impact on the river, land, and communities of Ottawa County, particularly the many farms and farming communities. Since fish, mussels, and insects do not recognize County lines, ecological improvements from the Project site will benefit the entire river downstream of the Project Site to Lake Michigan, much of which is in Ottawa County.

Every benefit of the Project also benefits the river downstream of the Project. The Project's many goals will improve stability and growth in fish population, improve spawning habitat, and provide better care and management of mussel species. Reintroduction of rapid-type habitat to the Grand River will not only benefit aquatic species, but it will also bring the Grand River closer to its natural state from the Project site to its terminus in Ottawa County. The benefits realized in the river itself impact the river shore, and the agricultural and rural land and communities abutting the river. Ottawa County's ecology will benefit greatly from the Project.

But the benefits are not just ecological. The Project, especially the revitalization of the rapids and removal of dangerous low-head dams, will encourage expanded public use of the river and further supports The Grand River Greenway Vision of connecting Grand Rapids and Grand Haven for residents and visitors to explore by foot, bike or kayak (via the Idema Explorers Trail an Grand River Heritage Water Trail). The enhancement of recreation opportunities such as paddling, rafting, tubing, and angling in the Grand River will allow our small cities and townships to further efforts to attract tourists to their hospitality businesses. In fact, Ottawa County Parks is already coordinating with partners in Kent County, including GRWW to ensure that the projects are complementary in their amenities, wayfinding, and marketing. These efforts are sure to grow in the future.

We state with confidence that at least twenty percent of the benefits of the Project will accrue to Ottawa County and the area downstream of the Project site.

Alan G. Vanderberg
Ottawa County Administrator

Jason Shamblin
Ottawa County Parks Director

APPENDIX E

Other Supporting Information

Aquatic Benefits Memo ERM 4/16/2021

ERM

3352 128th Avenue
Holland, Michigan
49424

Telephone: +1 616 399 3500
Fax: +1 616 399 3777

www.erm.com

Memo

To	Wendy Ogilvie
From	Heather Heater and Steve Koster
Date	16 April 2021
Reference	0476625
Subject	Suggested Approach to Assessment of Aquatic Benefits from the GRWW Project to Agricultural Areas

Concept:

Ecological benefits from the Project will be realized throughout the Grand River watershed, including the segment downstream of the Project. These benefits will include downstream fish population stability and growth due to improved spawning habitat and reproductive success in the Project Area, funded conservation projects for mussel species throughout the Grand River, benefits to other aquatic species, and the potential for permanent but small and spatially discrete increases in downstream mussel populations. Over 20% of Project benefits would accrue to agricultural areas as approximately 60% of the Grand River watershed from the Project Area downstream to Lake Michigan is agricultural land, and the proportion of agricultural lands in the upstream portion of the watershed is similar, if not higher (Hanshue, S. K., and A. H. Harrington, 2017).

Benefits Assessment:

Habitat changes from the Project are designed to benefit federal- and state-listed fish and mussel species, other fish and mussel species, and fish species that host mussel offspring. Added habitat boulders would create refuge areas and pockets of eddies and back eddies that add habitat diversity for a variety of fish species, including the listed lake sturgeon and river redhorse. The additional areas of habitat within the Project Area would contribute to increases in population size and/or stability of fish, and would likely contribute to increases in population size and/or stability of mussel species in areas downstream of the Project as well. The largest benefit to downstream populations would likely occur for both the lake sturgeon and river redhorse, as these species should experience the largest change in total spawning habitat available in the lower Grand River.

A mitigation fund will be created as mitigation for the loss of unionid mussel species during salvage would be used for threatened and endangered mussel species monitoring and other conservation measures, which would benefit mussel species in the lower Grand River, both upstream and downstream of the Project Area. The Fund would provide not only funds for future mussel monitoring projects, but it would also provide grant funding for future conservation measures, which could benefit mussel species outside of the Project Area. Additionally, indirect beneficial impacts would result from creating mussel habitat to the extent that the project's

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Mitigation Fund is utilized for mussel habitat improvement projects either downstream or upstream of the Construction Area

Only 1% of river habitat in the lower peninsula of Michigan is composed of rapid-type habitat, which is important to the ecology and life cycle of many aquatic species. The existing site has been degraded by the low-head dams and has contributed to increased channelization of the river at this location. Enhancing rapid-type habitat through the Project would provide greater ecological diversity, which should benefit the greater watershed.

The Project is designed to increase Preferred Hydrophysical Habitat (PHH) for mussels by 78% over existing conditions. Therefore, more mussels should be able to inhabit the area than under existing conditions. If more mussels inhabited the Project Area, then more reproduction should occur in the Project Area, which would increase the chances of offspring being transported downstream and potentially inhabiting downstream locations. Comparatively, the increased benefits to mussel species populations likely would not be as great as to populations of fish species. Although the added PHH should increase mussel productivity, there likely is not enough adequate mussel habitat downstream of the Plaster Creek recipient site to significantly increase mussel abundance.

EA Modifications:

Revisions will be made to the following Plan-EA Sections:

- Summary – OMB Factsheet: Revision to watershed size and land use information to include entire Grand River Watershed, including agricultural information.
- Sections 4.6.1 and 4.6.2 – Affected Environment: Briefly describe fish and mussel species habitat and presence in the downstream portion of the Grand River.
- Section 6.6.2 – Environmental Consequences: Describe the aquatic ecological benefits described above.
- Appendix B – Figure 2: Watershed Land Use Map.

References:

Hanshue, S. K., and A. H. Harrington. 2017. Grand River assessment. Michigan Department of Natural Resources Fisheries Report 20, Lansing.

APPENDIX E

Other Supporting Information

Grand River Water Quality

12 Digit HUC: 040500060310 **AUID: MI040500060310-01**
Rivers/Streams in HUC 040500060310 **RIVER 10.9356 Miles**
Includes: Grand River between Bellamy Creek and Red Creek

Designated Use: **Warm Water Fishery** Designated Use Support: **Not Supporting**

Parameter	Parameter Attainment	Parameter Category	Action ID	Action Name
TEMPERATURE	Not meeting criteria	5	None	

12 Digit HUC: 040500060507 **AUID: MI040500060507-06**
Rivers/Streams in HUC 040500060507 **RIVER 4.06 Miles**
Includes: Grand River from Brandywine Creek to Plaster Creek

Designated Use: **Fish Consumption** Designated Use Support: **Not Supporting**

Parameter	Parameter Attainment	Parameter Category	Action ID	Action Name
PERFLUOROOCTANE SULFONATE (PFOS	Not meeting criteria	5	None	

12 Digit HUC: 040500060705 **AUID: MI040500060705-01**
Rivers/Streams in HUC 040500060705 **RIVER 64.5364 Miles**
Includes: Grand River

Designated Use: **Fish Consumption** Designated Use Support: **Not Supporting**

Parameter	Parameter Attainment	Parameter Category	Action ID	Action Name
PERFLUOROOCTANE SULFONATE (PFOS	Not meeting criteria	5	None	

12 Digit HUC: 040500060708 **AUID: MI040500060708-01**
Rivers/Streams in HUC 040500060708 **RIVER 8.6564 Miles**
Includes: Grand River, not including tributaries

Designated Use: **Fish Consumption** Designated Use Support: **Not Supporting**

Parameter	Parameter Attainment	Parameter Category	Action ID	Action Name
PERFLUOROOCTANE SULFONATE (PFOS	Not meeting criteria	5	None	

Designated Use: **Other Indigenous Aquatic Life and Wildlife** Designated Use Support: **Not Supporting**

Parameter	Parameter Attainment	Parameter Category	Action ID	Action Name
LOSS OF INSTREAM COVER	Not meeting criteria	5	None	

APPENDIX E

Other Supporting Information

Water Rescue Activity 2019-2023

2019-2023 Water Rescue Activity - Where Water Units Arrived On Scene

Severity	Description	Count	Total On Scene Time	Total Units Deployed	Total Personnel Deployed
1	Less than 22 minutes on scene time	10	2:31:30	81	196
2	Search & Rescue, Extended Operations (incl. craft recovery)	45	4:12:52	292	723
3	Death, Injury, Extended Operations (incl. body recovery)	23	21:48:54	145	389

	2019	2020	2021	2022	2023	Averages per year
Number of Incidents	11	15	13	19	20	15.6
Number of Total Units deployed	65	108	76	124	145	103.6
Number of Total Personnel deployed	186	282	162	293	385	261.6
Average Total On Scene Time Severity 2 & 3	2:33:16	1:08:56	1:17:28	0:54:04	1:03:58	1:17:21
Average Total Personnel deployed Severity 2 & 3	16.91	18.80	12.46	15.42	19.25	16.57
Individuals Rescued	4	5	9	10	15	8.6
Civilian Injuries	2	4	3	5	6	4
Civilian Deaths	1	1	2	1	0	1
Water/ Ice/ River Rescue Training Hours	122.5	193.5	339	1787	1589.75	806.35

Total Responses by Severity and Water Units Arriving on Scene				
	1	**2**	**3**	All
GRW03	7	26	17	50
GRW05	1	13	7	21
GRW09	0	2	1	3
GRW47	0	6	4	10
GRW49	1	9	4	14
GRD03	7	27	16	50
Total:	16	83	49	148

APPENDIX E

Other Supporting Information

Cultural Resources Memorandum of Agreement 9/30/2022

NRCS Agreement N2622MOU0012399

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
THE MICHIGAN STATE HISTORIC PRESERVATION OFFICER,
THE MICHIGAN STRATEGIC FUND,
THE CITY OF GRAND RAPIDS, MICHIGAN,
GRAND RAPIDS WHITEWATER, INC.,
AND THE GRAND VALLEY METROPOLITAN COUNCIL

REGARDING

Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

WHEREAS, the Natural Resources Conservation Service (NRCS) plans in cooperation with the Grand Valley Metropolitan Council (GVMC), the City of Grand Rapids (City) and Grand Rapids Whitewater, Inc. (GRWW) to carry out the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project (Project) located in the City of Grand Rapids, Michigan pursuant to the Watershed Protection and Flood Prevention Act of 1954, Public Law 83-566, as amended (WPFPA) (16 U.S.C. Sections 1001-1008, 1010, and 1012)through NRCS's Regional Conservation Partnership Program (RCPP) agreement number 1603 with GVMC; and

WHEREAS, the Project consists of (1) restoring aquatic habitat diversity and suitability for native Great Lakes drainage fish and mussel species, especially threatened, endangered, and special concern native species, in the Grand River; (2) reducing public safety hazards generated by the existing four beautification (low-head) dams (each, a "low-head dam", and, collectively as, the "low-head dams"); and (3) installing diversified hydraulic features that would improve aquatic habitat and aesthetics. Restoration of the site will require the demolition and removal of the low-head dams; and

WHEREAS, NRCS has determined that the removal of the low-head dams is an undertaking (Undertaking) subject to review under Section 106 of the National Historic Preservation Act (NHPA), as amended, 54 U.S.C. §306108 (Section 106), and its implementing regulations, 36 C.F.R. Part 800; and

WHEREAS, NRCS is the responsible federal agency with funding authority over the Undertaking pursuant to the WPFPA; and

WHEREAS, GVMC is the applicant for federal assistance through the RCPP and is responsible for ensuring the habitat restoration requirements of the RCPP agreement between the NRCS and the GVMC are met. GVMC will be signing this Memorandum of Agreement (MOA) as an invited signatory; and

WHEREAS, the City is the sponsoring local organization and permit applicant, and will be responsible for establishing contracts for demolition of the low-head dams and resulting habitat restoration and will be signing this MOA as an invited signatory; and

WHEREAS, GRWW is leading the design and engineering of the Project and will closely coordinate with the City and other partners to ensure the original intent of the design is accomplished and will be signing this MOA as an invited signatory; and

WHEREAS, the State Historic Preservation Officer is part of the State Historic Preservation Office (SHPO) which was transferred to the Michigan Strategic Fund (MSF) pursuant to Executive Order 2019-13; and

WHEREAS, NRCS has defined the Undertaking's Area of Potential Effects (APE) as the footprint of the low-head dam removal, an 840 m (2,756 feet) stretch of the Grand River flowing through the City from 40 m (130 ft) upstream of Bridge Street to Fulton Street and staging areas along the river; the low-head dams to be demolished are located between I-196 and Fulton Street and installation of substrate improvements within an area approximately 121,800 m^2 (30 acres) in size as further shown in the APE map attached hereto as Appendix A; and

WHEREAS, NRCS has determined, and the SHPO has concurred in their response letter regarding the Undertaking also referred to as SHPO Environmental Review 20-876, that the Undertaking will have an adverse effect on the low-head) dams in the Grand River due to their demolition and removal from the river. The low-head dams are eligible for listing on the National Register of Historic Places (NRHP) as documented in the NRHP Evaluation attached hereto as Appendix B, and NRCS has consulted with the SHPO and the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians Tribal Historic Preservation Officer (THPO) to develop this MOA pursuant to 36 Code of Federal Regulations Part 800 (36 C.F.R. Part 800), the regulations implementing Section 106 of the National Historic Preservation Act (54 U.S.C. § 306108); and

WHEREAS, the low-head dams are eligible for listing on the NRHP under the following eligibility criteria: Criterion A as a series of structures that conveys the long history of the City with the Grand River and for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown Grand Rapids and Criterion C, given that the low-head dams are works of architecture and engineering and embody the distinctive characteristics of a type, period or method of construction. The mitigation measures documented in the stipulations below must address the criteria that qualify the low-head dams for listing on the NRHP; and

WHEREAS, NRCS has reached out to the 12 Federally Recognized Tribes, and the two State Historic Tribes within Michigan as well as the Miami Tribe of Oklahoma with information and updates regarding the planned Undertaking. The Little River Band of Ottawa Indians, the Miami Tribe of Oklahoma, the Pokagon Band of Potawatomi, and the Saginaw Chippewa Indian Tribe of Michigan, responded to NRCS consultations and indicated that they should be contacted in the event a post review discovery is made; and

WHEREAS, the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians, [redacted] responded to NRCS consultations with interest and NRCS pursued consultation through the THPO**;** and

WHEREAS, NRCS has consulted with the Grand Rapids Public Museum (GRPM) regarding the effects of the Undertaking on historic properties and has invited GRPM to sign. GRPM will be signing this MOA as a concurring party; and

WHEREAS, in accordance with 36 C.F.R. § 800.6(a)(1), NRCS has notified the Advisory Council on Historic Preservation (ACHP) of its adverse effect determination with specified

documentation, and the ACHP has chosen not to participate in the consultation pursuant to 36 C.F.R. § 800.6(a)(1)(iii); and

WHEREAS, NRCS has provided the public the opportunity to comment on the Undertaking and proposed mitigation measures by issuing a public notice through local media, on the NRCS Michigan website, partner websites and posting at local public libraries. Two public meetings were held virtually on November 10th and 29th, 2021, to provide information on the original purpose and present mitigation measures to address the removal of the low-head dams. Over the course of 30 days, 47 public comments were received and provided to the SHPO. Seven comments specifically addressed the removal of the low-head dams. These seven were reviewed and considered in development of this MOA. Remaining comments addressed other issues not related to the low-head dams; and

WHEREAS, an architectural historian will be present to monitor and document the low-head dam removal since the historic structures eligible for listing on the NRHP are extant engineered structures. An archaeologist will not be onsite during low-head dam removal for monitoring below ground disturbance because the riverbed was significantly disturbed when the low-head dams were installed and planned ground disturbance for the Undertaking will be limited. Dredging or scraping of the river for demolition of the dams will not exceed the previous level of disturbance associated with construction of the dams. Ah-Nab-Awen Park, a staging area, has three to five feet of fill. An archaeologist will be available to respond in the event a post review discovery is made during construction in accordance with the Inadvertent Discovery Plan for Cultural Resources or Human Remains attached hereto as Appendix E (Inadvertent Discovery Plan); and

WHEREAS, the term "Signatory" is defined in this MOA to include both Signatories and Invited Signatories; and

WHEREAS, nothing in this MOA shall be construed as requiring a Signatory or Concurring Party to expend funds in violation of the Anti-deficiency Act, codified at 31 U.S.C. § 1341, as amended; and

WHEREAS, terms and parties not otherwise defined in this MOA shall have the meaning assigned to them in the Glossary of Terms attached hereto as Appendix G.

NOW, THEREFORE, NRCS, SHPO, MSF, the City, GRWW, and GVMC agree that the Undertaking shall be implemented in accordance with the following stipulations in order to take into account the effect of the Undertaking on historic properties.

STIPULATIONS

NRCS shall ensure that the following measures are carried out:

I. MONITORING OF LOW-HEAD DAM REMOVAL BY ARCHITECTURAL HISTORIAN

The City and GRWW will provide a qualified architectural historian to conduct monitoring of the removal of one of the low-head dams within the coffered de-watered area to document the resource as it exists in accordance with SHPO's Documentation Standards attached hereto as Appendix C (Documentation Standards). As the plans show that the low-head dams are identical in design and construction, observation of one removal is expected to provide sufficient information on construction of the low-head dams. Note that if the field conditions at the time of removal of the

first coffered low-head dam do not facilitate the desired observations, NRCS may request that the removal of the second low-head dam within a coffered area, also be monitored as described below. The architectural historian will be monitoring demolition of a low-head dam since the historic property being removed is an extant engineered structure. An archaeologist will not be onsite during monitoring because ground disturbance will be limited. Dredging or scraping for demolition of the dams will not exceed the previous level of disturbance associated with construction of the dams. Ah-Nab-Awen Park, a staging area, has three to five feet of fill. An archaeologist will be available to respond in the event a post review discovery is made during construction in accordance with the Inadvertent Discovery Plan. The monitoring will:

A. Focus on identifying and documenting the form and content of the low-head dam with sketch drawings and high-resolution photographs

B. Focus on how the low-head dam was constructed and any evidence of maintenance or modifications post-construction

C. Allow the City's architectural historian to attempt to recover any significant architectural elements identified within the coffered area as feasible and safe within the constraints of low-head dam removal site activities and schedule

D. Include application of the Inadvertent Discovery Plan as needed during all Project activities. During monitoring of removal of the low-head dams, the architectural historian on site will implement the Inadvertent Discovery Plan if needed and NRCS shall engage archaeological and tribal representative assistance as appropriate.

E. Allow the City's architectural historian to coordinate with NRCS to arrange for curation and display if significant architectural elements and/or archaeological remains are recovered.

The final report from the City's architectural historian shall follow the Documentation Standards and will be submitted to NRCS within 90 days of completion of the monitoring work. NRCS will then submit the final report to the SHPO for deposit in the State Archives of Michigan, and with the City's Community Archives and Research Center. The historic documentation developed from monitoring shall adhere to the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Fed. Reg. 44716 (Sept. 29, 1983)).

II. PRESENTATION OF INTERPRETIVE MATERIALS

The following actions will be completed within one year of completion of low-head dam demolition.

A. Interpretive Panel(s)

i. The City and GRWW, in consultation with NRCS, will provide interpretative panel(s) to be placed along the river walkway in Ah-Nab-Awen Park or on the GRPM grounds (Panel(s)).

ii. The Panel(s) will be constructed on a durable outdoor product with UV resistant, graffiti resistant, and burn resistant material. Examples can be found at: http://www.pulsedesign.com/outdoor-interpretive-signs-historic-preservation-site-educational-exhibits

iii. The City and GRWW in consultation with NRCS and the other consulting parties will develop an interpretive design to describe the content of the Panel(s).

iv. Content, including text and images, for the Panel(s) will be reviewed by NRCS, in consultation with the SHPO, to ensure the content meets the Secretary of the Interior's Professional Qualifications Standards. NRCS will provide a draft image of all Panel(s)

to the signatories for comment for a period of 30 days. NRCS will consider all timely comments in developing final designs and text for the Panel(s).

v. The City and GRWW will install the Panel(s) during site restoration of Ah-Nab-Awen Park. The City shall ensure maintenance of the Panel(s). A digital copy of the Panel(s) will also be provided to the SHPO and the City for archiving.

B. River Restoration Photo Monitoring Project

i. GVMC is collecting photos of the current conditions and future low-head dam removal locations in the River Restoration Photo Monitoring Project. (https://www.lgrow.org/river-restoration)

ii. GVMC will create a timelapse video from these photos to document the entire low-head dam removal and watershed restoration process and make the video available to the public. The final product will be archived with the State Archives of Michigan and the City.

C. Museum Collections, Exhibits

The City will coordinate with a local historical institution to assure they have access to any appropriate documentation of the Project and removal of the low-head dams that they would like to incorporate into their educational programming, collections, or exhibits. Educational materials and exhibits shall comply with Federal Curation Regulations found at 36 C.F.R. § 79 as attached hereto as Appendix D (Federal Curation Regulations).

III. QUALIFICATIONS STANDARDS

NRCS shall ensure that all work carried out pursuant to this MOA shall be done by or under the direct supervision of historic preservation professionals who meet the Secretary of the Interior's Professional Qualifications Standards found at 36 C.F.R. § 61 (SOI Standards). NRCS shall ensure that all consultants retained for services pursuant to the MOA Agreement meet the SOI Standards.

The Section 106 regulations (36 CFR § 800.4(c)(1)) acknowledge that Indian tribes and Native Hawaiian organizations (NHOs) possess "special expertise" in assessing the eligibility of historic properties that possess religious and cultural significance to them. Individuals recognized by a tribe or NHO as possessing this special expertise do not have to meet the SOI Standards for purposes of Section 106 review.

IV. CURATION STANDARDS

Any artifacts collected and accessioned will be curated according to the Federal Curation Regulations.

V. PROJECT MODIFICATIONS AND CHANGES

Neither the NRCS, GVMC, the City nor GRWW shall alter any plan, scope of services, or other document that has been reviewed and commented on pursuant to this MOA (except to finalize documents commented on in draft form), without first affording the signatories to this MOA the opportunity to review the proposed change and determine whether it shall require that this MOA be amended. If one or more such signatory determines than an amendment is needed, the signatories to this MOA shall consult in accordance with Stipulation XIV to consider such an amendment.

VI. COMPLIANCE WITH OTHER FEDERAL, STATE, TRIBAL AND LOCAL LAWS

A. NRCS shall coordinate its compliance with Section 106 with other applicable federal, state/tribal, and local laws and reviews as appropriate.

B. Historic and prehistoric human remains from non-federal, non-tribal lands are subject to protection under Michigan burial/unmarked grave/cemetery law(s), the Michigan Attorney General's Opinion No. 6585 and Michigan Penal Code, Act 328 of 1931 Chapter XXVI, Section 750.160. As such, if human remains are discovered during removal of the low-head dams and watershed restoration, work in that portion of the Project shall stop immediately. The remains shall be covered and/or protected in place in such a way that minimizes further exposure of and damage to the remains, and NRCS shall immediately consult with the SHPO and THPO. If the remains are found to be Native American, in accordance with applicable law, a treatment plan shall be developed by NRCS and SHPO in consultation with appropriate federally recognized Indian tribes. NRCS shall ensure that any treatment and reburial plan is fully implemented. If the remains are not Native American, the appropriate local authority shall be consulted to determine final disposition of the remains. Avoidance and preservation in place is the preferred option for treating human remains.

VII. POST-REVIEW DISCOVERIES

If properties are discovered that may be historically significant or unanticipated effects on historic properties found, once notified of the discovery, NRCS shall continue to implement the Inadvertent Discovery Plan.

VIII. COMMUNICATION AMONG MOA PARTIES

Electronic mail (email) will serve as the official correspondence method for all communications regarding this MOA and its provisions. A list of all Signatory contacts and email addresses is attached hereto as Appendix F (Contact Information). Contact Information may be updated without an amendment to this MOA. It is the responsibility of each Signatory or Concurring Party to immediately inform NRCS of any change in name, address, email address, or phone number of any point-of-contact. NRCS shall forward updated Contact Information to all Signatories and Concurring Parties by email.

IX. ANTIDEFICIENCY ACT

NRCS's obligations under this MOA are subject to the availability of appropriated funds, and the stipulations of this MOA are subject to the provisions of the Anti-deficiency Act. NRCS shall make reasonable and good faith efforts to secure the necessary funds to implement this MOA in its entirety. If compliance with the Anti-deficiency Act alters or impairs NRCS's ability to implement the stipulations of this MOA, NRCS shall consult in accordance with the amendment and termination procedures found at Stipulations XIV and XV of this MOA.

X. EMERGENCY SITUATIONS

Should an emergency situation occur which represents an imminent threat to public health or safety, or creates a hazardous condition, NRCS shall immediately notify the SHPO, THPO and the ACHP of the condition which has initiated the situation and the measures taken to respond to the emergency or hazardous condition. Should the SHPO, THPO or the ACHP desire to provide technical assistance to NRCS, they shall submit comments within seven (7) calendar days from receipt of the notification, if the nature of the emergency or hazardous condition allows for such coordination.

XI. DURATION

This MOA will expire if its terms are not fully carried out within five (5) years from its execution. Prior to such time, NRCS may consult with the other Signatories to reconsider the terms of this MOA and amend it in accordance with Stipulation XIV below.

XII. AGREEMENT MONITORING AND REPORTING

A. On each anniversary following the execution of this MOA, until it expires or is terminated,

NRCS shall provide all Signatories and Concurring Parties to this MOA a summary report detailing work undertaken pursuant to its terms. Such report shall include any scheduling changes proposed, any problems encountered, and any disputes and objectionsreceived in NRCS's efforts to carry out the terms of this MOA.

B. The City, GRWW, and GVMC shall submit quarterly summary reports (Quarterly Reports) to NRCS detailing (1) any scheduling changes proposed, (2) any problems encountered, (3) any disputes and objections received and (4) all efforts to carry out the responsibilities and terms of this MOA.

C. NRCS shall create annual reports based on the Quarterly Reports and distribute to all Signatories and Concurring Parties.

XIII. DISPUTE RESOLUTION

Should any Signatory or Concurring Party to this MOA object (Objection) at any time to any actions proposed or the manner in which the terms of this MOA are being implemented, NRCS shall consult with such Signatory or Concurring Party to resolve the Objection. If NRCS determines that such Objection cannot be resolved, NRCS will:

A. Forward all documentation relevant to the Objection, including the NRCS's proposed resolution, to the ACHP. The ACHP shall provide NRCS with its advice on the resolution of the Objection (Advice) within thirty (30) days of receiving adequate documentation (Advice Period).

1. If the ACHP provides its Advice within the Advice Period, NRCS shall prepare a written response (Response) prior to reaching a final decision on the Objection (Final Decision) that takes into account any timely advice or comments regarding the Objection from the ACHP, Signatories and Concurring Parties, and provide them with a copy of the Response. NRCS will then proceed according to its Final Decision.

2. If the ACHP does not provide its Advice within the Advice Period, NRCS may make its Final Decision and proceed accordingly. Prior to reaching the Final Decision, NRCS shall prepare a Response that takes into account any timely comments regarding the Objection from the Signatories and Concurring Parties, and provide them and the ACHP with a copy of the Response.

B. NRCS's responsibility to carry out all other actions pursuant to the terms of this MOA that are not the subject of the Objection remain unchanged.

XIV. AMENDMENTS

This MOA may be amended when such an amendment is agreed to in writing by all Signatories. The amendment will be effective on the date a copy signed by all the Signatories is filed with the ACHP.

XV. TERMINATION

If any Signatory to this MOA determines that its terms will not or cannot be carried out (Objecting Signatory), the Objecting Signatory shall immediately consult with the other Signatories to attempt to develop an amendment pursuant to Stipulation XIV, above. If, within thirty (30) days (or another time period agreed to by all Signatories), an amendment cannot be reached, any Signatory may terminate the MOA upon written notification to the other Signatories.

Once the MOA is terminated, and prior to work continuing on the Undertaking, NRCS must

either (a) execute a new MOA pursuant to 36 CFR § 800.6 or (b) request, take into account, and respond to the comments of the ACHP under 36 CFR § 800.7. NRCS shall notify the Signatories as to the course of action it will pursue.

XVI. USDA STIPULATIONS

A. The Signatories and their respective agencies will handle their own activities and utilize their own resources, including the expenditure of their own funds, in pursuing these objectives. Each signatory will carry out its separate activities in a coordinated and mutually beneficial manner.

B. Nothing in this MOA shall obligate either the Department of Agriculture or any of the Signatories to obligate or transfer any funds Specific work projects or activities that involve the transfer of funds, services or property among the Signatories and their respective agencies will require execution of separate agreements and be contingent upon the availability of appropriated funds. Such activities must be independently authorized by appropriate statutory authority. This MOA does not provide such authority. Negotiation, execution and administration of each such agreement must comply with all applicable statutes and regulations.

C. This MOA is not intended to, and does not create, any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity, by a party to this MOA against the United States, its agencies, its officers, or any person.

Execution of this MOA by the NRCS, SHPO and MSF and implementation of its terms is evidence that NRCS has taken into account the effects of this Undertaking on historic properties and afforded the ACHP an opportunity to comment.

SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
THE MICHIGAN STATE HISTORIC PRESERVATION OFFICER,
THE MICHIGAN STRATEGIC FUND
THE CITY OF GRAND RAPIDS, MICHIGAN,
GRAND RAPIDS WHITEWATER, INC.,
AND THE GRAND VALLEY METROPOLITAN COUNCIL REGARDING
Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

Natural Resources Conservation Service

GARRY LEE Digitally signed by GARRY LEE
Date: 2022.09.14 17:38:14
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_____Date: _____

Garry Lee, State Conservationist

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SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
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THE MICHIGAN STRATEGIC FUND
THE CITY OF GRAND RAPIDS, MICHIGAN,
GRAND RAPIDS WHITEWATER, INC.,
AND THE GRAND VALLEY METROPOLITAN COUNCIL REGARDING
Removal of Four Beautification (Low-Head) Dams in the Grand River,
Grand Rapids, Kent County, Michigan, a component of the Lower Grand River
Watershed Habitat Restoration and Farmland Conservation Project

Michigan State Historic Preservation Office

DocuSigned by:
Martha MacFarlane-Faes Date: 9/30/2022
178C0ED7954D456
Martha MacFarlane-Faes, Deputy State Historic Preservation Officer

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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

Michigan Strategic Fund

DocuSigned by:
Valerie Hoag
FC2098818155402...

Date: 9/30/2022

Valerie Hoag, Fund Manager

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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

INVITED SIGNATORIES:

The City of Grand Rapids, Michigan

DocuSigned by:
By: _____ Date: _____
E607110D861A4E2...
Rosalynn Bliss, Mayor

DocuSigned by:
Attest: _____ Date: _____
D9E73BB4D3CD44E...
Joel Hondorp, City Clerk

Approved as to form:

DocuSigned by:
AFFIX
Mayor's Signature
Dept. of Law
_____ Date: _____
FD57E7E3FAE0466...
City Attorney

SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
THE MICHIGAN STATE HISTORIC PRESERVATION OFFICER,
THE MICHIGAN STRATEGIC FUND
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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

INVITED SIGNATORY:

Grand Rapids WhiteWater, Inc.

_____ Date: _____
Steve Heacock, President & CEO

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SIGNATORY PAGE

MEMORANDUM OF AGREEMENT
AMONG
THE NATURAL RESOURCES CONSERVATION SERVICE,
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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

INVITED SIGNATORY:

Grand Valley Metropolitan Council



_____Date: _____

John Weiss, Executive Director

SIGNATORY PAGE

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Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project

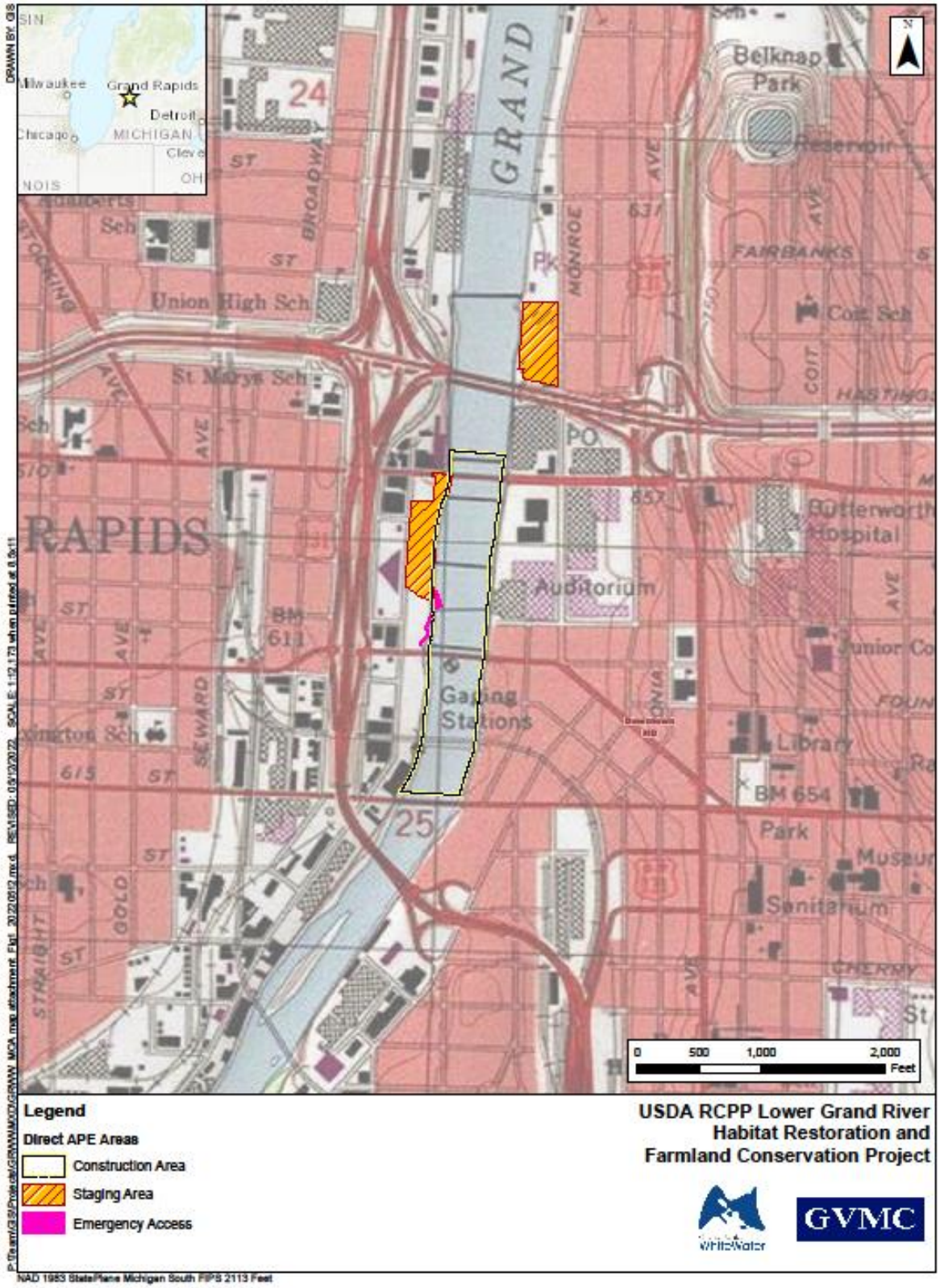
CONCURRING PARTY:

Grand Rapids Public Museum

Dale A. Robertson Date: 9/14/22

Dale A. Robertson, President & CEO

Appendix A - *APE Map*



Appendix B – *NRHP Evaluation*
(49-page document)



NRHP Evaluation of Four Beautification Dams in the Grand River, Grand Rapids, Kent County, Michigan

February 18, 2021

Project No: 0476625

The business of sustainability

ERM

Signature page

February 18, 2021

NRHP EVALUATION OF FOUR BEAUTIFICATION DAMS IN THE GRAND RIVER, GRAND RAPIDS, KENT COUNTY, MICHIGAN



Jeffrey L. Holland
Historian



Emily Tucker-Laird
Architectural Historian

ERM
3352 128th Avenue
Holland MI 49424

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ABSTRACT

The Michigan State Historic Preservation Office (MI SHPO) has requested a National Register of Historic Places (NRHP) evaluation of the eligibility of four low-head dams in the Grand River in Grand Rapids, Michigan that would be affected by the Grand Rapids Whitewater Project (Project), which proposes the removal of these dams. With the support of the City of Grand Rapids and Grand Rapids Whitewater (GRWW), Environmental Resources Management (ERM) prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are eligible for the NRHP, and if so, whether the Project may result in adverse effects to these cultural resources. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) is the lead federal agency with funding authority over the undertaking.

The Project spans approximately 0.7 miles along the downtown portion of the Grand River, and includes the removal of four low-head, historic-aged dams associated with the early industrial and commercial growth of Grand Rapids, as well as other changes in the river. Another dam in the Grand River upstream of the Project, the Sixth Street Dam and Fish Passage, has already been recommended eligible for the NRHP, and has been addressed as a separate undertaking. This report evaluates the four dams located from just north of Bridge Street to just north of Pearl Street. In order to evaluate the significance of the dams, ERM collected information on the dams and their context within the history of Grand Rapids from experts knowledgeable in local history, city planning, and historical public works. Documents, maps, and photographs were collected from the Grand Rapids City Archive and Record Center, the Grand Rapids Public Museum, the Grand Rapids Public Library, and the Grand Rapids Historical Commission.

Based on the information gathered, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are potentially eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. ERM also recommends that the Project would have an adverse effect on the properties. The Project plan as currently proposed requires removal of all the dams and does not allow for avoidance or minimization of adverse effects. ERM recommends that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project on the four low-head dams.

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Acronyms and Abbreviations

Name	Description
ACHP	Advisory Council on Historic Preservation
APE	Area of Potential Effects
Ca.	Circa
CFR	Code of Federal Regulations
ERM	Environmental Resources Management
GRCARC	Grand Rapids City Archive and Record Center
GRHC	Grand Rapids Historical Commission
GRPL	Grand Rapids Public Library
GRPM	Grand Rapids Public Museum
GRWW	Grand Rapids Whitewater
MI SHPO	Michigan State Historic Preservation Office
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
Project	Grand Rapids Whitewater Project
USGS	United States Geological Survey

1. INTRODUCTION

1.1 Overview

Michigan State Historic Preservation Office (MI SHPO), in the course of consultation regarding the Project, has requested an evaluation of National Register of Historic Places (NRHP) eligibility of four low-head dams in the Grand River in Grand Rapids that would be affected by the Project, which proposes the removal of these dams in an effort to restore the river to a more natural state. With the support City of Grand Rapids and Grand Rapids Whitewater (GRWW), Environmental Resources Management (ERM) prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are potentially eligible for the NRHP, and if so, whether the Project may result in adverse effects to these cultural resources.

The Project requires funding authorization from the NRCS, and must comply with the provisions of the National Environmental Policy Act (NEPA) of 1970 and the National Historic Preservation Act (NHPA) of 1966. The need for federal authorization requires Project review under Section 106 of the NHPA, as amended. Section 106 of the NHPA (54 United States Code § 306108) requires federal agencies, including NRCS, to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment. Historic properties are defined as cultural resources that are listed or eligible for listing in the NRHP (36 Code of Federal Regulations [CFR] 60). GRWW, as a non-federal party, is assisting the Natural Resources Conservation Service (NRCS) in meeting its obligations under Section 106 by preparing the necessary information, analyses, and recommendations as authorized by 36 CFR § 800.2(a)(3).

On December 20, 2018, ERM, on behalf of NRCS, submitted a request for initial consultation regarding the Lower Grand River Watershed Habitat Restoration Project. On June 18, 2020, NRCS submitted an update to that submittal. MI SHPO responded on June 29, 2020 with a request for more information regarding the four low-head dams to be removed as part of the river restoration. Additional information was provided on November 2, 2020, to which MI SHPO responded with a request for further information regarding the known history and current condition of the four low-head dams (December 17, 2020, ER20-876). MI SHPO requested that additional information be provided about the dams to be removed by the Project, along with historical context that would help frame their potential eligibility for the NRHP. The current report was prepared to satisfy that request.

The Project includes the following:

- The Construction Area—the area within the wetted channel of the Grand River from approximately 130 feet upstream of the Bridge Street Bridge to the upstream edge of the Fulton Street Bridge
- The Project Area—the areas where Project activities would occur:
  - Portions of the land on both sides of the Grand River from the 6th Street Dam to Fulton Street (where construction access or staging areas would occur)
  - The wetted channel of the river from 130 feet upstream of the Bridge Street Bridge to the upstream face of the Fulton Street Bridge (the Construction Area)
  - Three recipient sites in the river for the placement of relocated unionid mussels. The three recipient sites are mussel beds near Ada, Michigan; at Riverside Park just upstream of Grand Rapids; and between Plaster Creek and the M-11 (28th Street) Bridge.

The Project's Area of Potential Effect (APE) is defined for direct effects as the Construction Area and Project Area, and for indirect effects as areas immediately adjacent to the Construction Area. Direct effects on the four low-head dams scheduled for removal are the subject of this report. Proposed earth

disturbance is not planned beyond the confines of the active river channel except for construction access points and temporary staging areas on the banks.

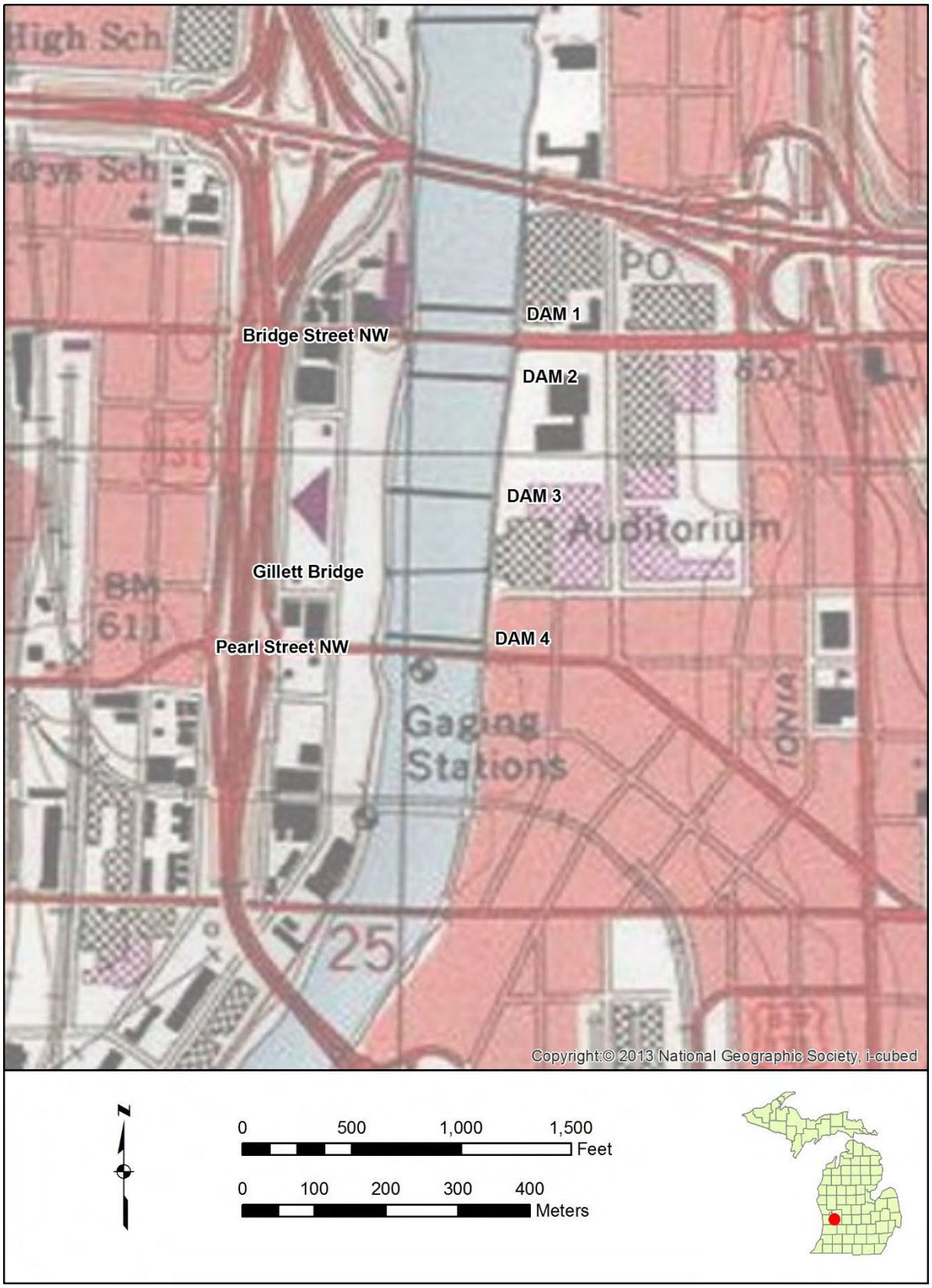

Figure 1.1-1: Topographic Map Showing Location of Dams



Figure 1.1-2: Current Aerial Imagery of Beautification Dams

The Project spans approximately 0.7 miles along the downtown portion of the Grand River, and includes the removal of four low-head, historic-aged dams associated with the twentieth century commercial growth of Grand Rapids, as well as other changes in and near the river (Figures 1.1-1 and 1.1-2). Another dam in the river at Grand Rapids, the Sixth Street Dam and Fish Passage, was constructed earlier than the other four, and was originally intended for water power. It was repaired and improved in 1926 as part of the planned improvements to the river recommended by city planner Harland Bartholomew. This dam has already been determined eligible for the NRHP (Robinson et al. 2020; B. Grennell to C. Sedlacek, letter dated 6 October, 2020). The current report evaluates the four dams located from just north of Bridge Street to just north of Pearl Street. In order to evaluate the significance of the dams, ERM collected information on the dams and their context from online sources and experts knowledgeable in local history, city planning, and historical public works. Documents, maps, and photographs were collected from the Grand Rapids City Archive and Record Center (GRCARC), the Grand Rapids Public Museum (GRPM), the Grand Rapids Public Library (GRPL), and the Grand Rapids Historical Commission (GRHC).

The four dams were constructed in 1927 as part of a plan to beautify the river through downtown. The creation of canals on both sides of the river for power and industrial use had led to low water levels in the river during dry periods, creating fetid pools and the growth of brush in the channel. The construction of low-head dams to create run-of-the-river pools had been recommended by Harlan Bartholomew as part of the 1925 City Plan (Bartholomew 1925). The proposed undertaking would entail removal of all four dams to reinstitute rapids in the riverbed, improving aquatic habitat diversity, improving public health and safety, expanding use of the river, and improving recreational use of the river. This report will evaluate the potential NRHP eligibility of the four Beautification Dams proposed for removal as part of the Project.

1.2 Management Recommendations

Based on the information gathered, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. ERM also recommends that the Project would have an adverse effect on the properties. The Project as currently proposed requires removal of all the dams and does not allow for avoidance or minimization of adverse effects. ERM recommends that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project

2. HISTORIC CONTEXT

When settlers began to congregate around the Baptist Mission on the west bank of the Grand River and the trading post established by Louis Campau on the east side of the river at what is now Grand Rapids in the 1820s, the river was described as a mile-long cascade of rapids that was 300 yards wide and dropped a total of 10 to 15 feet. A map made in 1830 (Grand Rapids Public Library 1830) shows the rapids that spanned the length of the city's street grid (Figure 2.0-1). The potential water power that the river could provide was immediately recognized, and by at least 1833, the river was being used for power. In 1835, the first dam was constructed on the river. The stone wing dam was located near Eleventh Street to the north of the Project area, and diverted water into the East Side Power Canal to provide waterpower to a sawmill and gristmill. The canal was extended for a mile along the river and was completed in 1842, providing power to a number of industries until it was abandoned in 1925. In 1849, a log and stone dam was constructed across the width of the river in an attempt to expand the canal for navigation. The canal project was a failure, but the horseshoe-shaped dam near Sixth Street remained until after 1878 (Figure 2.0-2) (Biolchini 2019; Robinson, et al. 2020).



Figure 2.0-1: Map of Grand Rapids in 1830 Showing the Rapids through the City (North is to the right) (GRPL)

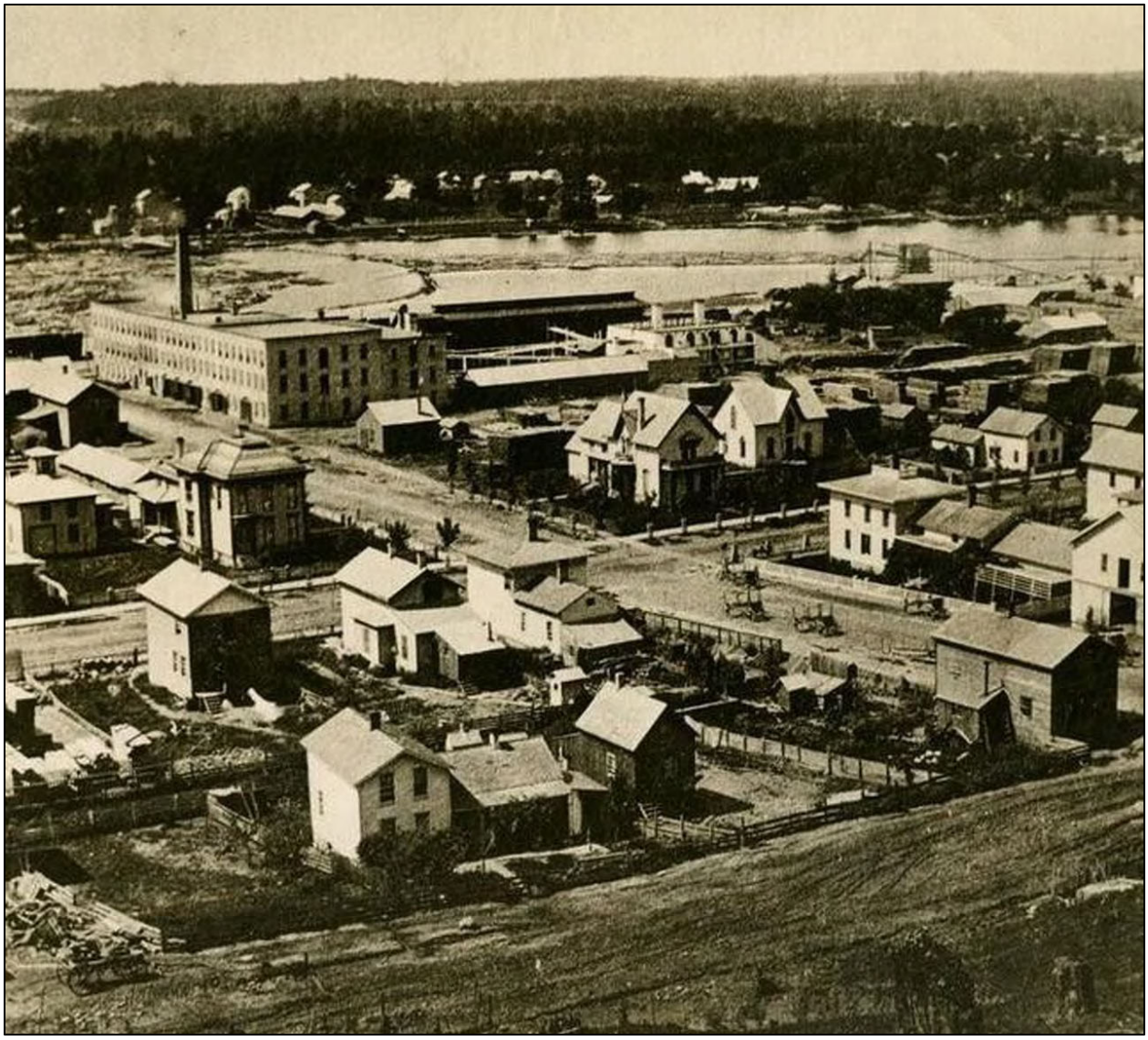

Figure 2.0-2: View of Grand Rapids in 1865 with the 1849 Horseshoe Dam in the Background (GRPL)

In 1866, the West Side Water Power Association began construction on the West Side Canal. Through an agreement with the East Side Water Power Company, the water rights would be split between the two companies, and a new, more permanent timber crib dam would be constructed across the river at Fourth Street that would serve both canals. This was known as the water power dam, or Fourth Street Dam (Figure 2.0-3). It was located a few blocks south of the earlier horseshoe dam, which remained in place until at least 1878 but was gone by 1888 (GRCARC 1873, 2019; Sanborn Map Company 1888). The Fourth Street Dam was later known as the Sixth Street Dam (Robinson et al. 2020).

In the early twentieth century, Grand Rapids experienced a series of disastrous floods. The first of these in 1904 damaged a 150-foot section of the Fourth Street Dam. At that time, it was suggested that a concrete dam replace the 1866 timber crib dam, although it appears that the dam was simply repaired (*Grand Rapids Herald* 1904). The city hired Lyman E. Cooley, an engineer from Chicago, to make recommendations regarding flood control and improving water power. Cooley proposed in 1904 that flood

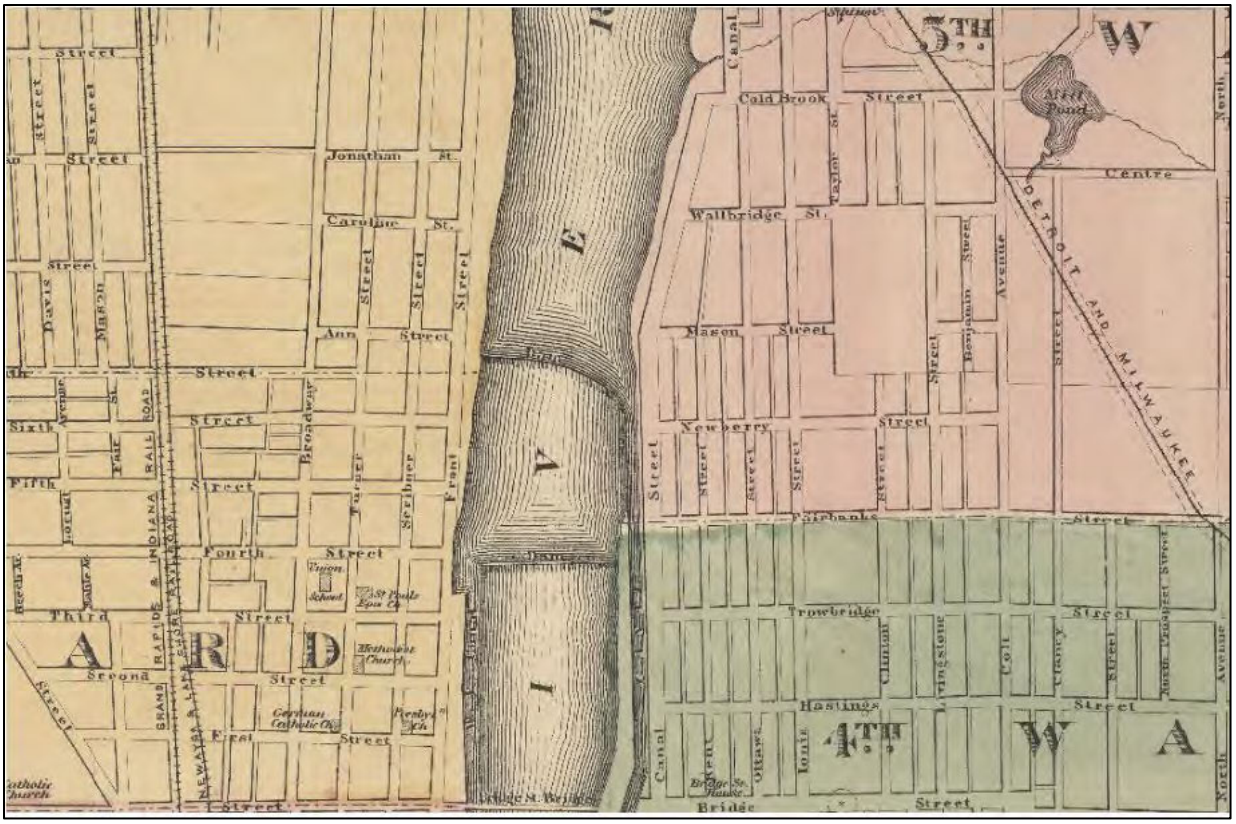

Figure 2.0-3: Map of Grand Rapids in 1873 Showing the 1866 Fourth Street Dam, the 1849 Horseshoe Dam, and the East and West Side Canals (GRCARC)

walls be constructed through the city, and work on these was begun soon after (Figure 2.0-4; Lydens 1966:122). In 1909, Cooley proposed that a new dam be constructed 300 feet north of Bridge Street. This dam was apparently not constructed (Biolchini 2019; Cooley 1909; Forist and Gleisner 2015).

In 1915, another major flood took out a 100-foot section of the western part of the Fourth Street Dam. Plans were proposed for the repair of the dam, with both a timber crib replacement and an upgrade to concrete being considered. The design of the concrete section is nearly identical to the plans later used for the Beautification Dams downstream. It appears from later plans that the damaged section was replaced with concrete, and the remaining timber crib section was replaced in 1926 when the beautification project was undertaken (GRCARC 2019).

The idea of a series of low-head dams on the Grand River in order to maintain water in the river bed and prevent the accumulation of trash and brush in the river was proposed by city planner Harland Bartholomew, whose firm was hired by the Grand Rapids Planning Department in the early 1920s to develop a master plan for the city (GRPL 2017). The diversion of water for the East and West Side Canals and city water works had resulted in the river often lacking a constant flow, resulting in the accumulation of trash and brush in the riverbed (Figure 2.0-5). The low-head dams would maintain the flow of the river and would “add greatly to the appearance and provide ample water surface for boating,” according to Bartholomew (Bartholomew 1925; Biolchini 2019; GRPM ca. 1926). An appropriation was approved for the beautification project in March 1926, but it was not until May 1927 that a bid of $24,112 was accepted from a Grand Rapids firm for the construction, with an expected completion date of

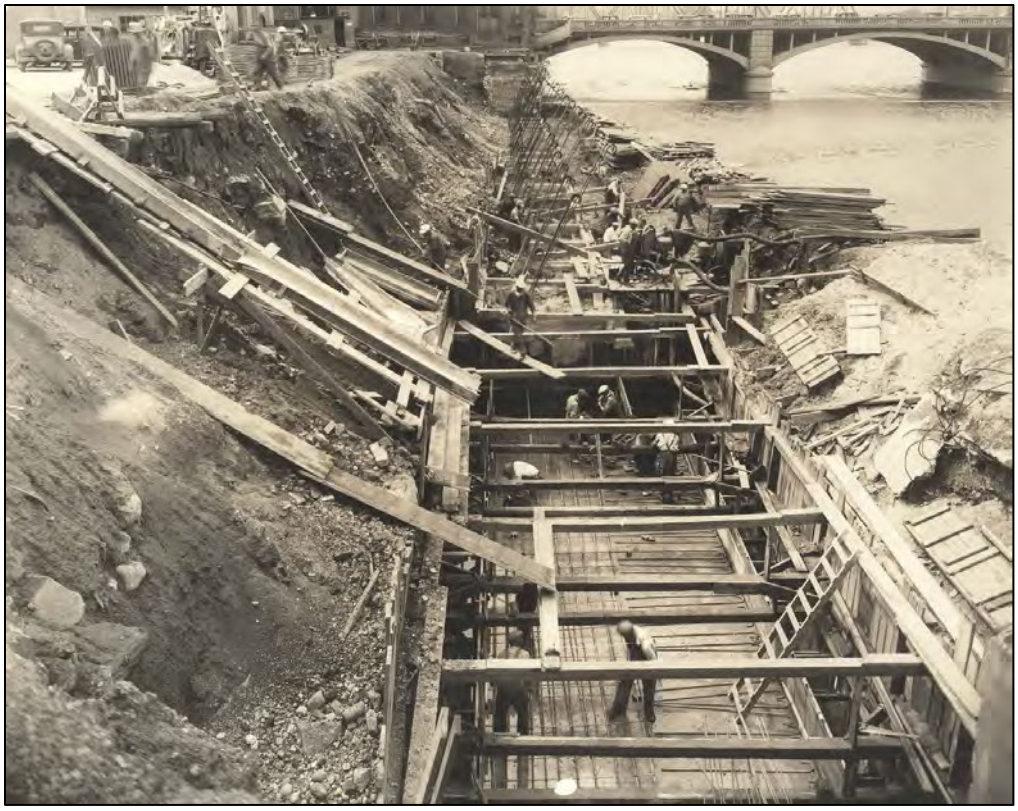

Figure 2.0-4: Construction of Flood Walls on the East Side of the River above the Pearl Street Bridge (GRCARC)



Figure 2.0-5: View of Downtown and the River Showing Brush Growing in the Riverbed Downstream of the Fourth Street Dam (GRPM)

January 1, 1928. The *Grand Rapids Press* praised the city for approving the plan, which would help the river "take on some of the beauty which existed before drought and the west side canal removed all liquid attractions" (*Grand Rapids Press* 1927a, 1927b).

The dams were constructed by diverting water using a coffer dam, leaving the riverbed dry (Figure 2.0-6) (*Grand Rapids Herald* 1927). They were completed by January 2, 1928, when a report of the Engineers' Office noted that it had overseen the placement of the dams at a cost of $37,000. In April 1928, the mayor remarked that the dams had "improved the appearance of the river 100 percent." In July 1928, the *Grand Rapids Press* remarked, "By expenditure on a series of carefully placed dams Grand Rapids has succeeded, without increasing its flood hazard in restoring some of the beauty of Grand river between the main dam at Fourth street and a point two or three hundred feet north of Pearl Street bridge" (*Grand Rapids Press* 1928a, 1928b).

The dams have remained in place to the present, with no known significant changes. The purposes of the dam construction project were well realized, as the water level was maintained, and public and private development became more focused on the river in the twentieth century. Numerous parks and public and private attractions have been established on both sides of the river, including the Gerald R. Ford Presidential Museum, Grand Rapids Public Museum, the Civic Auditorium (now part of the DeVos Place Convention Center), Ah-Nab-Awen Park, and Sixth Street Park.

Details related to the conception, design and construction of the Beautification Dams, as well as their place within the context of city planning in general and the work of Harland Bartholomew in particular, are discussed in greater detail in Section 4.



Figure 2.0-6: Dry Bed of the Grand River during Construction of Beautification Dams, View to the South from Bridge Street Bridge; Dam #2 is in the Foreground (GRCARC)

3. METHODS

3.1 Survey Methods

The current investigation was prompted by a request from the MI SHPO for additional information about the four low-head dams and their historical context to assist in a determination of eligibility. In a comment letter dated December 17, 2020, MI SHPO requested survey information about the nature and condition of the dams and a discussion of their potential NRHP eligibility within a proper historical context.

Because of accessibility issues due to the COVID-19 pandemic and the fact that the dams are currently covered by water, ERM architectural historians undertook a remote survey of the properties based on historical plans and historical and current photographs from a variety of sources including the GRCARC, GRWW, GRPL, Google Earth, and previous site visits. The photographs were used to record the structures' overall appearance and details. Topographic maps and aerial photographs were used to record the relationship of the structures to each other and the surrounding landscape features and infrastructure.

A Michigan State Architectural Properties Identification Form was completed as part of the recordation process, which is attached in Appendix A.

3.2 Documentary Research

In order to assess the significance of the dams, ERM collected information from knowledgeable experts in local history, city planning, and historical public works. ERM conducted online research to identify historic themes, events, and patterns important in the development of local, regional, and national significance. Local government records and information provided by knowledgeable local organizations also were examined to establish a context for the development of the water control systems in Grand Rapids, as well as specific details relating to the system as built and as it exists today. Documents, maps, and photographs were collected from the GRCARC, the GRPM, the GRPL, and the GRHC.

3.3 NRHP and Effects Evaluation

The four dams were evaluated with respect to their eligibility for listing on the NRHP using published guidance from the National Park Service. According to 36 CFR 60.4 (Andrus and Shrimpton 2002), cultural resources eligible for listing on the NRHP are defined as buildings, structures, objects, sites, and districts that have "integrity" and that meet one or more of the criteria outlined below. Criterion D is typically relevant to archaeological sites. Historic resources are generally evaluated in relation to Criteria A, B, and C. Criterion C is typically applicable to architectural resources but also may be relevant in the case of resources that are associated with landscape architecture (like cemeteries or battlefields) or engineering (like dams, bridges, railroads, and mines).

- Criterion A (Event). Association with one or more events that have made a significant contribution to the broad patterns of national, state, or local history
- Criterion B (Person). Association with the lives of persons significant in the past
- Criterion C (Design/Construction). Embodiment of distinctive characteristics of a type, period, or method of construction; or representation of the work of a master; or possession of high artistic values; or representation of a significant and distinguishable entity whose components may lack individual distinction
- Criterion D (Information Potential). Properties that yield, or are likely to yield, information important in prehistory or history. Criterion D is most often (but not exclusively) associated with archaeological resources. To be considered eligible under Criterion D, sites must be associated with specific or

general patterns in the development of the region. Therefore, sites become significant when they are seen within the larger framework of local or regional development.

"Integrity" is perhaps the paramount qualification of NRHP eligibility, and can be related to any or all of the following (Andrus and Shrimpton 2002):

- Location: the place where the historic property (or properties) was/were constructed or where the historic event(s) occurred
- Design: the combination of elements that create the form, plan, space, structure, and style of a property (or properties)
- Setting: the physical environment of the historic property (or properties)
- Materials: the physical elements that were combined to create the property (or properties) during the associated period of significance
- Workmanship: the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory
- Feeling: the property's (or properties') expression of the aesthetic or historic sense of the period of significance
- Association: the direct link between the important historic event(s) or person(s) and the historic property (or properties).

The four dams were evaluated in relation to these criteria and attributes, and then the criteria of adverse effect were applied for the proposed undertaking in accordance with ACHP regulations at 36 CFR 800.5. Specifically,

> An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the National Register. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative.

4. SURVEY RESULTS

This section presents the findings of the historic architectural investigation carried out for the Project. One resource, consisting of four low-head dams in the Grand River at Grand Rapids, known as Beautification Dams, was evaluated as part of the Section 106 review for the Project. The dams would be removed as part of the Project, and thus would be subject to direct effects from the Project.

4.1 Previous Investigations

A literature review of previously recorded resources determined that the Beautification Dams had not been previously recorded as historic resources. An Architectural Properties Identification Form was completed as part of the current investigations (Appendix A).

4.2 Current Survey Findings

The Beautification Dams consist of four low-head concrete dams ranging from 1.5 to 3 feet in height and approximately 425 to 440 feet in length, located in the Grand River between the Interstate 196 Bridge and the Pearl Street Bridge. The four dams together constitute the evaluated resource, and are collectively referred to as the Beautification Dams in the Grand River. They are recommended eligible for the NRHP and are summarized in Table 4.2-1. A view of each dam is shown in Figures 4.2-1 through 4.2-4.

Table 4.2-1: Summary of Beautification Dams in the Grand River

Number	Location	Length*	Height†
Dam #1	135–155 feet north of the center of the Bridge Street Bridge	437 feet	3 feet
Dam #2	148–175 feet south of the center of the Bridge Street Bridge	440 feet	1.5 feet
Dam #3	336–373 feet north of the center of the Gillette Pedestrian Bridge (Interurban Bridge)	440 feet	2 feet
Dam #4	85 feet north of the center of the Pearl Street Bridge	425 feet	1.5 feet

* Estimated length based on aerial photographs

† Based on ca. 1927 profile drawings



Figure 4.2-1: Dam #1, View to the Northeast



Figure 4.2-2: Dam #2, View to the East



Figure 4.2-3: Dam #3, View to the East



Figure 4.2-4: Dam #4, View to the West

4.2.1 Beautification Dams History

Low-head or low-stage dams typically run the width of a river or stream and allow the water flow to pass over all or most of its length. They can be as high as 15 feet, but are more commonly just a few feet in height. These types of dams are common throughout the United States and are usually constructed to raise the water level for civic, industrial, or agricultural use. They also enhance recreational opportunities. Many low-head dams were constructed across the U.S. in the eighteenth and nineteenth centuries to power gristmills and small industries (Tschantz and Wright 2011:8).

The use of low-head dams for beautification and recreation, rather than commercial and industrial uses, coincided with the emergence of city planning as a professional pursuit in the early twentieth century, and a shift in public attitudes toward the environment and the revitalization of urban areas through public improvement projects and regulatory policy (Hill 2000:153). Harland Bartholomew was a prominent city planner from the 1920s to the 1980s, known for advocating for zoning laws and creating the concept of the “City Efficient.” His firm, Harland Bartholomew & Associates (HB&A) developed more than 500 city plans and more than 300 zoning proposals for cities in the U.S. and internationally (Barone 2018:438).

Bartholomew began working on a plan for Grand Rapids as early as 1921 (GRPL 2017). His plan for Grand Rapids was based on similar principles to those he applied in other cities, both large and small. The plans were based on zoning, a concept that was being recognized by city leaders as the most efficient way to maintain property values and grow their cities in a controlled manner. Bartholomew’s zoning classes were based on variations on three factors: use, building height, and lot size. Industrial uses were zoned to the outskirts of the city, along rail lines and waterways, while the downtown area was designated for commercial use. Planning firms worked with city planning commissions to develop a plan that the commission could promote to city officials, civic groups, and business leaders. The planning commissions also worked to build public support for the plans. The goal was to get buy-in from a variety of interests in the city by highlighting the economic advantages that would accrue from a comprehensive zoning plan. In Grand Rapids, the City Planning Commission presented their early planning work at a municipal fair called “City Show” in 1920 (Moskowitz 1998:308–309).

Bartholomew produced a number of documents for the City of Grand Rapids between 1921 and 1927. His overall vision was presented to the public in 1924 through the *Grand Rapids Press* (1924a), which published a rendering of the “Future Grand Rapids” produced by Bartholomew (Figure 4.2-5). The Grand River occupied the prominent spot in the oblique aerial view and was flanked by a tree-lined esplanade on the east bank and a park with trees, open spaces, and walkways on the west bank. The bridge at the bottom of the drawing is the Bridge Street Bridge, with the next two bridges being the interurban rail bridge (Gillette Pedestrian Bridge) and the Pearl Street Bridge. No dams are evident in the view, but the river is full from bank to bank, with no obstructions. Eventually, the esplanade along the river was constructed in the form of the Riveredge Trail, and parks were established along the west side of the river, as envisioned in the plan. The changes proposed in the plan, including a “beautiful river front,” were praised by the paper as “outstanding” (Grand River Press 1924b).

Bartholomew’s City Plan for Grand Rapids included a section on riverfront improvement (Bartholomew 1925:100–103). He stated that the river was the city’s “raison d’etre,” but had fallen into insignificance in the commercial age. However, Bartholomew maintained that opportunities for development were available, and that the city should purchase as much of the riverfront property as possible. The flood walls in place along portions of the river were seen as a positive influence that would permit linear parks adjacent to the river. He recommended the construction of additional walls and the reclaiming land adjacent to the east side of the river that was occupied by the East Side Canal and constructing a road alongside the river. This would separate the buildings from the riverside docks and encourage more aesthetic architecture. The improvements would not interfere with the commercial or industrial activities of

the city, because the river no longer had value to those interests. The plan for the river was plainly laid out, including improving the appearance below the existing 6th Street dam:

> Grand Rapids must complete its flood wall as a protective measure. It would seem that this work would offer the best opportunity to carry out a more thorough riverfront improvement program. Not only should the banks be improved by the use of wall, terraces, small parks and plazas, but the appearance of the river below the dam should be improved. During the dry seasons certain stretches of the rapids have the appearance of an abandoned stone quarry overgrown with weeds and littered with tin cans, crates and rubbish. Several low-stage dams could be constructed at intervals which would maintain water constantly in the river. This would add greatly to the appearance and provide ample water surface for boating [Bartholomew 1925:102].

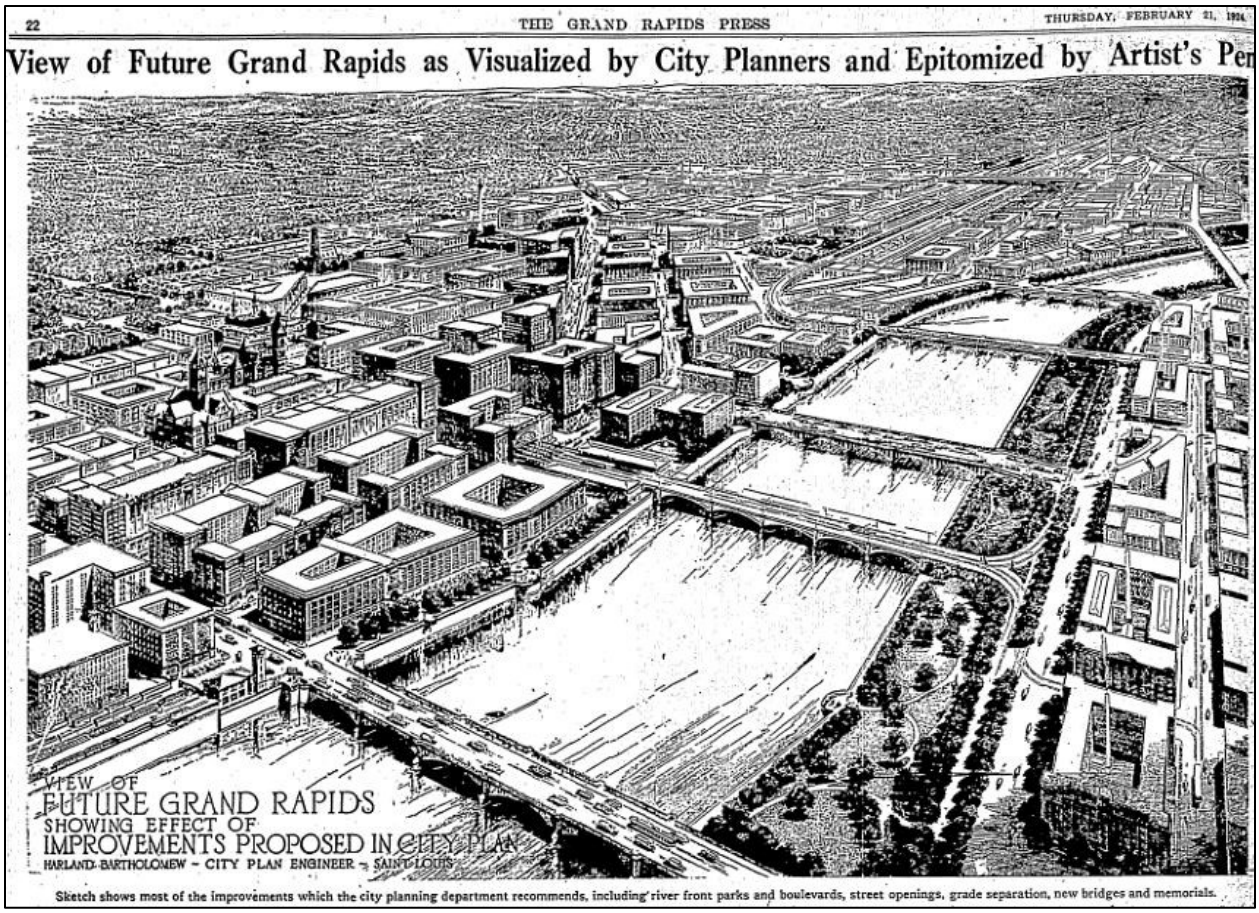

Figure 4.2-5: Artist Rendition of Harland Bartholomew's City Plan (1924)

In October 1925, the city reached an agreement with the Consumers Power Company (the former West Side Water Power Association) and the East Side Power Company to purchase the rights to the East Side Canal, which would be closed to form a sewer and a riverside park. The city had held an option on the rights to the canal for some time, and it appears that the acquisition of the property was part of the effort to carry out the plans for beautification of the river. The agreement stipulated that the city "reserved perpetual right to sufficient water for all city purposes, and that "sufficient water must be kept running over

the large dam to keep a series of smaller dams filled the year around" (*Grand Rapids Press* 1925). The story in the *Grand Rapids Press* stated that the city would keep the river clean, and "To this end it has secured the necessary options for construction of three dams, one just north of Bridge-st., one just south of Bridge-st., and third just north of Pearl-st., calculated to hold enough water to hide the ugly bottom, now strewn with all manner of debris and overgrown with weeds." According to the article, the "pretentious program of beautification, as sketched by Harland Bartholomew of St. Louis, city planning expert responsible for Grand Rapids' zoning ordinance, now approaches a step nearer realization."

The value of improving the river both economically and aesthetically was not lost on observers, even in the planning stages. The *Grand Rapids Press* noted of the plan in 1925 that, "Advantage will be taken of the open sloping west bank, which now is a mass of weeds, and a modest program of landscaping and care is expected to do wonders." The acquisition of the canal land allowed for a reorganized street plan and the availability of valuable land. "When this wilderness of rubbish, old iron and decrepit buildings has been cleared away the increased value of the property, according to the analysis of [assistant to the city's consulting engineer] Mr. Tenlloor, will have justified the trouble, and the city will be rid of perhaps its greatest fire menace" (*Grand Rapids Press* 1925).

The original plan apparently included five dams, but only four were constructed due to water rights of the last user of the West Side Canal for a water wheel (*Grand Rapids Press* 1927a, 1928b). The city appropriated $7,500 in March of 1926 for "…beautification of Grand River through the erection of dams intended to create a greater depth of water inside the city limits" (*Grand Rapids Press* 1926). However, it was not until May of 1927 that a bid was accepted for the project. The $24,000 bid of Peninsular Construction Company of Grand Rapids was over the city's estimate for the work, but was less than the only other bid received. The plans at that time were for the dams to be constructed of concrete and approximately 470 feet long. The dams were to be located 100 feet north of Bridge Street, 36 feet south of Bridge Street, at Brumrich Street, 50 feet north of Pearl Street, and 35 feet south of Pearl Street (*Grand Rapids Press* 1927a). The locations given approximate the final placements, which are detailed in Table 4.2-1.

Profile plans of the dams are shown in Figure 4.2-6 (GRCARC ca. 1927). It is not clear if the dams were built to these exact specifications, as no as-built drawings have been located. The profiles indicate that Dam #1 would have a height of 3 feet, Dam #2 and Dam #4 would be 1.5 feet high, and Dam #3 and Dam #5 would each be 2 feet high. Dam #5 was eventually dropped from the plan. A profile map of the river made in 1928 indicates that the actual dams were lower (GRCARC 1928). Current elevations taken across the dams show irregular heights across the width of the dams and only about a 1–1.5-foot drop between them. This may be due to erosion of the tops of the dam as a result of water scouring. The profiles in Figure 4.2-6 show a typical low-head concrete dam shape that has a slightly sloping upstream face with a beveled cap and a ramp-like downstream face to break the fall of the water. Each dam would have a flap or drain valve at the base. Figure 4.2-7 shows the profile of the dams after construction, which is consistent with the plans. The valve appears to have been constructed as a gated opening rather than an outlet in the base of the dam, as can be seen in Figure 4.2-8.

Work on the coffer dam to divert the river during construction began by July 1927 (*Grand Rapids Herald* 1927). As noted above, the dams were completed on schedule by January 1, 1928, although the $37,000 cost was considerably more than the $24,000 bid. Figure 4.2-9 shows Dam #1 after construction, looking north, with the Sixth Street Dam in the background.

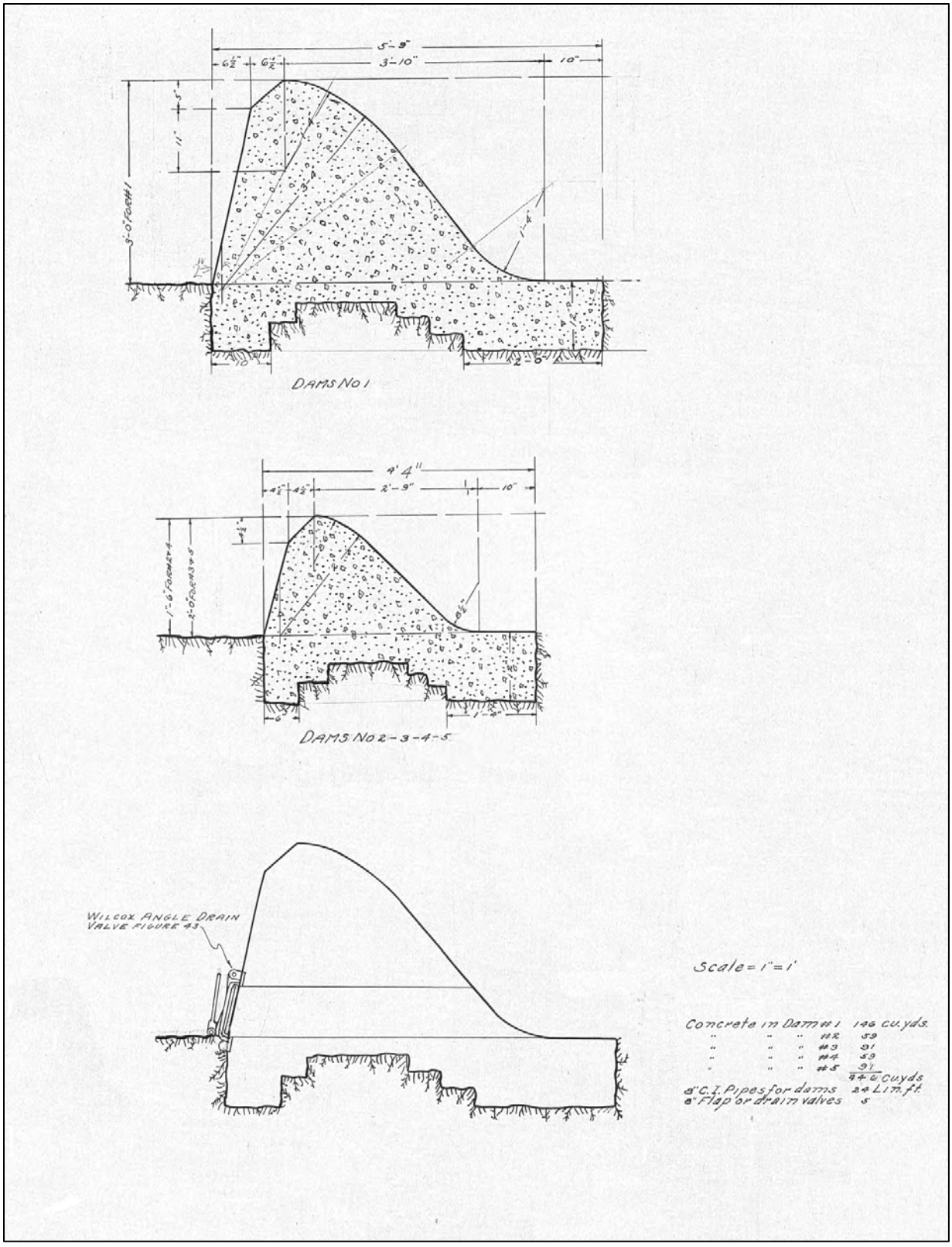

Figure 4.2-6: Engineering Drawings Showing Profile of Dams, ca. 1927 (GRCARC)



Figure 4.2-7: View of Dam #1, North of Bridge Street, 1927, Showing Dam Profile (GRCARC)



Figure 4.2-8: View of Dam #1, North of Bridge Street, 1927, Showing Opening Near Center (GRCARC)



Figure 4.2-9: Dam #1 after Construction, 1927, with Water Flowing in the River Bed (GRCARC)

4.2.2 Beautification Dams: Architectural Description and Evaluation

The Beautification Dams in the Grand River are four low-head, concrete dams that run the width of the river in downtown Grand Rapids. They vary in height from 1.5 to 3 feet, and in length from approximately 425 feet to 440 feet. They are anchored in bedrock to a depth of approximately 1 foot. Historical drawings and photographs indicate that a gated opening was located in each dam, but the nature and location of these openings in the current dams is not clear due to the dams being obscured by water. The dams have the same basic profile as shown in Figures 4.2-6 and 4.2-7. The form and construction technique is typical of low-head dams constructed throughout the United States during the period.

NRHP Evaluation: ERM recommends that the Beautification Dams in Grand River are potentially eligible for the NRHP under Criterion A for their association with events important to the history of Grand Rapids. The dams reflect efforts in the early twentieth century to improve the city through planning, zoning, and public works projects. The result was a shift in the orientation of the downtown area to embrace the river as an attraction for enjoyment and recreation. Parks and trails were established along the banks, and new buildings were constructed with an emphasis on attractive architecture that encouraged public use of the surrounding spaces. ERM recommends that the dams are also significant under Criterion B for their association with Harland Bartholomew, one of the most influential city planners of the twentieth century.

Beginning in St. Louis in 1916, Bartholomew and his firm developed plans for hundreds of cities, influencing zoning decisions and promoting urban renewal and beautification. Bartholomew's plan for Grand Rapids specifically called for the installation of the dams, which consequently influenced the development of the downtown area in the way in which he intended. Although the Beautification Dams retain sufficient architectural integrity to convey the resources' historical significance, their design is utilitarian and common to contemporary structures across the country. As a result, they do not represent exceptional design or engineering and do not constitute an outstanding example of architecture associated with historic water control features. Therefore, ERM recommends the Beautification Dams in Grand River are not potentially eligible for the NRHP under Criterion C. For similar reasons, ERM recommends that the dams are not likely to yield information important to history and are thus not potentially eligible under Criterion D.

Assessment of Effects: The function of the Beautification Dams would not be retained as a result of their removal, although the Project is intended to restore the beauty of the original rapids that once characterized the river. The placid, quiet waters created by the dams would be replaced by faster moving water that would create a different atmosphere than that which characterized the river between 1927 and the present. Although the goal of the Project, in part, is similar to that of the 1925 Bartholomew plan in making the river attractive for expanded recreation and use, the nature of the experience for those using the river space would be different from that intended by Bartholomew. Therefore, it is ERM's opinion that the proposed removal of the dams would compromise the character-defining features of the dams that make them historically significant, and the action would constitute an adverse effect.

5. CONCLUSION AND RECOMMENDATIONS

ERM conducted an evaluation of the NRHP eligibility of four low-head dams in the Grand River in Grand Rapids, which would be affected by the Grand Rapids Whitewater Project. With the support of the City of Grand Rapids and GRWW, ERM prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are potentially eligible for the NRHP, and if so, whether removal of the dams as part of the Project would result in adverse effects to these cultural resources. The findings of the current study are intended to support the Section 106 review of the proposed undertaking, which is subject to funding by the NRCS.

Based on the information gathered and presented here, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are potentially eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. Although the Beautification Dams retain sufficient architectural integrity to convey their historical significance, their design is utilitarian and common to contemporary structures across the country, and is not likely to yield information important to history. Therefore, ERM recommends that the Beautification Dams are not potentially eligible for the NRHP under Criteria C and D.

The function of the Beautification Dams to maintain water levels across the width of the Grand River would not be retained as a result of their removal. Although the goal of the Project, in part, is similar to that of the 1925 Bartholomew plan in making the river attractive for expanded recreation and use, the nature of the experience for those using the river space would be different from that intended by Bartholomew. Therefore, it is ERM's opinion that the proposed removal of the dams would compromise the character-defining features of the dams that make them historically significant, and the action constitutes an adverse effect. The Project plan as currently proposed requires removal of all of the dams and does not allow for avoidance or minimization of adverse effects. It is ERM's recommendation that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project.

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APPENDIX A ARCHITECTURAL PROPERTIES IDENTIFICATION FORM

Michigan SHPO Architectural Properties Identification Form

Property Overview and Location

Street Address	Grand River, between I-196 Bridge and Pearl Street Bridge				
City/Township, State, Zip Code	Grand Rapids, Michigan, 49503				
County	Kent				
Assessor's Parcel #	N/A				
Latitude/Longitude (to the 6th decimal point)	Lat:42.968836		Long: -85.674529		
Ownership	Private ☐	Public-Local ☒	Public-State ☐	Public-Federal ☐	Multiple ☐

Property Type

Building ☐ select sub-type below Commercial ☐ Residential ☐ Industrial ☐ Other ☐	Structure ☒ Object ☐

(Insert primary photograph below.)



Architectural Information

Construction Date	1927	
Architectural Style	Dams (4)	
Building Form	Low-head dams	
Roof Form	N/A	
Roof Materials	N/A	
Exterior Wall Materials	N/A	
Foundation Materials	Bedrock anchor	
Window Materials	N/A	
Window Type	N/A	
Outbuildings	Yes ☐	No ☒
Number/Type:		

Eligibility

Individually Eligible	Criterion A ☒	Criterion B ☒	Criterion C ☐	Criterion D ☐
Criteria Considerations:		a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐		
Component of a Historic District	Contributing to a district ☐	Non-contributing to a district ☐	Historic District Name	
Not Eligible ☐				

Area(s) of Significance	Events important to history of Grand Rapids, association with Harland Bartholomew						
Period(s) of Significance	1927						
Integrity – Does the property possess integrity in all or some of the 7 aspects?							
Location ☒	Design ☒	Materials ☒	Workmanship ☒	Setting ☒	Feeling ☒	Association ☒	
General Integrity:	Intact ☒	Altered ☐	Moved ☐	Date(s):			
Historic Name	Beautification Dams						
Current/Common Name	Beautification Dams						
Historic/Original Owner	City of Grand Rapids						
Historic Building Use	Dams						
Current Building Use	Dams						
Architect/Engineer/Designer	Harland Bartholomew & Associates						
Builder/Contractor	Peninsular Construction Company						

Survey Date	7 Nov 2018	Recorded By	ERM	Agency Report #	

For SHPO Use Only	SHPO Concurrence?: Y / N	Date:

Form date: 2/28/2020

Narrative Architectural Description

Provide a detailed description of the property, including all character-defining features and any accessory resources. This is required for all properties.

The Beautification Dams in the Grand River are four low-head, concrete dams that run the width of the river in downtown Grand Rapids. They vary in height from 3 feet to 1.5 feet, and in length from approximately 425 feet to 440 feet. They are anchored in bedrock to a depth of approximately 1 foot. The only feature of the dams is an opening, presumably for flow and debris control. The dams have the same basic profile. The form and construction technique is typical of low-head dams constructed throughout the United States during the period.

History of the Resource

Provide information on previous owners, land use(s), and construction and alteration dates in a narrative format. This is required for all intensive level surveys, NRPQs, and nominations, and recommended for other identification efforts.

(see Figures at end of form)

Low-head or low-stage dams typically run the width of a river or stream and allow the water flow to pass over all or most of its length. They can be as high as 15 feet, but are more commonly just a few feet in height. These types of dams are common throughout the United States and are usually constructed to raise the water level for civic, industrial, or agricultural use. They also enhance recreational opportunities. Many low-head dams were constructed across the U.S. in the eighteenth and nineteenth centuries to power gristmills and small industries (Tschantz and Wright 2011:8).

The use of low-head dams for beautification and recreation, rather than commercial and industrial uses in the early twentieth century coincided with the emergence of city planning as a professional pursuit, and a shift in public attitudes toward the environment and the revitalization of urban areas through public improvement projects and regulatory policy (Hill 2000:153). Harland Bartholomew was a prominent city planner from the 1920s to the 1980s, known for advocating for zoning laws and creating the concept of the “City Efficient.” His firm, Harland Bartholomew & Associates (HB&A) developed more than 500 city plans and more than 300 zoning proposals for cities in the U.S. and internationally, making it likely the largest city planning firm in the country (Barone 2018:438).

Bartholomew began working on a plan for Grand Rapids as early as 1921 (GRPL 2017). His plan for Grand Rapids was based on similar principles to those he applied in other cities, both large and small. The plans were based on zoning, a concept that was being recognized by city leaders as the most efficient way to maintain property values and grow their cities in a controlled manner. Bartholomew’s zoning classes were based on variations on three factors: use, building height, and lot size. Industrial uses were zoned to the outskirts of the city, along rail lines and waterways, while the downtown area was designated for commercial use. Planning firms worked with city planning commissions to develop a plan that the commission could sell to city officials, civic groups, and business leaders. The planning commissions also worked to build public support for the plans. The goal was to get buy-in from a variety of interests in the city by highlighting the economic advantages that would accrue from a comprehensive zoning plan. In Grand Rapids, the City Planning Commission presented their early planning work at a municipal fair called “City Show” in 1920 (Moskowitz 1998:308–309).

Bartholomew produced a number of documents for the City of Grand Rapids between 1921 and 1927. His overall vision was presented to the public in 1924 through the *Grand Rapids Press* (1924a), which published a rendering of the “Future Grand Rapids” produced by Bartholomew (Figure 1). The Grand River occupied the prominent spot in the oblique aerial view and was flanked by a tree-lined esplanade on the east bank and a park with trees, open spaces, and walkways on the west bank. The bridge at the bottom of the drawing is the Bridge Street Bridge, with the next two bridges being the interurban rail bridge (Gillette Pedestrian Bridge) and the Pearl Street Bridge. No dams are evident in the view, but the river is full from bank to bank, with no obstructions. Eventually, the esplanade

along the river was constructed in the form of the Riveredge Trail, and parks were established along the west side of the river, as envisioned in the plan. The changes proposed in the plan, including a "beautiful river front," were praised by the paper as "outstanding" (Grand River Press 1924b)

Bartholomew's City Plan for Grand Rapids included a section on riverfront improvement (Bartholomew 1925:100–103). He stated that the river was the city's "raison d'etre," but had fallen into insignificance in the commercial age. However, Bartholomew maintained that opportunities for development were available, and that the city should purchase as much of the riverfront property as possible. The flood walls in place along the river were seen as a positive influence that would permit linear parks adjacent to the river. He recommended reclaiming land adjacent to the east side of the river that was occupied by the East Side Canal and constructing a road alongside the river. This would separate the buildings from the riverside docks and encourage more aesthetic architecture. The improvements would not interfere with the commercial or industrial activities of the city, because the river no longer had value to those interests. The plan for the river was plainly laid out:

> Grand Rapids must complete its flood wall as a protective measure. It would seem that this work would offer the best opportunity to carry out a more thorough riverfront improvement program. Not only should the banks be improved by the use of wall, terraces, small parks and plazas, but the appearance of the river below the dam should be improved. During the dry seasons certain stretches of the rapids have the appearance of an abandoned stone quarry overgrown with weeds and littered with tin cans, crates and rubbish. Several low-stage dams could be constructed at intervals which would maintain water constantly in the river. This would add greatly to the appearance and provide ample water surface for boating. (Bartholomew 1925:102)

In October 1925, the city reached an agreement with the Consumers Power Company (the former West Side Water Power Association) and the East Side Power Company to purchase the rights to the East Side Canal, which would be closed to form a sewer and a riverside park. The city had held an option on the rights to the canal for some time, and it appears that the acquisition of the property was part of the effort to carry out the plans for beautification of the river. The agreement stipulated that the city "reserved perpetual right to sufficient water for all city purposes,"…and that "sufficient water must be kept running over the large dam to keep a series of smaller dams filled the year around" (*Grand Rapids Press* 1925). The story in the *Grand Rapids Press* stated that the city would keep river clean, and "To this end it has secured the necessary options for construction of three dams, one just north of Bridge-st., one just south of Bridge-st., and third just north of Pearl-st., calculated to hold enough water to hide the ugly bottom, now strewn with all manner of debris and overgrown with weeds." According to the article, the "pretentious program of beautification, as sketched by Harland Bartholomew of St. Louis, city planning expert responsible for Grand Rapids' zoning ordinance, now approaches a step nearer realization."

The value of improving the river, both economically and aesthetically was not lost on observers, even in the planning stages. The *Grand Rapids Press* noted of the plan in 1925 that, "Advantage will be taken of the open sloping west bank, which now is a mass of weeds, and a modest program of landscaping and care is expected to do wonders." The acquisition of the canal land allowed for a reorganized street plan and the availability of valuable land. "When this wilderness of rubbish, old iron and decrepit buildings has been cleared away the increased value of the property, according to the analysis of [assistant to the city's consulting engineer] Mr. Tenlloor, will have justified the trouble, and the city will be rid of perhaps its greatest fire menace" (*Grand Rapids Press* 1925).

The original plan apparently included five dams, but only four were constructed due to water rights of the last user of the West Side Canal for a water wheel (*Grand Rapids Press* 1927a, 1928b). The city appropriated $7,500 in March of 1926 for "…beautification of Grand River through the erection of dams intended to create a greater depth of water inside the city limits" (Grand Rapids Press 1926). However, it was not until May of 1927 that a bid was accepted for the project. The $24,000 bid of Peninsular Construction Company of Grand Rapids was over the city's estimate for the work, but was less than the only other bid received. The plans at that time were for the dams to be constructed of concrete and approximately 470 feet long. The dams were to be located 100 feet north of Bridge Street, 36 feet south of Bridge Street, at Brumrich Street, 50 feet north of Pearl Street, and 35 feet south of Pearl Street (*Grand Rapids Press* 1927a).

Profiles plans of the dams are shown in Figure 2 (GRCARC ca. 1927). It is not clear if the dams were built to these

exact specifications, as no as-built drawings have been located. The profiles indicate that Dam #1 would have a height of 3 feet, Dam #2 and Dam #4 would be 1.5 feet high, and Dam #3 and Dam #5 would each be 2 feet high. Dam #5 was eventually dropped from the plan. A profile map of the river made in 1928 indicates that the actual dams were lower (GRCARC 1928). Current elevations taken across the dams show irregular heights across the width of the dams and only about a 1–1.5-foot drop between them. This may be due to erosion of the tops of the dam as a result of water scouring. The profiles in Figure 2 show a typical low-head concrete dam shape that has a slightly sloping upstream face with a beveled cap and a ramp-like downstream face to break the fall of the water. Each dam would have a flap or drain valve at the base. Figure 3 shows the profile of the dams after construction, which is consistent with the plans. The valve appears to have been constructed as a gated opening rather than an outlet in the base of the dam, as can be seen in Figure 4.

Work on the coffer dam to divert the river during construction began by July 1927 (*Grand Rapids Herald* 1927). As noted above, the dams were completed on schedule by January 1, 1928, although the $37,000 cost was considerably more than the $24,000 bid. Figure 5 shows Dam #1 after construction, looking north, with the Sixth Street Dam in the background.

Statement of Significance/Recommendation of Eligibility

Provide a detailed explanation of the property's eligibility for the National Register. Include an evaluation under at least one of the four National Register Criteria and one Area of Significance. Include a discussion of the seven aspects of integrity, and make a recommendation about eligibility. This is required for all properties.

The Beautification Dams retain integrity of location, as they have not moved from their original location. In addition, the associated bridges and the river have remained unchanged, and most of the buildings surrounding the dams are original to the construction of the dams, which means the dams still retain integrity of setting. The Beautification Dams do retain their design and material integrity as no alterations to the utilitarian structures are known. Furthermore, the dams retain integrity of workmanship and association as a structure that conveys the craftsmanship of a utilitarian design tied to water control and public works improvement projects. Finally, the Beautification Dams retain integrity of feeling when viewed as a whole, with the river and surrounding bridges. For these reasons, ERM recommends that the Beautification Dams in Grand River are potentially eligible for the NRHP under Criterion A for their association with events important to the history of Grand Rapids. The dams reflect efforts in the early twentieth century to improve the city through planning, zoning, and public works projects. The result was a shift in the orientation of the downtown area to embrace the river as an attraction for enjoyment and recreation. Parks and trails were established along the banks, and new buildings were constructed with an emphasis on attractive architecture that encouraged public use of the surrounding spaces. ERM recommends that the dams are also significant under Criterion B for their association with Harland Bartholomew, one of the most influential city planners of the twentieth century. Beginning in St. Louis in 1916, Bartholomew and his firm developed plans for hundreds of cities, influencing zoning decisions and promoting urban renewal and beautification. Bartholomew's plan for Grand Rapids specifically called for the installation of the dams, which consequently influenced the development of the downtown area in the way in which he intended. Although the Beautification Dams retain sufficient architectural integrity to convey the resources' historical significance, their design is utilitarian and common to contemporary structures across the country. As a result, they do not represent exceptional design or engineering and do not constitute an outstanding example of architecture associated with historic water control features. Therefore, ERM recommends the Beautification Dams in Grand River are not potentially eligible for the NRHP under Criterion C. For similar reasons, ERM recommends that the dams are not likely to yield information important to history and are thus not potentially eligible under Criterion D.

References

List references used to research and evaluate the individual property. For NRPQ's include copies of key documents.

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_____ 1924b. “The Future City.” 22 February.

_____ 1925. “Power Company and City Ready for Canal Deal.” 17 October.

_____ 1926. “Asks More Cash to Conduct City in Coming Year; Would Beautify River.” 29 March.

_____ 1927a. “Grand Rapids Firm Bids Lowest on Beauty Dams.” 26 May.

_____ 1927b. “For a Wet River.” 7 July.

_____ 1928a. “A Promising Start.” 25 April.

_____ 1928b. “Our River.” 25 July.

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Figure 1: Artist Rendition of Harland Bartholomew's City Plan (1924).

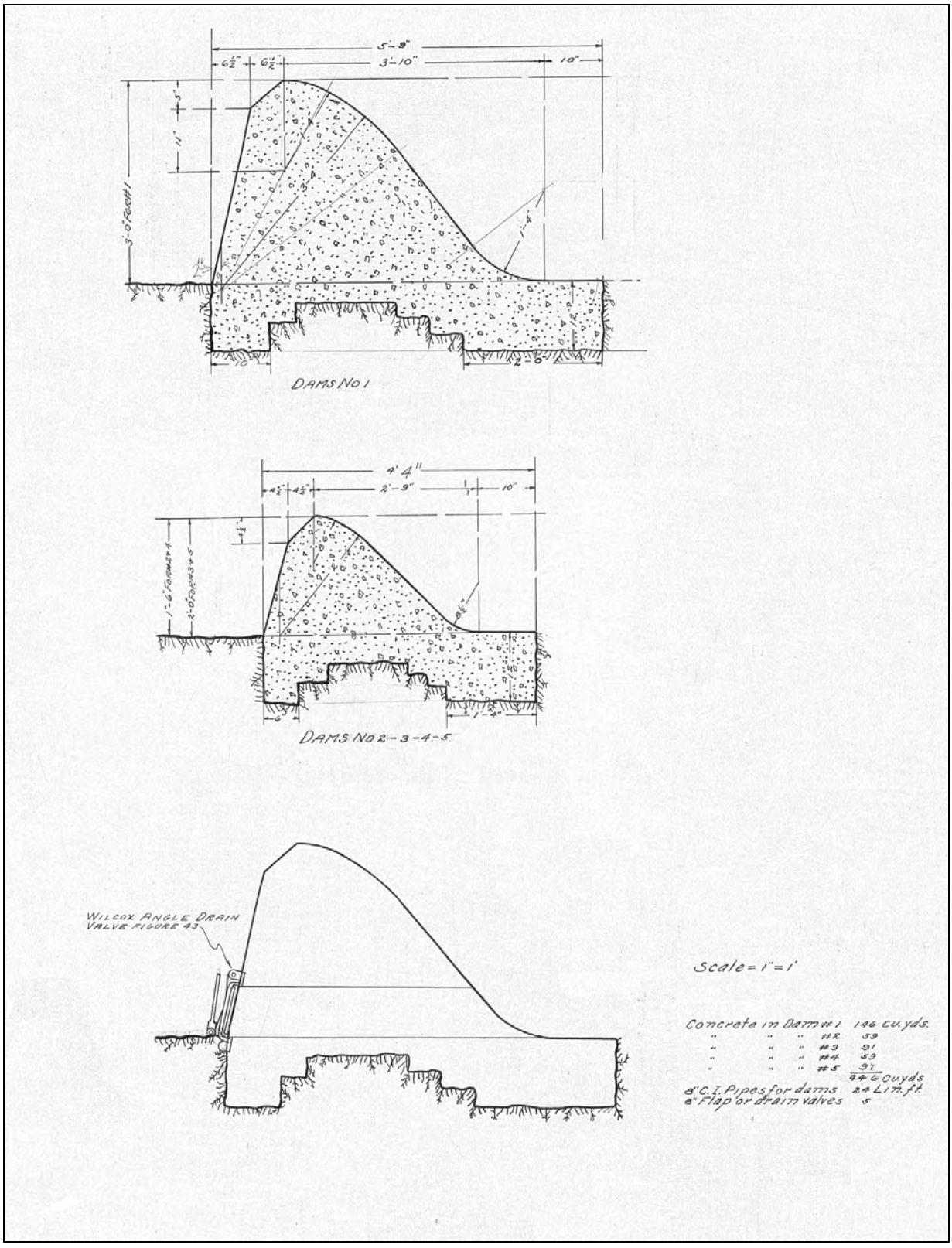


Figure 2: Engineering Drawings Showing Profile of Dams, ca. 1927 (GRCARC)



Figure 3: View of Dam #1, North of Bridge Street, 1927, Showing Dam Profile (GRCARC).



Figure 4: View of Dam #1, North of Bridge Street, 1927, Showing Opening Near Center (GRCARC).



Figure 5: Dam #1 after Construction, 1927, with Water Flowing in the River Bed (GRCARC).



Dam #2, View to the East.



Dam #3, View to the East.



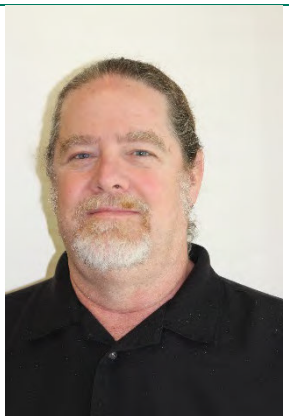
Dam #4, View to the West.

APPENDIX B RESUMES

Jeffrey L. Holland

Historian

Mr. Holland has over 30 years of experience on Cultural Resources Management projects throughout the eastern United States, the Midwest, and Texas. He has conducted historical research and documentation for National Register properties and districts, HABS/HAER recordation, Assessments of Effects reports, and cultural resources survey, testing, and data recovery projects. He has also authored popular histories for major industrial facilities and summaries of archaeological projects for public education. Mr. Holland's specialties include slavery, African American history, nineteenth century agriculture, the Civil War, and the history of military installations, utilities, and infrastructure in the twentieth century.



Experience: 30+ years' experience in Section 106, NEPA, and Historic Preservation Planning for government, energy, and industrial sectors

Email: jeffrey.holland@erm.com

LinkedIn: https://www.linkedin.com/in/jeff-holland-54993548/

Education

- M.A., History (with Historical Archaeology Apprenticeship), College of William & Mary, 1995
- B.A., History, Davidson College, 1984

Fields of Competence

- Historical research, documentation, and assessment of NRHP properties
- NEPA, Section 106
- Historic preservation planning
- Genealogical research
- Cemetery relocation
- Historical archaeology

Languages

- English, native speaker

Key Industry Sectors

- Energy
- Military
- Utilities
- Transportation

Publications

- Holland, Jeffrey. 2007. Landownership and Hardship: Interpreting the Landscape of an African-American Community in Eastern Gwinnett County, Georgia. *Early Georgia* 35(2).
- Holland, Jeffrey. 2006. *Under One Roof: The Story of Air Force Plant 6.* Aeronautical System Center, Acquisition Environmental, Safety, & Health Division, Wright-Patterson Air Force Base, Ohio.
- Garrow, Patrick H., and Jeffrey L. Holland. 2005. Camp Lincoln and the Army of Southeastern Missouri. *Missouri Archaeologist* 66 (Dec):93–118
- Pietak, Lynn Marie, and Jeffrey L. Holland. 2003. Excavations at the Colclough Farmstead: Exploring Rural Life in Nineteenth and Twentieth Century Northeastern Mississippi. *Mississippi Archaeology* 37(2):165–218.

Key Projects at ERM

Energy Client, Pipeline Project, 2015–2019
Conducted cultural resource investigations as part of the permitting of a 600-mile natural gas pipeline in three states. Prepared historical contexts, conducted research on properties, assessed effects of project on resources, prepared mitigation plans for NRHP-eligible properties. Federal Energy Regulatory Commission issued Programmatic Agreement approving implementation of mitigative measures to complete compliance with Section 106 of the National Historic Preservation Act.

Energy Client, Wind Energy Project, 2019–2020
Prepared a Cumulative Visual Effects Assessment for a proposed off-shore wind energy installation of 800-megawatts in the waters of Rhode Island and Massachusetts. The analysis incorporated 17 lease areas and 761 wind generating turbines from the proposed project and reasonable foreseeable future projects. The assessment focused on three historic properties, including a Traditional Cultural Property and a National Historic Landmark.

Energy Client, Wind Energy Project, 2017–2019
Developed context and assessed historic significance for resources in three county area of northeast Pennsylvania that might be affected by a series of proposed wind turbines sites. The context addressed thematic resource types of primary significance in the region including coal industry related sites, railroads, and agricultural properties.

Energy Client, NRHP Evaluation of LNG Terminal, 2019
Developed context and assessed historical significance of an LNG terminal in Alaska completed in 1969 that was the first to export LNG from the United States. The research addressed the process involved in liquefying natural gas and changes to the plant over time. The plant was recommended as eligible for the NRHP.

Energy Client, NRHP Evaluation of Abandoned Pipeline, 2018
Served as author of reports for four western states assessing the historical significance of a 700-mile former oil pipeline converted to natural gas that was slated for abandonment. The assessment was conducted in accordance with a Notice of Exemption issued by the Advisory Council on Historic Preservation regarding abandoned historic natural gas pipelines.

Manufacturing Client, NRHP Evaluation of Historic Orchard Property, 2018
Conducted historical research and produced historical context for historic apple orchard and other historic properties in Jefferson County, West Virginia. Assessed significance of properties and potential direct and visual effects of a fiber manufacturing facility.

Energy Client, Wind Energy Project, 2016–2017
Developed context and assessed historic significance for resources in four county area of northeast West Virginia that might be affected by a series of proposed wind turbines sites. The context addressed a number of resource types including historic coaling and lumber communities, railroads, and industrial sites. Assessed architectural resources for NRHP eligibility under Criteria A and B through local history sources, deed research, and genealogy. Prepared inventory forms for data entry.

Key Projects Prior to Joining ERM

Energy Client, NRHP Documentation, 2014
Researched the ownership history and development of the William Evans farmhouse and associated buildings using county records, historical maps, census returns, and other primary and secondary sources as part of a Memorandum of Agreement to mitigate the effects of a transmission line with a permanent archival record of the property

Government Agency, Nuclear Power Program History, 2013
Conducted historical research using documents from the agency's corporate libraries, records in the National Archives, contemporary newspaper articles, and secondary sources on the nuclear power industry to produce a fully-referenced, illustrated history of what was for many years the nation's largest nuclear power program. The agency commissioned this historical overview of its nuclear power program to provide a concise reference for the agency.

Government Agency, HABS Documentation, 2012
Examined project records and historic photographs, along with other primary and secondary sources to establish the history of the former project offices of the Falcon Dam Project on the Rio Grande, constructed in 1951.

Government Agency, NRHP Assessment, Levees and Water Control Features, 2010–2011
Researched the records of the U.S. Boundary and Waters Commission and the Bureau of Reclamation to assess the significance of two levees constructed on the Rio Grande to control flooding. The levees interfaced with irrigation systems constructed prior to the levees, which also had historic features.

Government Agency, Oral History Documentation of Federal Housing Project, 2009
Conducted historical research on two housing projects slated for demolition using records at the local historical societies and libraries. Current residents of the developments were interviewed about their experiences in public housing. The documentation was part of a recordation of the two facilities intended to produce a comprehensive history of the public housing prior to the sale of the properties by the city.

Energy Client, Pipeline Project, 2008
Produced statewide contexts for five states, as well as more specific histories for dozens of counties and parishes along a 507-mile natural gas transmission pipeline in the southeast U.S. Historical research was also conducted on identified architectural resources to aid the assessment of their NRHP significance. The project was conducted on a short time schedule.

Military Agency, Air Force Facility History, 2006
Served as Historian and Author for the production of a pictorial history of Air Force Plant 6, an aircraft assembly plant operated by Bell Aircraft Company during World War II and later by Lockheed Aeronautics Company and its successors. The book is a fully-illustrated, perfect-bound history of the plant intended for a general audience and was distributed to libraries, government agencies, and other interested organizations.

Government Agency, Cultural Resources Survey of Redevelopment Property, 2006
Researched agency records and photographs on site and at the National Archives Southeast Region Branch in Atlanta, as well as local facilities to document the history and historic significance of a portion of the agency's reservation. The site included numerous industrial properties related to weapons manufacture in World War I, New Deal agricultural programs, and hydroelectric power. The assessment of the facilities was later used to develop an adaptive reuse plan for the property.

Government Agency, Archaeological Data Recovery in Historic District, 2006
Served as a Historian for this investigation of two blocks of a commercial and residential street in a historically black neighborhood of Savannah, Georgia. Using Sanborn Fire Insurance maps, city directories, and a variety of historical sources, documented neighborhood development, racial and social composition, and landscape characteristics over a period of approximately 100 years. The information was applied to the archaeological evidence from the excavation of features related to domestic and business activities on the street during the early twentieth century. A popular pamphlet on the results of the investigation was also produced.

Government Agency, Historical Research for NRHP Historic District Nomination, 2005
Conducted background research on the history of town in West Georgia, the evolution of the built environment within the district, and the construction date of the buildings, as part of a survey of 60+ properties for this historic downtown historic district. The information was used for an NRHP nomination submitted to the Georgia SHPO, and the district was listed in 2007.

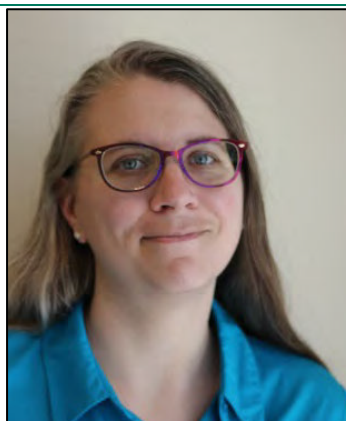
Energy Client, NRHP Assessment of Hydroelectric Power System, 2004
This project involved a review of historical documents related to the design and construction of 11 dams and powerhouses along two major rivers in North and South Carolina. Published histories, company documents, contemporary accounts were consulted, and similar large-scale power and flood-control projects in the Southeast and in the United States were studied to assess the significance of a series pf projects that spanned two states and included multiple facilities along an entire river system.

Military Agency, Context and NRHP Assessment of Korean War and Cold War Structures, 2003
Conducted background research to develop historic contexts to aid in the interpretation and assessment of BASOPS structures from the Korean War and Cold War periods at Fort Bliss and Briggs Army Airfield, Texas. The assessment of the facilities required the application of NRHP guidelines for properties of exceptional significance but less than 50 years old.

Emily Tucker-Laird

Senior Architectural Historian and Archaeologist

Ms. Tucker-Laird is Secretary of the Interior Qualified as an architectural historian and archaeologist. Emily is based in ERM's Duluth Georgia office, and attached to the cultural resources field services group. Emily has extensive experience working as a Principal Investigator. Her projects have included intra and interstate pipelines, electrical transmission lines, wind projects, solar projects, microwave towers, and treatment plans. In addition to fieldwork, Emily has experience supervising and coordinating for complex projects, and developing treatment plans for historic property concerns. Emily's has consulted with a wide range of state and federal agencies, as well as local stakeholders and interested parties.



Experience: 15 years of experience in the field of Cultural Resource Management

LinkedIn: https://www.linkedin.com/in/emily-tucker-laird-9224b4132/

Email: emily.laird@erm.com

Professional Affiliations & Registrations

- Society of Architectural Historians
- Register of Professional Archaeologists
- The Vernacular Architecture Forum

Fields of Competence

- Architectural surveys and evaluations
- Development of research and fieldwork designs for cultural resources
- National Register of Historic Places eligibility evaluation and assessments for historic resources
- Compliance with state, and federal cultural resource regulations, including guidelines set forth by various State Historic Preservation Offices, the National Historic Preservation Act and the National Environmental Policy Act
- Phase I, II, and III Archaeological Field Investigations and report preparation
- Project management and coordination

Education

- M.A., Anthropology, Ball State University, 2013
- M.S., Historic Preservation, Ball State University, 2003
- B.S., Social Sciences, University of Pittsburgh, 1999

Languages

- English, native speaker

Key Industry Sectors

- Power generation and transmission
- Oil and gas
- Public and private land development
- Telecommunications

Key Projects

Energy Client, Wind Project, 2016
Architectural historian 2016 for a 72-turbine wind project in Grant and Tucker County West Virginia. Key tasks included field survey and reporting, and analysis of visual simulations. Project met the requirements of the West Virginia Public Service Commission, and Section 106.

Energy Client, Pipeline Project, 2015-present
600-mile-long natural gas pipeline extending from West Virginia to North Carolina. Architectural Historian and Principal Investigator for historic architecture survey and assessment of effects and Historic Architecture Task Manager responsible for overseeing treatment plans to mitigate project effects. Task Manager for FCC tasks. Responsibilities also include consultations with the FERC, SHPO, and consulting parties.

Energy Client, Transmission Line Project, 2017
Six transmission line alternatives in Fairfax County, Virginia. Cultural resource specialist who prepared sections of the routing study, SCC application, and pre-application analysis, and conducted the technical review for the cultural resource investigations conducted for a proposed line to be sited in northern Virginia.

Energy Client, Pipeline Project, 2016
Architectural Historian for a 96-mile natural gas pipeline in Calcasieu, Jefferson Davis, Acadia, and Evangeline parishes. Completed architectural survey to meet the requirements of the FERC and LASHPO.

Telecommunications Client – Nationwide 2014-2015
Architectural Historian and Archaeologist for a nationwide NEPA Program Management Team serving a major national telecommunications carrier. Provide QA/QC oversight on cultural resources submittals and client deliverables. Tasks include assuring that all compliance submittals conform to regulatory requirements as well as meeting client standards, and assuring that required documentation of compliance is included in all client deliverables.

Key Projects before Joining ERM

Energy Projects, 2012
Muscle Shoals Reservation, Alabama: Architectural Historian for the HABS Level II documentation of selected resources of the Tennessee Valley Authority Muscle Shoals Reservation. The architectural survey included a detailed survey of both the interior and exterior of 20 resources. Final products included a photographic record, historical context of each resource, and architectural descriptions.

City Planning Project, 2010
Georgetown, SC Historic District Survey: One of a team of Architectural Historians recording 900 resources within the National Register-listed historic district. Final products included a comprehensive historic district inventory, maps which identified building by period of construction and contributing status, South Carolina Department of Archives and History Intensive-level historic structure forms and photographs, and a report.

Macon Cemetery Preservation Corporation, 2007
Cemetery Preservation Plan in Georgia: Architectural Historian for a conditions assessment of the 13-acre Linwood Cemetery. Containing over 4,000 burials. Identified the extent of interments, overall conditions across the cemetery, and specific graves and markers requiring repair and stabilization. The product of the work was an assessment of the cemetery's condition and a preservation plan.

Energy Client, Lateral Pipeline Project, 2013-2015
75-mile crude oil pipeline in Illinois and Indiana: Principal Investigator for historic structures, Field Director and Crew Coordinator for the project. Managed several crews, and subcontractors, met with the land office to determine what was available for survey, and acted as the health and safety officer.

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Appendix C – *SHPO Documentation Standards*
(68-page document)

MICHIGAN ABOVE-GROUND SURVEY MANUAL

UPDATED BY
KATIE KOLOKITHAS AND DIANE TUINSTRA

2018



STATE HISTORIC PRESERVATION OFFICE

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THE MICHIGAN ABOVE-GROUND SURVEY PROGRAM

INTRODUCTION

This manual provides standards and guidelines for conducting surveys of above-ground historic resources in Michigan. The State Historic Preservation Office (SHPO) recommends that this manual guide those individuals planning and carrying out surveys and requires compliance with the requirements identified in this manual for projects funded by SHPO grant funding or requiring review or approval from SHPO. This manual provides information regarding approaches to identification, documentation, and evaluation of historic above-ground sites, buildings, and features in accordance with the *Secretary of the Interior's Standards for Identification, Evaluation, and Preservation Planning*. This manual is designed to provide guidance for all types of above-ground surveys, including:

- Surveys funded by the federal Historic Preservation Fund and administered by the State of Michigan;
- Surveys required by the State Historic Preservation Office (SHPO) under Section 106 of the National Historic Preservation Act; and
- Surveys intended to provide an informational database for the establishment of local historic districts under Michigan's local historic districts enabling act, Public Act 169 of 1970, as amended, or for other preservation planning purposes, including preparation of National Register of Historic Places nominations.

This manual does not provide instruction for archaeological surveys. For information about archaeological surveys, please contact SHPO's archaeologists at 517-373-1618.

SURVEY IN MICHIGAN

The Michigan statewide survey program was started in the late 1960s under the direction of SHPO, but with the participation of numerous partners including local communities, regional planning agencies, and citizens around the state. In the 1980s, SHPO created *Surveying Michigan's Historic and Architectural Resources: A How-To Guide*, which directed the survey program for a number of years. In the 1990s, a series of eight survey manuals were used as the guide for the program. In 2001 a new survey manual was written by Robert Christensen and Barbara Wyatt called *Manual for Historic and Architectural Surveys in Michigan*. This 2018 manual replaces the 2001 manual.

In 2016 the Michigan SHPO initiated a project to make the survey data collected over the past fifty years more accessible to the public by creating a GIS-based program to collect, store, and map data. The project, called MiSHPO, will allow for online submission of survey reports and data as well as Section 106 applications, National Register nominations, and more. When MiSHPO is complete and ready to accept online submission of surveys, this manual will be updated with the necessary information to guide the electronic submission of surveys through that portal.

RECONNAISSANCE-LEVEL AND INTENSIVE-LEVEL SURVEYS

Survey refers to the process of identifying and gathering data on a community's historic resources. There are two main types of survey for above-ground resources: Reconnaissance-level and Intensive-level Survey. Survey can include field survey, the physical search for and recordation of historic properties; background research to establish historic context for the properties within the project area; and historical research on surveyed properties. The final products of a survey should include the following:

- Survey Report
- Color-photographs of the historic properties
- Inventory or data information on each property

Reconnaissance-level survey identifies properties of architectural significance and updates existing information in SHPO files. The reconnaissance survey documents properties using photographs, brief descriptions, condition, and location information. Limited research on the history of the buildings, sites, and features is undertaken. Reconnaissance-level surveys look primarily at the architectural integrity of the properties or National Register criteria C. This type of survey is the first step in the preservation planning process and can be undertaken in a limited or broad geographic area. The products of a reconnaissance-level survey include information entered into the survey report, survey forms, and the MiSHPO system. Reconnaissance-level surveys should be used as a means to determine where to focus intensive-level survey efforts.

Intensive-level survey seeks to identify and thoroughly document significant properties and districts through research and evaluation of the National Register of Historic Places criteria within the broader historic context. Intensive-level surveys are more complex, time-consuming, and represent a larger financial commitment for a community. These surveys also provide the most detailed information about an area's history and historic properties. Intensive-level survey begins with a reconnaissance survey or an update of an older survey. The survey then continues with research on potentially significant properties using primary sources, researching the community history, evaluating the properties for National Register significance, identifying historic districts, and completing MiSHPO submission information. Finally, many intensive-level surveys provide recommendations for future preservation activities.

PURPOSE OF SURVEY

The National Historic Preservation Act of 1966, as amended, requires all SHPOs to direct and conduct survey. The act states, "It shall be the responsibility of the State Historic Preservation Officer to administer the State Historic Preservation Program and to—in cooperation with Federal and State agencies, local governments, and private organizations and individuals—direct and conduct a comprehensive statewide survey of historic properties and maintain inventories of such properties."

Survey can serve many purposes including but not limited to the following:

- To provide a basis for local planning
- To provide data to support locally designated historic districts, National Register of Historic Places districts, or individual property designations
- To comply with environmental review requirements under Section 106 of the National Historic Preservation Act
- To achieve or maintain Certified Local Government (CLG) status
- To develop heritage tourism initiatives
- To provide information for thematic studies
- To provide a permanent record for the future

FREQUENTLY ASKED QUESTIONS ABOUT SURVEY

WHAT IS THE DIFFERENCE BETWEEN A RECONNAISSANCE-LEVEL SURVEY AND AN INTENSIVE-LEVEL SURVEY?

A reconnaissance-level survey identifies properties based on their architectural significance and provides basic property information for SHPO files. Reconnaissance surveys include limited historical research on the individual buildings and are used as a tool to determine where to concentrate more intensive research. Intensive-level survey seeks to identify and thoroughly document properties and districts through research and evaluation of the National Register criteria. These surveys provide a more extensive context for the area and research on each individual building.

SHOULD WE DO A RECONNAISSANCE-LEVEL SURVEY OR AN INTENSIVE-LEVEL SURVEY?

The purpose of the survey helps to determine the appropriate level of research. Reconnaissance-level surveys are a good first step and preservation planning tool while intensive-level surveys provide a more complete picture of the surveyed area. Determination of the level of review required for your project can be made through consultation with SHPO.

THERE ARE TREES/BRUSH/UTILITY LINES BLOCKING MY PHOTOGRAPH, WHAT SHOULD I DO?

We ask surveyors to do their best to take photographs without obstructions such as vegetation and utility lines, but we understand that in certain conditions obtaining a good photograph of a building may be difficult. Surveys should be conducted in the spring or fall when the leaves are not on the trees. If the surveyor is not able to obtain a clear photograph of the building they should be sure to describe the architectural characteristics in detail.

IS IT OKAY TO TRESPASS IN ORDER TO SURVEY A PROPERTY AND TAKE PHOTOGRAPHS?

No. Surveyors are required to stay in the public right of way while conducting their fieldwork. Permission from the property owner must be obtained in order to access the property.

WHY CAN'T I USE MY PHONE TO TAKE PHOTOGRAPHS?

While there have been many advances in the technology of smart phone cameras, SHPO is asking surveyors to continue to use a high quality digital camera to take their official photographs. Many phones do not allow users to change the resolution while taking photographs.

WHAT IS MISHPO? HOW DO I GET ACCESS TO THE SYSTEM?

MiSHPO is SHPO's new database and online submission system that will eventually allow consultants, federal agencies, and members of the public to submit their surveys, Section 106 applications, National Register nominations, Tax Credit applications, and other items directly to SHPO online. Any individual will be able to obtain a log-in through the website for the online submission portal. In order to get access to the database to conduct research on known sites, individuals and agencies or companies must purchase a license to gain access to SHPO's data. This manual will be updated once the system is fully operational.

WHAT DOES ELIGIBILITY MEAN? WHO DETERMINES THIS?

Eligibility is the assessment of whether a historic property meets the criteria for listing in the National Register of Historic Places. Persons meeting the professional qualifications as identified in the Code of Federal Regulations 36 CFR Part 61 can make recommendations based on their research of the eligibility of a property or district and SHPO will review the research and agree or disagree with the recommendations.

HOW DO I FUND A SURVEY IN MY COMMUNITY?

Surveys are funded by a variety of sources including private funding, grant funding, and municipal funding. Grant funding is occasionally offered through SHPO's Certified Local Government (CLG) grant program to eligible communities. SHPO uses its federal allocations to fund surveys as well and these are presented as RFPs for consultants. Sometimes a local municipality will utilize their general funds to conduct a survey, usually under the direction of a qualified consultant. Survey is a fundable activity for federal projects in which a survey is required under Section 106 of the National Historic Preservation Act of 1966. At this time SHPO does not offer grant funding to individuals to conduct survey work.



SURVEY PLANNING AND FIELDWORK

Survey is often initiated by a few people and undertaken to address a specific need in a community, but the survey planning process needs to include a much larger group of interested participants. Planning should be a community effort with qualified architectural historians and historians listening and being actively involved with community members to determine what areas are significant to them. Many surveys involve a planning committee that includes any or all of the following:

- Community organizations
- Local historians or representatives of local historical societies, historical commissions, or historic district commissions
- Faculty of local educational institutions with relevant expertise
- Representatives of executive and legislative branches of local government
- A member of the community's planning staff
- Members of the local board of realtors

Surveys should be publicized to the community through different avenues. The surveyor should also notify local law enforcement to explain the nature of the survey activity and make them aware of their presence. Surveyors should also carry identification at all times.

QUALIFICATIONS

Reconnaissance-level surveys must be undertaken by a lead investigator who meets the Secretary of Interior's Professional Qualifications Standards in the Code of Federal Regulations, 36 CRF Part 61. Lead investigators should be trained architectural historians and have experience with research and photography. The investigator should also be well versed in the National Register criteria. For Intensive-level surveys, the researcher or research team should be qualified as architectural historians and historians. An individual may qualify as both.

SHPO maintains a list of qualified consultants and while this list is not exhaustive of the consultants in the state of Michigan, it does provide a list of individuals who have submitted their credentials to the office for review. **Inclusion in this list does not constitute endorsement by SHPO or guarantee that any work product carried out by persons on the list will necessarily meet federal and state requirements.** Before engaging the services of any consultant, it is always advisable to contact references named by the consultant— especially those people for whom a consultant has worked. Inquiring about the nature of the project and the quality and timeliness of the work performed may provide an indication of a consultant's ability to successfully complete your project.

WHAT TO SURVEY

One of the fundamental issues in planning a survey is determining what to include in the project. This determination should be guided by the purpose for which the survey is being carried out, yet tempered by the need to complete the project within a defined budget. Surveys typically fall into two categories:

- Survey everything within the set boundaries, regardless of age, and
- Survey everything more than forty years old within the set boundaries

Surveying everything within the boundaries regardless of age is the most thorough documentation method, but it is also the most expensive and time consuming. This type of survey is appropriate for smaller municipalities or neighborhoods with several hundred properties or fewer. Surveying only what is known to be over forty years old is appropriate for cities and larger municipalities. The forty-year date range is to allow for the National Register's fifty-year age criterion and additional time so the survey is not outdated as soon as it is complete.

The goal of every survey should be to document a full range of types of historically significant properties in the survey area. Historic resources come in many forms—some are not as obvious. The National

Register property types are to be used for surveys in the State of Michigan. For full definitions of these terms according to National Register Bulletins 16A and 24, please see Appendix A, the Architectural History Survey Glossary of Terms.

- Buildings
- Site
- Structure
- Object
- District

Many historic resources such as parks, cemeteries, farms, mill and factory complexes, and residential properties can be complex properties that contain a variety of individual historic features. In an intensive-level survey, the property as a whole and each of its historic features should be surveyed. In a reconnaissance-level survey, it may be appropriate to survey only the entire property and key historic features rather than each and every historic element. Examples of this would include houses and grounds, farms, government complexes, churches, cemeteries, parks, factory and mill complexes, and utilities.

Churches in particular rarely stand alone, and the complexes often include cemeteries, educational buildings such as schools, teachers' residences, parsonages, or rectories, along with additions to the main building. The whole complex may be fronted by ornamental fencing or a gate. All of the various components of such church complexes should be surveyed. Farmstead Survey is discussed further in Appendix B Farmstead Survey Standards.

Questions often arise on whether features such as roadways and walkways; bridges; trees, boulders and other natural features; and mobile home parks or manufactured home developments should be included in the survey.

- For roadways and walkways, only intact, well-preserved examples surfaced with paving brick or other materials not commonly used today, should be included in the survey. Historic examples of public stairways should also be included in the survey.
- Many bridges in Michigan have been previously surveyed in the statewide highway bridge surveys, but some local highway bridges, particularly those no longer in highway use may have been missed. SHPO can provide you with a list of the bridges that have been previously surveyed. Historic culverts, pedestrian bridges, and railroad bridges should be included in the survey.
- Natural features are normally not included in the survey. If they are directly associated with historic events—not merely planted or placed at the site to commemorate them—they should be surveyed. Examples would be witness trees the original surveyors of Michigan used to describe corners of sections or quarter-sections, and trees associated with important persons or events.
- Mobile home and manufactured communities should be included in the survey if they are more than forty years old as they may possess significance in terms of landscape design, social history, and architecture.

CONTRACTING SURVEYS

A few communities will find themselves in the fortunate position of having persons with the requisite background, experience and skills to take on their surveys as volunteer projects, but most will need to contract for some or all of the work. SHPO maintains a list of consultants interested in survey work who meet the basic federal qualifications for historian and/or architectural historian. The list is updated frequently and is available on SHPO's website. This list should not be considered all-inclusive; there may be other consultants in your area who are not listed. It must also be emphasized that inclusion on the list is not a guarantee of high-quality work, and credentials and experience should be reviewed and references consulted. For additional detail regarding the hiring of a consultant and the RFP process please see Appendix C Contracting Surveys.

USING VOLUNTEERS

Some survey projects have been carried out entirely as volunteer projects, and volunteers can certainly assist in specific tasks such as the field survey work and property-specific research. Using volunteers in contracted survey projects, however, should be done with caution and a clear knowledge of the level of commitment of each volunteer. SHPO's experience has been that volunteers are sometimes not sufficiently motivated to carry out assigned tasks without defined deadlines.

ADVISORY BOARD

An advisory board comprising local historians, planners, members of a local historic district commission, and interested citizens can be an asset in a survey. The board may suggest resources for research, people to interview, and collections of information. A valuable role of the board is to be an emissary of good will during the project and an advocate for the survey's use after it is complete.

FIELD WORK

Field work is one of the most important steps in the survey process. Field work should:

- Record locational and descriptive data on each property
- Photograph properties and context views
- Map the property locations

One of the important steps before beginning fieldwork is the preparation of maps. Maps should be obtained from the local community to create base maps that will be used in the field and then in the preparation of the final map. The more detailed the maps, the more useful they will be in precisely locating the surveyed resources and in assisting users of the survey materials in their comprehension of the survey area's historic resources. Maps should show all streets and current property lines and/or building outlines.

More information on mapping in the MiSHPO system will be provided later in this manual.

RECORDING DATA IN THE FIELD

The collection of field survey data is one of the most important steps in the survey process. Field survey will provide locational and descriptive information—and perhaps some historical background information obtained by informants—about each property, which will ultimately form part of the record for the property. Prior to beginning field work, surveyors should review the list of required fields or data categories and instructions for the MiSHPO system. Surveyors should also include as much information as possible in each of the fields. Some examples of required fields include:

- Address (number, street direction and street name)
- City/village or township
- County
- Survey date and surveyor
- Historic name and current name
- Current building materials
- Additions, removals, and condition of the property

Many surveyors use paper survey forms and enter the data into the system at a later date. Many surveyors also create their own paper forms for use in the field. The SHPO Survey and Information Coordinator or the National Register Coordinator are available to review survey forms prior to the

commencement of field work. See Appendix D for a sample field form that can be customized and reproduced.

At this time, the use of survey applications for smart phones is not available for use with the MiSHPO program, but SHPO hopes to develop one in the coming years so surveyors will be able to utilize the technology in the field.

PHOTOGRAPHIC DOCUMENTATION

Every property included in the survey, including each building and other surveyed feature in a complex property or district, requires a minimum of one high quality photograph to show as much of the property as possible. Each surveyor is required to use a digital Single Lens Reflex (SLR) camera with a minimum capture size of eight mega-pixels. Images must be shot at the highest photo resolution possible.

Images must be delivered as an unaltered JPEG image on disk or thumb drive. Each image must be a minimum of 2000 pixels and 3000 pixels. Please consult with SHPO staff regarding file naming conventions for survey photos.

Survey photography is documentary. Good photographs can be taken if the photographer keeps several things in mind beyond the normal photographic considerations. These include composition, clarity, lighting quality and direction, and perspective distortion. Prior to beginning photography, a plan should be made based on the direction the building faces relative to sunlight, timing of possible obstructions (holiday decorations, leaves, vehicles, etc.), daylight, and weather.



CLARITY

The major cause of unclear photographs is camera movement. The best way to avoid this is to place the camera on a firm support or tripod when the photograph is being taken. If a tripod is unavailable, using a faster shutter speed and gently squeezing the shutter button can enhance image clarity.

COMPOSITION

Generally, a ¾-view of a building is preferred, to show as much building detail as possible in a single view. Since a record is produced for each property, do not include the adjacent buildings in the inventory photographs. If necessary, more than one photograph should be taken to document large or complicated buildings.

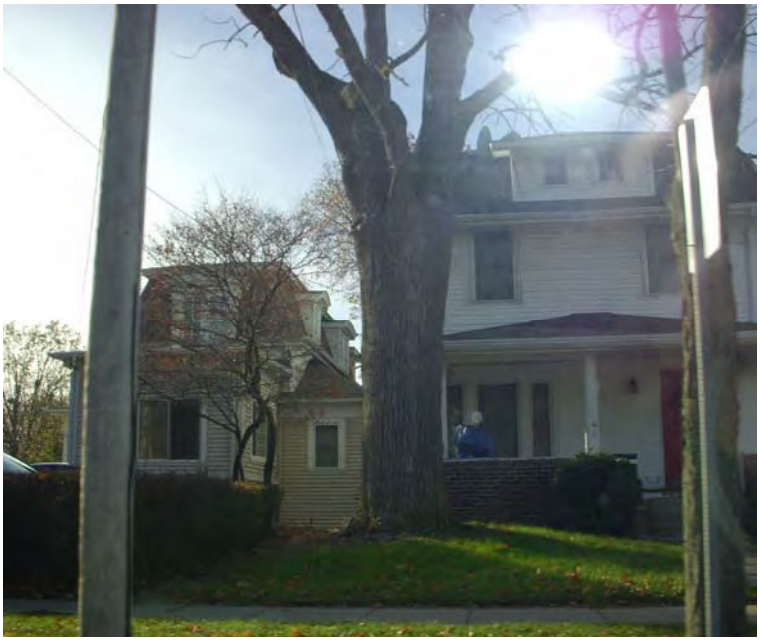




LIGHTING QUALITY AND DIRECTION

A building is modeled and described by the sunlight, and the relationship of the sun to the property varies from case to case. A photo of a rusticated building, for example might be enhanced by sun using direct light to bring out the texture. A building with a broad overhang is sometimes best photographed in hazy sun because deep shadows can obliterate details. It is difficult, therefore, to generalize, except to say that the photographer should study the subject and make a determination based on a building's inherent characteristics.





Be careful about backlighting, or placing the sun directly behind the camera, because such flat lighting can obscure the shadow lines that give a building character and depth.



PERSPECTIVE DISTORTION

An otherwise well-thought-out photograph can be ruined by perspective distortion. The only way to get rid of this distortion completely is to have the film plane of the camera exactly vertical when taking the photograph. Tipping the camera up to capture the top of the building is the most common perspective distortion, this makes the building appear to be falling over backwards. The best way to limit the impact of this distortion is by using a perspective-control (PC) lens. Those without access to such equipment, however, should follow a few simple tips. The easiest solution is to back up far enough from the subject to include the entire building without tilting the camera upward. This can be accomplished by either moving away from the subject or by changing the camera to a wide-angle setting. Surveyors should use caution when using a wide-angle lens as this can exaggerate any tilting of the camera.

A telephoto lens that tends to flatten buildings can be used to reduce the impact of the perspective distortion. Users of a telephoto lens should be aware that the lens can also exaggerate camera motion, so a tripod is recommended.

Surveyors can also stand on a rise, truck, ladder or other equipment to elevate themselves and reduce the perspective distortion.

More information on photography is available in National Register Bulletin 23 *How to Improve the Quality of Photos for National Register Nominations*.

Other photography tips include the following:

- Avoid signs, cars, people, trees, and poles in the foreground as much as possible
- Lens filters and shields should be used to minimize glare
- Use imagination in finding the position that will allow the best view of the property







DESCRIBING HISTORIC PROPERTIES

Architecture should be described using appropriate terminology for architectural styles, building forms, and other characteristics. Surveyors should make use of architectural style guides, studies of specific building types, and other source material that provide background information about the architecture they are surveying. The following resources should prove useful for nearly every survey:

- Architectural Dictionaries and Terminology Guides:
  - Phillips, Steven J. *Old-House Dictionary*. NY: John Wiley & Sons, Inc., 1994.
  - Burden, Ernest. *Illustrated Dictionary of Architecture*. Third Edition. NY: McGraw-Hill, 2012.
  - Roth, Leland M. *American Architecture: A History*. Second Edition. CO: Westview Press, 2016.
- Houses:
  - McLennan, Marshall. "Common House Types in Southern Michigan." In Michigan Folklife Reader, edited by C. Kurt Dewhurst and Yvonne R. Lockwood, 15-45. East Lansing: Michigan State University Press, 1987.
  - McAlester, Virginia and Lee McAlester. *A Field Guide to American Houses (Revised).* NY: Alfred Knopf, 2015.
- Farms and Agricultural Buildings:
  - Michigan Agricultural Experiment Station bulletins and Michigan Cooperative Extension

Service bulletins, found at the Michigan State University Library, contain useful background information on farm and building layouts and design.

- *The Agricultural Landscape of Michigan: An Historic Context for the Theme of Agriculture*. Lansing, MI: Michigan State University for Michigan Department of Transportation, 2004. On file at SHPO and MDOT.
- Dandekar, Hemalata C. *Michigan Family Farms & Farm Buildings: Landscapes of the Heart & Mind*. Ann Arbor: The University of Michigan Press, 2010.
- Noble, Allen G. *Wood, Brick & Stone: The North American Settlement Landscape.* 2 vols. Amherst, Ma: University of Massachusetts Press, 1984. Volume 2 deals with barns and farm structures.
- Noble, Allen G., and Hubert G. H. Wilhelm, eds. *Barns of the Midwest*. Athens, OH: Ohio University Press, 1995.
- Visser, Thomas Durant. *Field Guide to New England Barns and Farm Buildings*. Hanover, NH: University Press of New England, 1997.

- Mid-Century Modern Resources
  - APT Building Technology Heritage Library. https://archive.org/details/buildingtechnologyheritagelibrary. Includes house plan books for postwar housing companies.
  - *Historic Residential Suburbs. Guidelines for Evaluation and Documentation for the National Register of Historic Places.* U.S. Department of the Interior. National Park Service. Washington, DC. 2012.
  - Jester, Thomas C. *Twentieth-Century Building Materials: History and Conservation*. Los Angeles: Getty Conservation Institute. 2014.
  - *A Model for Identifying and Evaluating the Historic Significance of Post-World War II Housing*. National Cooperative Highway Research Program Report 723. Transportation Research Board Washington, DC. 2012.
  - *The Ranch House in Georgia. Guidelines for Evaluation.* Stone Mountain, Georgia: New South Associates.
  - Statewide Search for Subdivision Plats. www.dleg.mi.us/platmaps/sr_subs.asp. Michigan Department of Licensing and Regulatory Affairs (LARA).
- Schools
  - Michigan State Historic Preservation Office. *An Honor and an Ornament: Public School Buildings in Michigan*. Lansing, Michigan: Department of History, Arts and Libraries, 2003.
  - Michigan Superintendent of Public Instruction. Superintendent of Public Instruction Annual Reports. Lansing, MI: State of Michigan Superintendent of Public Instruction. The annual reports of 1859, 1864, 1869, 1893, 1913-1914, 1915-1916, and 1916-1917 contain illustrated material on school building design and furnishings, including standard plans.
- Commercial Architecture
  - Longstreth, Richard. *The Buildings of Main Street: A Guide to American Commercial Architecture.* Walnut Creek, CA: AltaMira Press, 2000.
- Industrial Architecture
  - Bradley, Betsy Hunter. *The Works: The Industrial Architecture of the United States.* NY: Oxford University Press, 1999.

For specific questions concerning architectural terminology, contact the Survey and Designation staff at SHPO.



HISTORICAL RESEARCH

All surveys should include a historical research component. Historical research in survey provides the framework for evaluating the historic significance of the surveyed properties and their eligibility for inclusion in the National Register of Historic Places.

The primary difference between reconnaissance-level survey and intensive-level survey is that intensive-level survey includes in-depth historical research on each of the surveyed properties. Reconnaissance-level survey only records property-specific information from readily available sources. Both levels of survey should include research in two areas: 1) the general history of the survey area or community and 2) study of historical themes applicable to the survey area. Intensive-level survey will include the individual property history information as well.

The survey report must include a summary history of the area that introduces the important historic themes and places them in a broader context. The history should be written as a narrative rather than in timeline format. It should include key dates in the area's chronology and introduce the area's early settlement history, driving forces behind its growth and economy (including significant people or ethnic groups) and other developmental factors. An example for Port Hope (see below), taken from the Port Hope multiple property nomination for the National Register, introduces each of the significant historic themes represented by properties included in the nomination: lumbering, forest fires of 1881 and relief efforts, agriculture, transportation, ethnic history, and architecture.

Thematic narratives should be identified through consultation with National Register Bulletin 15, "How to Apply the National Register Criteria for Evaluation" (page 8), which defines a theme as "a means of organizing properties into coherent patterns based on elements such as environment, social/ ethnic groups, transportation networks, technology, or political developments that have influenced the development of an area during one or more periods of prehistory or history."

ARCHITECTURAL NARRATIVE

For most survey projects, architecture will prove a relevant theme, and an architectural narrative will be necessary. Architectural narratives too often tend to be generic discussions focusing on style that provide little detail about the specific survey area. This should be avoided! It may be worthwhile for the person preparing the architectural narrative to begin with a fresh review of architecture while in the field. Working from only the survey photos months after the completion of the field survey may hinder insightful analysis of the architecture.

The purpose of the architectural narrative is to place the survey area's architecture in the broader context of the community and region in which it is located. The architectural narrative should discuss the architecture in terms of property types. Property types should be defined using the list in Appendix E.

The architectural narrative should discuss all property types within the broad categories (residential, commercial, or agricultural) for which a substantial number of properties are present. For example, for rural survey areas containing numerous farms, the broad range of agricultural building and structure types present should be discussed and analyzed. For older, in-town neighborhoods containing many old stable/carriage house buildings, the architectural narrative should include some discussion of this building type. Conversely, property types represented in the survey area by only one or a very small number of properties—typically churches, schools, and other institutional resources—need not be included in the architectural narrative. For the few institutional properties present in most survey areas, any needed architectural analysis can be presented within the narratives for the themes with which the properties are associated, such as religion or education.

Just as for the entire survey report, an important purpose of the architectural narrative is to educate public officials, planners, property owners, and the general public about what is interesting and significant from an architectural standpoint about the survey area's properties. A relatively small number of high-style properties in the survey area certainly merit discussion and analysis, but the narrative should focus on

the common property types and forms generally represented by the vast majority of surveyed properties whose significance will not be obvious to the report's readers.

The narrative should be organized by broad property type, such as residential and commercial. The discussions of property types should be arranged in the overview in the approximate order of their predominance. In most survey areas, residential properties will form by far the greatest proportion of the surveyed resources; in such cases, the residential section should come first in the architectural narrative.

In the discussion of each property type, discussion and analysis of the issues of form and massing should almost always precede any discussion of style. For example, in a section of an architectural narrative that discusses single-family houses within a broad category of domestic (i.e. residential) architecture, the houses should be discussed in terms of the specific house forms present, such as bungalow or upright-and-wing, before they are discussed in terms of their architectural style. Building forms characteristic of the survey area and broader community, such as a certain house form prevalent in a survey area, but less common elsewhere, should be identified. Any locally distinct varieties of standard architectural styles and the common use of distinctive decorative elements in the local architecture, such as a polychromatic brickwork found in many houses in the Dutch settlement area of West Michigan, should be noted and discussed.

Examples of pattern-book, pre-cut, and manufactured architecture should be discussed, if possible, as part of the architectural narrative. While originals of old pattern and plan books and catalogs are hard to come by, many of these books have been reprinted by a variety of publishers, and more are being done every year. Dover Publications, Inc., the publisher of by far the greatest number of reprints, is the architectural historian's friend, having reprinted dozens of old plan and pattern books since the 1960s, with most of them still in print in inexpensive paper editions. These pattern books—especially those by the Aladdin Company and Sears, Roebuck and Company—will be useful for survey in Michigan.

The narrative should provide information about architects, engineers, artisans, craftspeople, and contractors who worked in the survey area. Biographical data, such as birthplace and birth and death dates, educational background, firm affiliations and dates, and important commissions are important pieces of information that should be sought and included in the narrative. Newspaper obituary notices are an important source of information. In addition, the following can be useful sources of information on architects and engineers:

- *American Institute of Architects Historical Directory of AmericanArchitects*
- *Avery Obituary Index of Architects.* Microform/Columbia University. Boston, MA: G.K. Hall, 1984.
- Downs, Winfield Scott, ed. *Who's Who in Engineering. A Biographical Dictionary of the Engineering Profession.* New York: Lewis Historical Publishing Co., Inc. (Editor, title and publisher vary between editions). Eight editions were published between 1922 and 1959.
- Koyl, George S., ed. *American Architects Directory*. New York: R. R. Bowker Co. Editions were issued in 1956 and 1962.
- Withey, Henry F., and Elsie Rathburn Withey. Biographical Dictionary of American Architects (Deceased). Los Angeles: New Age Publishing Co., 1956.

RECONNAISSANCE-LEVEL SURVEY

The level of research for a reconnaissance-level survey will be limited to those documents and resources that are easily accessible including old county and fire insurance maps and published histories, as well as information such as historic name and date, gleaned from inspections of the property. The recording of specific information from directories, tax assessors' records, and other more detailed sources is generally not a part of a reconnaissance survey. For some of the properties, no historical information will be located.

INTENSIVE-LEVEL PROPERTIES

For properties surveyed at the intensive-level at least a basic level of information should be gathered for each of the properties forty-or-more-years-old, with more in-depth research performed on those that appear to possess more than typical historical or architectural significance. The surveyor must provide a basic, standard level of historical documentation for all of the surveyed properties and help determine which of them possess significance according to the National Register criteria.

The amount of time spent on research for a given property in an intensive-level survey should correspond to the property's apparent historic significance. Property-specific research can be the most time-consuming aspect of a survey project, but it is the most important. Surveyors should have realistic expectations about what information is available, so that research efforts can be appropriately directed. Sometimes finding basic information for a property, such as the precise date of construction and an architect or builder, will be impossible.

SOURCES OF INFORMATION FOR HISTORICAL RESEARCH

The sources of information that will be used for general history, thematic, and property-specific research will vary with the nature and location of resources, but the following will generally be useful tools.

- Published and unpublished histories
- County maps and atlases, plat books, and fire insurance maps
- City and county directories
- State gazetteers and business directories
- Tax assessors' records
- Tax records
- Building permit records
- Local historians and knowledgeable informants, including long-term property owners
- Federal census records
- State census records
- Rural property inventories
- Vertical and newspaper clippings files
- Photograph collections
- Birdseye views
- Biographical albums and records
- Newspapers
- Property abstracts
- Public land records
- Federal land patent records

While secondary sources can be useful to begin your research and uncover potential primary sources, they should be used with caution and primary sources should be used as the main documentation whenever possible.



SUMMARY HISTORY FOR PORT HOPE

EXAMPLE

Port Hope began in 1858 with a sawmill and dock constructed by William R. Stafford, a partner in a firm established to log the area and market its products to Cleveland. Lumber continued to be the area's chief industry until forest fires in 1871 and 1881 destroyed most of the remaining timber. The 1881 fires, coming after decades of logging had left mountains of timber debris in their wake, not only destroyed most of the remaining forests in the area, but also cleared much of the debris left from logging activities, opening the Port Hope area and much of the Thumb to farming far more than the lumber industry itself. The land was fertile. As a result, in the 1880s and 1890s agriculture became the major livelihood of Port Hope's residents. Many early settlers in Port Hope in the 1860s and 1870s were Germans and in the late nineteenth century the Germans became Port Hope's largest ethnic group. Cheap water transportation on the lakes made possible the community's economic growth in the nineteenth century. Lumber and, later, agricultural products were shipped to market exclusively by boat prior to the construction of a railroad line to the town. The opening of a rail link to the existing line at Harbor Beach in 1903 took place at the same time that commerce on the lakes was in decline because of competition from the ever-growing railroad network. The railroad line gave Port Hope a greater market for its agricultural products and encouraged further development of agriculture in the area. Port Hope's architecture in the nineteenth and early twentieth centuries reflected the development of the town and the contemporary architectural tastes of the nation at large and of Michigan's Thumb region.



LUMBER INDUSTRY THEMATIC NARRATIVE FOR PORT HOPE

EXAMPLE

Commercial logging in Michigan began in the 1830s, 40s, and 50s with the development of improved sawmilling technology and the introduction of steam-powered sawmills. Extensive logging began along the east shore of Lake Michigan and the west shore of Lake Huron in the Lower Peninsula and gradually worked its way inland along the major waterways. The sawmills were located at the mouths of the streams and the logs driven downstream to them during the spring high waters. Chicago was the first the principal destination of timber cut along Michigan's west shore, while the mills on the Lake Huron side of the state served Detroit, Toledo, Cleveland, and Buffalo for the most part. In 1860 there were nearly one thousand sawmills operating in Michigan producing in that year about 800 million board feet of lumber, principally white pine. The fine quality of the wood and the phenomenal growth of Michigan's and the Midwest's population in the years after 1860 led to rapidly expanding lumber production in Michigan. Production statewide reached a maximum of 4,292,000,000 board feet in 1888. Production began to decline thereafter because of the depletion of timber lands; however, Michigan continued to be the leading producer of lumber in the nation in 1900.

Commercial logging along the west shore of Lake Huron began in the 1830s and was well underway at Port Huron, Saginaw, Bay City, and other places by the late 1840s. Port Huron reached its high point of lumber production—56 million board feet—in 1873. The Saginaw Valley reached its high point of production of more than one billion board feet in 1882. More northerly points such as Alpena and Cheboygan reached their peak production in the late 1880s and early 1890s. Much of the production from the east shore mill towns was sent to market in ships and barges, and Bay City and Saginaw in particular became large shipbuilding centers in the late nineteenth century.

Eastern investors, a number from Maine and New Hampshire, played an important role in the Michigan lumber boom beginning as early as the 1840s, if not before. These investors witnessed the gradual depletion of the northern New England pine woods in the mid-nineteenth century and the consequent rise in value of the remaining timber lands. They recognized the opportunities for profit from Michigan timber lands, which could still often be bought at bargain prices from Uncle Sam and the lumber inexpensively shipped by water to an ever-growing market. Single investors often bought thousands of acres of land, logged them off over many years, and then resold as much land as possible while developing some themselves for agricultural purposes.

Huron County, at the tip of the Thumb between Lake Huron and Saginaw Bay, was established as a county in 1859. The first sawmills—small, water-powered affairs—were established in 1838 and 1839. John Hopson put up the first steam sawmill in 1850 at Rock Falls south of Harbor Beach. Lumber and shingle manufacturing quickly became the county's chief industries. The principal woods were pine, hemlock, cedar, basswood, beech, maple, birch, and ash. A series of forest fires burned over much of the county in October 1871, at the same time that the Chicago Fire raged. Nevertheless, in 1874 the county produced 36 million board feet of lumber. In 1876 several planks cut at Verona Mills in the county were displayed at the Centennial Exposition in Philadelphia. The planks were sixteen feet long, five feet two inches wide, four inches thick, and without knots or other flaws. In September 1881, however, another series of disastrous fires burned over the bulk of Huron and much of several other counties and put an end to large scale logging in the county. Small scale operations continued for a few more years here and there.

In Port Hope William R. Stafford was a pioneer lumberman. Stafford (1829-1916) came to Michigan from Bath, New Hampshire, in 1849 and settled in Lexington, on the Lake Huron shore between Port Huron and Huron County. In 1852, Stafford became a partner in a mercantile business that apparently involved lumber. The business was reorganized in 1854 with Clark Haywood, another New Hampshire native and a former employee of Stafford's, as his partner.

In 1851, Stafford, Reuben B. Dimond, William Southard, and Josiah F. Wilson, all (with probably the exception of Dimond) New Hampshire natives who were personal friends and business associates, made a purchase of timber lands in the area near what became Port Hope. In 1857 or 1858, Stafford, Haywood, and a third New Hampshire native, former U.S. senator B. W. Jenness, then a resident of Cleveland, formed a partnership to exploit the timber resources of the Port Hope area. Stafford had charge of the sawmill the partners built in 1858 at what became the settlement of Port Hope. The mill produced lumber,

lath, and shingles. Jenness ran a lumberyard in Cleveland that the Port Hope mill supplied. During some years prior to the 1871 fires the mill produced 7 million board feet of lumber. The 1871 fire destroyed the mill, dock, and lumber on hand, a loss of $100,000 to Stafford & Haywood (Jenness had withdrawn in 1868). Stafford & Haywood rebuilt the mill and dock in 1872. As of 1874 they produced 1.4 million board feet out of the 36 million produced in the county. At least four operations in the county were larger. The 1881 fire burned the mill and dock again, a $40,000 loss, and, in 1884, Haywood also withdrew from the firm, leaving Stafford as sole owner. Stafford built a third, smaller sawmill and planing mill and sash and door factory to supply primarily local needs.

In 1880, R. C. Ogilvie built a second sawmill and dock at a cost of eight-thousand dollars. The mill and dock also burned in 1881. Ogilvie rebuilt in 1993, but the mill apparently closed for the lack of timber by about 1889. Stafford's sawmill is listed in the Michigan State Gazetteer and Business Directory as late as the 1893 edition, and probably closed in the early 1890s. Perhaps some lumber and other wood building products were shipped to Cleveland until the very end of local sawmilling operations. Mrs. C. J. Bisbee in her 1915 historical sketch of Port Hope states that "The mill operated until every bit of virgin timber was nailed into Ohio houses."

A by-product of logging in Michigan was salt manufacturing. What is known to geologists as the Michigan Basin, which includes the Lower Peninsula, is one of the greatest areas of halite concentration in the world. Subsurface deposits of rock salt and brine occur in many places. In 1859 the Michigan legislature, hoping to encourage salt production, authorized a bounty of ten cents per bushel produced. This bounty was soon repealed, but not before it had done its work in generating real interest in salt manufacturing. Michigan soon became the nation's leading salt producer, and by 1884 was producing half of the nation's salt.

Salt production in Huron County and elsewhere in Michigan was encouraged by the plentiful supply of wood. Wood fueled the engines that pumped the brine from which salt was obtained up to the surface and powered the furnaces that evaporated water from the great pans or vats of brine. Cheap fuel made Michigan salt the most inexpensive in the nation. In Huron County salt manufacturing began in 1863 in Port Austin and continued until about 1890. In 1884 the county had eleven salt-manufacturing operations, several of them using more than one well. The decline coincided not with the depletion of the brine deposits, but with the destruction of the forests that provided the cheap fuel.

In Port Hope the first salt-manufacturing enterprise, the Port Hope Salt Company (in which W. R. Stafford was the principal owner) was established in 1874. Its plant appears to have been typical of the Huron County salt "blocks." The first year the company produced 16,000 barrels of salt at 280 pounds per barrel. In 1884 the company used 10,000 cords of wood to produce 60,000 barrels. It had a well 800 feet deep (Huron County wells ranged from 600 to nearly 2,000 feet in depth) and four and one half inches in diameter. The brine was pumped to the surface into five evaporating "pans" and the brine settled to the bottom. So-called "bitter water" at the top was drained off. Furnaces provided the chief means of evaporation. A force of twenty coopers produced the needed barrels. Much of the salt produced went for dairy purposes, but the company also shipped much of its product to the mining regions of Montana. The Port Hope Salt Company closed in 1890.

Robert G. Ogilvie established a second salt-manufacturing concern in Port Hope in 1883. His operation had its own sawmill and barrel factory and produced 150 barrels of salt daily in 1884. Ogilvie's operation apparently closed by 1890.

The remains of the Port Hope Salt Company plant were dismantled in 1913-14, but the site has not been developed and some remains are still present. At the site of the Ogilvie salt block, some development has taken place and no remains are visible. No archaeological testing of either site has been done.



EVALUATION AND MAKING ELIGIBILITY RECOMMENDATIONS

Evaluation of the historic significance of the surveyed properties is the very heart of the survey project since the properties evaluated as historically significant are the ones to which future historic preservation planning efforts will be geared and the rest of the properties will likely be excluded from future preservation planning. Evaluation criteria for surveys of any kind should use the National Register of Historic Places Criteria for Evaluation.

CRITERIA: The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

A. That are associated with events that have made a significant contribution to the broad patterns of our history; or
B. That are associated with the lives of persons significant to our past; or
C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
D. That have yielded, or may be likely to yield, information important in history or prehistory.

CRITERIA CONSIDERATIONS: Ordinarily cemeteries, birthplaces, or graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties will qualify if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

A. A religious property deriving primary significance from architectural or artistic distinction or historical importance; or
B. A building or structure removed from its original location but which is significant primarily or architectural value, or which is the surviving structure most importantly associated with a historic person or event; or
C. A birthplace or grave of a historical figure of outstanding importance if there is no appropriate site or building directly associated with his productive life; or
D. A cemetery which derives its primary significance from graves of persons or transcendent importance, from age, from distinctive design features, or from associations with historic events; or
E. A reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or
F. A property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own exceptional significance; or
G. A property achieving significance within the past 50 years if it has exceptional importance.

EVALUATION PROCESS

Evaluating historic resources should involve assessing historic properties from three perspectives:

- Historic context
- Historic significance
- Historic integrity

HISTORIC CONTEXT

Historic resources must be understood within the framework of the historic themes with which they are associated and the place and time in which they occurred. The theme, geographic parameters, and temporal definition provide the context for understanding a property, for example, popular music (theme) in Detroit (place) from 1920 to 1975 (time frame). Evaluations need to include:

- Comparison with properties that are similar in terms of function, form or style
- Relationship to a historic event
- Comparison with other properties associated with the same historic theme(s) and in the same geographic area and time frame

The geographic area that forms one of the bases for evaluation may need to be larger than the survey area to provide an adequate context for evaluation. In general, evaluations should be made, at a minimum, within the context of the entire community.

The historical significance of an above-ground property refers to its importance in the history, architecture, or culture of the local area, state, or nation. Significance is defined in terms of the four National Register criteria: historic events, important people, distinctive physical characteristics, and information potential.

Historical integrity of a property refers to the extent that the physical components have survived from the historic period—in other words, how much the property reflects its historic appearance. The National Register criteria defines seven qualities of integrity that properties must meet: location, design, setting, materials, workmanship, feeling, and association.

If the history of a property is deemed important within one or more historic themes and if the property possesses a high degree of integrity, it is generally considered eligible for listing in the National Register of Historic Places. The surveyor makes recommendations on the eligibility of resources, which are then reviewed by SHPO staff, who make the final determination.

In addition to these instructions, survey personnel should review the *Secretary of the Interior's Standards for Evaluation*; *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*; and other National Register bulletins, as appropriate to the surveyed resources.

Evaluations should be done through the identification of the applicable themes and the related properties in the surveyed area through the creation of lists for inclusion in the survey report. The list for each theme should include not just properties that clearly possess historic significance but also a more representative sampling of all of the types of properties that reflect the theme. When placing these lists in the report, the properties should be organized by a broad property type category (such as Commercial or Domestic). Districts identified in the survey and properties such as farms, industrial complexes, parks, and cemeteries should each be listed and evaluated as whole complexes. Components should not be listed and evaluated separately unless the entire district or complex property turns out not to meet the criteria. Some properties will relate to more than one theme; these should be listed under all appropriate themes. The property list for architecture should be organized by styles, building forms, and other aspects of the survey area's architecture defined in the narrative as significant.

Using the National Register criteria, standards should be developed for evaluating properties associated with the survey area's defined historic themes. For each theme, define the following:

- Property types that are important in illustrating the theme
- How the National Register criteria apply to each property type on the basis of the important events, people, and patterns, etc., developed in the narratives (In some cases several property types may be grouped together.)
- The level of physical integrity a property must possess to be eligible for listing as an example of the property type

The following are examples of specific criteria established for individual property types or groupings of property types within a theme:

- The criteria under the theme of commerce might define a commercial building as eligible for the National Register if it housed a leading commercial enterprise by virtue of its size and role in the community (a department store in a large community or a general store in a small community, for example) or if it housed a specific business or business use for a long period of time (a hardware or clothing store, or a succession of shoe stores or ice cream parlors, that remained in business at the same location, for example).
- The criteria under the commerce theme might define a house as eligible for the National Register if it is associated with a pioneer merchant or businessperson who owned an important business or a business that remained in operation for a long time.

Criteria should be tailored to the survey area's historic themes and to the surveyed properties and property types. Avoid using a standard, "canned" criteria that applies to all themes.

EVALUATION AND RECONNAISSANCE-LEVEL SURVEY

Every reconnaissance-level survey should include at least a measure of evaluation based on the criteria and a recommendation of eligibility for the properties in the survey area. In order for a reconnaissance-level survey to be useful in future planning efforts, the surveyor should use available information, including basic historic information and the level of architectural integrity. For those resources with widely available histories, the surveyor should undertake the evaluation process in the manner described above utilizing all four National Register criteria. For those without a well-documented history, the survey report should include an eligibility recommendation for National Register criterion C: architecture. Reconnaissance-level surveys should be considered locally as the first step in a two-step process; however, funding often limits the ability of a community to complete the second step— intensive-level survey—in a timely manner.

EVALUATION AND INTENSIVE-LEVEL SURVEY

Evaluation of resources for an intensive-level survey should be undertaken utilizing all four National Register Criteria.

IDENTIFYING AND DOCUMENTING POTENTIAL HISTORIC DISTRICTS

One purpose of survey is to identify and document any potential historic districts located within a survey area. According to National Register Bulletin 15, "A district possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development. . . . A district derives its importance from being a unified entity even though it is often composed of a wide variety of resources. The identity of a district results from the interrelationship of its resources, which can convey a visual sense of the overall historic environment or be an arrangement of historically or functionally related properties."

Historic districts can encompass business districts, residential neighborhoods, rural villages or agricultural districts. These areas must possess significance under one or more of the National Register criteria and retain an adequate degree of architectural integrity. The boundaries of the potential historic district must include the full extent of the historic resources related to the applicable historic themes and time frames while excluding adjacent areas whose properties bear no strong relationship to them.

APPLYING THE CRITERIA

A CASE STUDY ON THE HOME OF A SETTLER FROM NEW YORK STATE

Robert O. Christensen

A building that was the Michigan home of a pioneer settler from New York State should be reviewed in terms of the broad pattern of migration to the area from upstate New York and the settler's importance as a reflection of that migration and as a member of the community, and conceivably, the importance of the building itself in reflecting the architectural tastes of the date in that area.

In reviewing eligibility, the history of the area should be considered. For the settler's house, it is important to know whether or not the migration from upstate New York to this area was a common pattern. If it was, the house can be viewed as possessing some significance through the connection with this broad pattern of local history. It is also important to know whether the settler played a significant role in local history. Was he or she a businessperson who established a general store that served the community for a long period of time, for example, or a farmer who played a key role in introducing a new and ultimately important crop? In other words, was the subject someone who made a definable contribution to local history?

Architectural significance also may be a factor in the evaluation. Does this upstate New York settler's house fall into a broad architectural pattern in illustrating the use of building forms or materials characteristic of upstate New York that were used by other early settlers who came from that area? Does the building exemplify commonly used traditional house forms or high-style design of its period, or is it an important example of its designer's work—whether the designer was a fashionable architect of national reputation or a local carpenter-builder?

Once some conclusions concerning how the building fits into the patterns of local history have been reached, an attempt should then be made to determine whether the house is of sufficient importance within these historical patterns to merit designation. For example, perhaps the settler was but one of a great number of such people who settled in the same general area and many of the houses these settlers built have survived. The evaluation of this particular building's importance in representing the theme of the eastern migration to the area might be much less than it would be if only a few of the early settlers' homes had survived, say in an urban area.

Here, the issue of physical integrity becomes important. If fifty houses that relate to the settlement of the area of New Yorkers survive, certainly some of them—all other things being equal—illustrate better than others what it was like for these New Yorkers to establish their lives in Michigan in the early days. Those that retain enough of their historic appearance and character to provide a clear illustration are of greater importance than those that have lost this ability.

Synthetic siding, major renovations that result in the loss of original materials such as trim, and moving from the original site reduce the ability of a building to convey its significant history. Most buildings do not remain in pristine form, and many have been moved. How much the alterations have reduced the overall ability of the building to illustrate the history must be evaluated. In effect, the standards for physical integrity for properties possessing historical significance only mildly related to the architecture differ somewhat from those of properties whose significance is primarily architectural.

The New York settler's house loses a strong measure of significance if it is moved off the property on which the pioneers actually settled. The house loses some measure of significance if synthetic siding is installed or other changes are made, but may retain sufficient integrity to be eligible if the changes made are reversible ones that do not change the fundamental character of the property.

On the other hand, a building that is viewed as eligible primarily because of its architectural value in illustrating high style or vernacular tastes of its time period may not be viewed as losing integrity by being moved (as long as the new setting is appropriate), but may be viewed as losing a substantial amount of integrity by being sided or changed in other ways that reduce the building's ability to illustrate the historic architectural finishes and materials.



SURVEY PRODUCTS AND REPORT

A final survey report is required for all survey projects. This report must be uploaded to the MiSHPO "My Applications" tab. The survey report should provide information on the purpose, parameters, methodology, limitations, findings, background, historical context, and descriptions on the findings. SHPO requires that report authors adhere to the most recent edition of the *Chicago Manual of Style and the* *Michigan State Historic Preservation Office Style Guide*.

SURVEY REPORT COMPONENTS: SECTION ONE

- COVER OR TITLE PAGE: Include the name of the survey, municipal unit(s) and counties, sponsoring agency, completion date of the final report, names and location of the person or firm responsible for carrying out the survey, and names of the report author and primary project personnel, if different.
- ACKNOWLEDGMENTS/FUNDING CREDIT: Most projects are funded by federal, state, or local funding and the source of funding should be acknowledged in the report. For project funded through the Historic Preservation Fund, the following acknowledgment of federal assistance is required behind the title page and before the executive summary:

The activity that is the subject of this project has been financed in part with Federal funds from the National Park Service, U.S. Department of the Interior, through the Michigan State Housing Development Authority. However, the contents and opinions herein do not necessarily reflect the views or policies of the Department of the Interior or the Michigan State Housing Development Authority, nor does the mention of trade names or commercial products herein constitute endorsement or recommendation by the Department of the Interior or the Michigan State Housing Development Authority.

This program receives Federal financial assistance for identification and protection of historic properties. Under Title VI of the Civil Rights Acts of 1964, Section 504 of the Rehabilitation Act of 1973, and the Age Discrimination Act of 1975, as amended, the U.S. Department of the Interior prohibits discrimination on the basis of race, color, national origin, disability, or age in its federally assisted programs. Michigan law prohibits discrimination on the basis of religion, race, color, national origin, age, sex, marital status, or disability. If you believe you have been discriminated against in any program, activity, or facility as described above, or if you desire further information, please write to:

Chief, Office of Equal Opportunity Programs
United States Department of the Interior
National Park Service
1849 C Street, NW
Washington, DC 20240

- EXECUTIVE SUMMARY: Briefly describe the scope of the survey project, its purpose and goals, and the results in terms of the survey products, evaluations of eligibility for the National Register of Historic Places, and recommendations for local districting and other actions. Provide a summary of National Register eligibility recommendations and any other recommendations for action from the Evaluation Results and the Planning Needs and Recommendations sections. The executive summary should direct the reader to the appropriate sections of the report (include page numbers) where more detailed information can be found. This information will be copied into the MiSHPO survey submission as the abstract. **As part of the executive summary, the following information is required for all surveys submitted to SHPO.**
    - Number of properties surveyed at the reconnaissance level and at the intensive level: break this down by municipal unit if survey work took place in more than one and break it down by area if survey activities took place in more than one survey area.
    - Number of acres and hectares surveyed (SHPO requires this information as it must be reported to the National Park Service).

- TABLE OF CONTENTS
- CREDITS AND CREDENTIALS: Indicate who worked on each part of the project, their areas of expertise, and how they qualify as historians or architectural historians according to the federal qualifications set forth in 36 CFR 61. This part of the report can also be used to acknowledge funding or other assistance rendered the surveyor or team.
- PROJECT OBJECTIVES AND METHODOLOGY: Explain why the survey was undertaken and the goals and objectives that the survey project was intended to fulfill. What situations, conditions, planning needs, or other circumstances led to the survey and how and by whom were the objectives developed. List any previous surveys or studies relating to the survey area and define any data gaps or outdated information in these studies that warranted new study. Describe in reasonable detail the work program that was developed to carry out the goals and objectives. Provide a verbal description of the survey area boundaries and set forth the various tasks and components of the project and the order in which they were undertaken. Identify sources—such as the local libraries, university archives, county register of deeds, or interviews and personal records of residents—of historical information to be used in the project.
- DATA LOCATION: List repositories for survey material, such as libraries, archives, planning departments, and SHPO. Indicate where copies of the full set of survey materials, photographs, and copies of the report have been deposited for future access.
- EVALUATION RESULTS SUMMARY:
    - RECONNAISSANCE-LEVEL SURVEY: The evaluation results section will contain recommendations concerning individual properties and areas deemed worthy of further study because of some potential for National Register of Historic Places eligibility. For each individual property, complex property, and district recommended for intensive level survey, provide at a minimum a single paragraph statement that contains a summary description of the resource and rationale for why it is viewed as worthy of intensive level study followed, in the case of resources consisting of multiple properties, by a specific boundary description. Provide a map illustrating the boundaries of areas recommended for intensive level survey (See Maps section of this chapter).
    - INTENSIVE-LEVEL SURVEY: The Evaluation Results section should contain specific recommendations concerning individual and complex properties and districts that appear to meet the National Register criteria along with clearly defined boundaries. For each individual or complex property evaluated as National Register eligible, list the property and its street address (or latitude/longitude to six digits) and municipal unit (if the survey included more than one municipal unit). For a district, provide a detailed boundary description and a rationale for the boundaries selected. For each individual and complex property and districts evaluated as National Register eligible, include a short summary description and significance statement that is similar to the summary paragraphs in National Register nominations. For each proposed district, provide a map that shows the boundaries for the district for inclusion in the Evaluation Results section of the report. The map should be no larger than an 8 ½'' x 11'' format or must be able to be folded to that size in a hard copy of the report.
- PLANNING NEEDS AND RECOMMENDATIONS: If appropriate, include recommendations for other measures that should be undertaken to encourage the future preservation of the survey area's historic resources. These can include recommendations for local historic district designation, for educational programs to increase public awareness (books, videos, websites, programming, etc.), for establishing financial incentive programs to encourage historically sensitive rehabilitations of downtown commercial buildings or

homes in historic districts, for zoning changes, etc. This may be more appropriate for surveys conducted during the Section 106 process. Information should also be included regarding Section 106 recommendations and information on avoiding Adverse Effects on the historic properties.

- PRESERVATION ISSUES AND THREATS: In considering the local preservation environment, the surveyors should note any known threats to buildings in the area and the nature of those threats. The surveyor will also be expected to provide information regarding threats to individual buildings.
- SURVEY MAPS: Provide a complete, final set of survey maps. These maps should be reproducible without color copying capabilities.

SURVEY REPORT COMPONENTS: SECTION TWO

Section Two of the report contains a descriptive overview of the survey area, the historical overview and context narratives, plus evaluation sections relating to the historic themes. This section should be arranged in the following order:

- DESCRIPTIVE OVERVIEW: Provide a summary description of the survey area that defines its physical character, including features such as location and setting, topography, land uses, and general character of the historic resources present. For survey areas that comprise several sections, provide a descriptive overview for each section. The description should begin with general information, including a description of the boundaries (if the survey doesn't encompass an entire community) and a discussion of the area's general character, including the setting and topography. More detailed information about the survey area's physical form and layout and its architectural character should follow. The length of the overviews will vary depending on the size and character of the survey areas. Paradoxically, it seems that for a large survey area, such as an entire community, a relatively short overview will generally make sense, while for a relatively small area, such as a neighborhood, a lengthier overview will often be warranted.
- HISTORICAL CONTEXT: See historical overview section above. This section should include a historical sketch of the development of the community that focuses on settlement patterns, immigrant groups, important industries, and dominant architectural traditions. This section should also include information on themes.
    - o THEMATIC NARRATIVES: The thematic narratives should be prepared as described in the Thematic Narratives section of Chapter 4 and should follow the historical overview for the survey area. Each historical narrative should be followed by evaluation standards for the theme and a list of properties associated with it.
- BIBLIOGRAPHY: The required citation style of Michigan SHPO is the most recent edition of the Chicago Manual of Style. The bibliography should contain a list of all references consulted during the course of the survey.

SURVEY REPORT COMPONENTS: SECTION THREE

Section Three of the report comprises the survey data itself, as well as the following components:

- INDEX LIST OF SURVEYED PROPERTIES: This should be organized by street and number in alphabetical and numerical order. The entry in each surveyed property should

reference the map on which the surveyed property is found (if there is more than one survey map). Individual properties and complex properties at single addresses (generally houses or estates, farms, industrial or institutional complexes, or parks or cemeteries) should be listed alphabetically by street and then numerically by address number. Historic districts should be listed alphabetically by historic name at the beginning of the index list.

- INVENTORY FORMS: Provide a complete set of printed Historic Resource Inventory Forms and a Historic District Inventory Form for all surveyed properties. The forms should be arranged in the same order as the index list. The Michigan SHPO has created a template that includes the mandatory terms for survey in the state (See Appendix D).
- SURVEY PHOTOS: Photographs should be taken in accordance with the above standards.

A survey report is an official document summarizing the results of an important planning activity that will hopefully promote and influence the course of historic preservation activities in the survey area for years to come. The credibility of the report and its conclusions and recommendations can be enhanced by a professional appearance or reduced by an appearance that is less than professional. The final version of the report should be free of typographical and grammatical errors. Reports prepared for SHPO will not be accepted if they contain typographical errors and other unprofessional characteristics. The overall layout and graphics, including mapping, should have a polished, professional appearance.

The survey report is not an academic exercise that will never see the light of day, but rather a public document that will likely be scrutinized for years to come not only by preservationists but also by those seeking to demolish historic properties. The report should be written in an objective tone that clearly demonstrates the significance of the historic resources. Avoid damning historic properties with faint praise. For example, the same building was described in earlier and later versions of the same report as follows:

“In contrast to the Ottawa Street Power Station is the extremely modest Art Deco store at 1136 S. Washington Avenue.”

“In contrast to the grandeur of the Ottawa Street Power Station is the modestly sized Art Deco store front at 1136 S. Washington Avenue. Although the building itself is very small, almost tiny, the unique octagonal windows and pencil-line concrete detailing above the twin entries make this building a distinguished and elegant part of the lively South Washington streetscape.”

The first of these statements says nothing to indicate that this building is significant; in fact, the implication is that it is unimportant, and thus expendable. The second statement, especially when read in combination with another statement about the building on a different page in the report makes unmistakeably clear the importance of the building as evaluated by the report’s authors: “One of the city’s unique structures is the diminutive but jewel-like Art Deco building at 1136 S. Washington.”

DISTRIBUTING SURVEY REPORTS

Every survey should be viewed as an opportunity to help preserve Michigan’s significant cultural resources. The survey products provide an explanation of a community’s development and constitute documentation regarding the location and significance of above-ground resources associated with various themes in a community’s history and architecture. These materials can be a tool for a variety of groups besides SHPO, including:

- Planners, to develop strategies to minimize the impact of development projects on significant resources; to facilitate their responsibilities, under federal law, regarding the protection of cultural resources; and to provide a basis for establishing priorities for the rehabilitation or conservation of neighborhoods
- Historic interest groups that promote local history and the preservation of significant properties or areas, that serve an educational role in the community, and that may be a repository for local historic collections

- Property owners desiring information about their houses or businesses
- Teachers, who use local history and the built environment in classes ranging from social studies to history to art
- The media, which needs background information for news coverage and special reports and programming
- Neighborhood organizations that work to enhance the quality of life in specific areas, and
- Youth groups that may sponsor projects that enhance the environment, including historic resources

Thus, survey reports should be widely available to both governmental and planning agencies and members of the general public. A sufficient number of survey reports should be produced to allow for distribution. The following agencies or organizations should receive a copy of the report:

- Local planning department
- County or regional planning agency
- SHPO (One digital copy and one paper copy)
- Local libraries
- Library of Michigan, Lansing
- Local or regional archives and repositories nearest the survey area, such as
    - Burton Historical Collection, Detroit Public Library
    - Michigan Historical Collections, Bentley Library, University of Michigan
    - Clark Historical Library, Central Michigan University
    - The university archives at Michigan Technological University, Oakland University, and Western Michigan University

We also encourage discussing with the local planning department the possibility of incorporating the survey data into a local Geographic Information System (GIS). These discussions should include SHPO staff.

RECOMMENDATION FOR INTENSIVE LEVEL SURVEY FOR AN AREA RESULTING FROM RECONNAISSANCE LEVEL SURVEY

EXAMPLE: "Island" Survey Area, Sault Ste. Marie

This primarily residential area located on the island formed by the St. Mary's River and the power canal contains a potential National Register-eligible historic district for which precise boundaries should be established as a result of intensive level survey work. The potential district extends east from the county courthouse along portions of Maple, Cedar, Spruce, Carrie, Dawson, Kimball, and Brady Streets and St. James Place in the general area bounded on the west by Bingham, north by Portage, east by Johnston, and south by the power canal and Lyon Street. The area contains a rich concentration of large and often high-style late nineteenth- and early twentieth-century houses, including most of the city's most architecturally distinguished Queen Anne houses plus notable examples of "Free Classic," Tudor, Arts-and-Crafts-influenced, and other styles of houses. It contains two substantial houses built with walls of local pinkish-brown sandstone. A row of very fine Arts-and-Crafts houses lines the south side of Carrie west from Johnston. The area also contains the Neoclassical former Carnegie Library building on Cedar Street plus the Gothic Revival (Catholic) St. Mary's Pro-Cathedral complex, which includes the Art Deco St. Mary's School directly behind the church between Maple and Cedar and the large schoolyard that extends west to Spruce.

The area that appears to merit intensive-level survey is bounded by Portage on the north, Bingham on the west, the power canal on the south, and Johnston on the east, and the two brick bungalows on the east side of Johnston south of Carrie.

RECOMMENDATION FOR NATIONAL REGISTER-ELIGIBLE DISTRICT RESULTING FROM INTENSIVE LEVEL SURVEY

EXAMPLE: Schoolcraft Historic District, Schoolcraft

DESCRIPTION: The recommended Schoolcraft Historic District comprises portions of nine blocks on the village's west side and is centered in the area bounded by Haywood on the east, Eliza on the south, West on the west, and Vienna on the north. It contains many of the community's oldest houses, dating from the 1830s and 40s, and some of its most architecturally distinguished houses, including Greek and Gothic Revival, Italianate, Eastlake, and "Free Classic" buildings. Many of the finest of these houses are located along the two blocks of West Cass Street.

SIGNIFICANCE: The proposed Schoolcraft Historic District occupies much of the original plat of Schoolcraft, laid out in 1831 for owner Lucius Lyons and named by him in honor of his friend, Henry R. Schoolcraft, explorer and Indian agent for the Michigan Territory. The commons Lyons set aside for church and school sites survives, having been made into a park in the 1890s after the only building ever constructed there, a church, was removed. The district, comprising almost the entire village before additional areas were platted beginning in 1835, contains the homes of many of the village's earliest white settlers. These include the person who platted the area for Lucius Lyons; the village's and county's first physician (and later the local Underground Railroad conductor); an owner and a proprietor of the village's first hotel, which stood in this area before Grand Street (US-131) was laid out and became the main street; a part owner of the village's first store; the village's first postmaster; and a participant in Michigan's constitutional convention (and later mayor of Kalamazoo). Anumber of these houses date from the early 1830s and are among the oldest buildings in the southwestern part of Michigan. The district's early

building stock contains examples of a broad range of house forms characteristic of the southern part of Michigan and of the New England and New York State origins of the earliest settlers. They include the I-house, gable-front, upright-and-wing, upright-and-double-wing, and gabled-ell forms. Examples of Greek Revival, Italianate, Gothic, Eastlake, and "Free Classic" houses are present, and some of them, especially along West Cass Street, are unusually distinguished examples of their styles within the overall context of the region's building stock.

BOUNDARY DESCRIPTION: the district boundary begins at the NW corner of lot 57; thence S to NW corner of lot 69; th W along N line of lot 68 to center of West St.; th S to center of Clay St.; th W to rear (W) line of lot 78; th S along rear (W) lines of lots from 78 to 139 and to center of Eliza St.; th E to center of West St.; th S along W line of lot associated with 322 W. Eliza to SW corner of property; th E to SE corner of property; th N to center of Eliza St.; th W to E line of lot 140; th N along E linesof lots 140, 137, 128, and 125 to SE corner of lot 116; th E along S line of lots 117 and 118 to SE corner of lot 118; th N along E line of lot 118 to SE corner of lot 111; th E along S line of lot 110 to center of Hayward St.; th N in center of Hayward to a point in line with N line of lot 62; th W along N line of lots 62 and 63 to center of Center St.; th N to a point in line with N line of lot 57; th W to Point of Beginning. All in Original Plat of the Village of Schoolcraft.

BOUNDARY RATIONALE: This boundary was drawn to include the areas within the original plat containing a concentration of houses relating to the village's earliest days as well as other historically and architecturally significant houses while avoiding those areas in which concentrations of historically and architecturally significant properties are not present.

SURVEY AREA DESCRIPTION FOR A COMMUNITY

EXAMPLE

Port Hope is a small village (population of 360 as of 1980) located on the shore of Lake Huron in the Thumb region of Michigan's Lower Peninsula. The Thumb, bounded on the east by Lake Huron north of Port Huron and on the northwest by Saginaw Bay, is a rural, agricultural area generally of low, slightly rolling topography. The principal part of Port Hope from approximately Main Street west lies on a nearly level plain that extends inland in all directions. East of Main Street the land drops off a short distance to a lower terrace along the lakeshore itself. The village is surrounded on the land side by farm country with scattered stretches of forest. A modern county park and several campgrounds and trailer parks occupy much of the lake frontage in the village, but to the north and south the shoreline is wooded and in some cases swampy. US-25 is the principal commercial street, passing through the small central business district, with its handful of clapboards and brick Late Victorian buildings, in the two blocks between School Street and Portland Avenue. US-25 southeast of the point where Main Street cuts off from it follows a modern alignment that cuts diagonally across the historic platted patterns of streets. Main Street on either side of the business district and the streets to the west—First, Second, Third, State, and School—is the residential portion of town and contains a mixture of mostly modest late nineteenth- and twentieth-century houses plus two older churches. The lakeshore terrace to the east historically was the site of mills and elevators, and presently contains several elevator complexes and other commercial enterprises, plus free-standing chimney stacks from long-ago-destroyed saw and planing mills. It appears that many of the streets in the north and southeast parts of town shown in the 1890 map as platted were never opened.

SURVEY AREA DESCRIPTION FOR A NEIGHBORHOOD

EXAMPLE

River Point is bounded on the north and west by the Grand River, east by the Red Cedar River, and south by the railroad line south of South Street, which forms the southern edge of the original part of Lansing platted in 1847. The neighborhood comprises two components, the commercial corridor along South Washington, which spills over slightly onto the side streets, and the larger residential area along Hazel, Elm, South, Grand, and Platt to the east. River Point's distinct edges define the neighborhood's character and make it a place apart from the rest of the city.

The South Washington corridor between the river and the railroad tracks possesses much visual interest because of the variety of older buildings present—from one of the city's largest early twentieth-century apartment buildings to a Spanish Mission-style former gas station to a Moderne enameled metal panel bowling alley to a Neoclassical bank building to one of Lansing's Art Deco jewels to a turn-of-the-century railroad station. The station is located just outside of the survey area; it is listed in the National Register of Historic Places.

The corridor's buildings have survived reasonably intact and restorable despite years of neglect and underutilization. Much of the commercial building stock consists of early twentieth-century two-story Commercial Brick blocks in which the facades rely for their decorative interest not on historical styling but on the brickwork itself. The most commonly seen trademarks of Commercial Brick are panels of brickwork and corbelled brickwork below the upper cornices or roofline. The range of buildings at 1131-1149 S. Washington, although as simply detailed as any Commercial Brick block in the city, are unusual for the uniform façade design with slightly recessed brickwork panels in the friezes carried throughout. The four-store front building at 1000-1006 displays the most intricate brickwork paneling of any of the area's numerous examples. Alternating panels of horizontal stretcher bricks and diagonal stretchers flanking central lozenge ornaments—the panels outlined by bands of headers with square blocks at the corners—stretch across the façade at frieze level. The three-storefront building at 1202-1206 S. Washington (each section of the building today is treated differently, with the central third clad in 1960s-looking metal sheathing that should come off one day) displays a robust Commercial Brick corbelled cornice in which projecting stretchers alternate with recessed headers. The Popoff Meat Co.'s northerly building employs an even more eye-catching corbelling technique in its cornice. In the alternating tiers of projecting and recessed corbelled brickwork, the recessed tiers begin one course above the projecting ones. This results, when sunlight falls on the façade, in a checkerboard-like appearance. Like Commercial Brick buildings elsewhere in Lansing, the South Washington ones exhibit considerable variety in brick hues and textures.

One of the city's unique structures is the diminutive but jewel-like Art Deco building at 1136 S. Washington. This symmetrical two-storefront limestone-clad building displays octagonal shop windows, fluted horizontal banding, chevrons, and dramatic striping on the façade. The façade is completely intact, including the doors with their streamlined push bars.

Another landmark, although not a commercial building, along South Washington is the Washington Arms Apartments located just south of the Grand River. Along with the Porter, located on Townsend at Lenawee, the massive red brick Washington Arms is probably the largest early twentieth-century apartment building in a city which until well into the twentieth-century century was almost exclusively a community of single-family houses, with only a relatively small number of two-family and townhouse buildings.

The streets east of Washington comprise the bulk of the River Point residential neighborhood (a few residential buildings are also found west of Washington, and notice will be taken of one of them in a few paragraphs). The River Point neighborhood is characterized by narrow streets and, except north of Hazel, small lot sizes. Houses stand close by one another and close to the street. Far from being drawback,

these factors along with the abundant shade from large trees give the neighborhood an intimate scale that is one of its most appealing features.

The houses in River Point appear to date primarily from the 1890s to the 1920s. There are none of the larger and more elaborately detailed houses found in some other Lansing neighborhoods. The houses are generally simple and of modest scale. Some of the larger of the oldest houses are narrow-fronted and deep two story, cross-gable houses such as 1135 S. Grand and a brick example at 1145 S. Grand. A number, such as 215 Hazel and 1134 Platt, are gable-front buildings where the entrance stands at the back of a shed-roof side porch. Among the neighborhood's early twentieth-century homes, the two-story square-plan "foursquares" found in other Lansing neighborhoods are present along with a small number of bungalows. The bungalows tend to display simple Arts-and-Crafts-inspired detailing including exposed rafter ends below the broadly projecting roofs and, in the case of 1140 S. Grand, door and window trim with elongated lintels and slanting sides. A small number of Colonials, including narrow and deep Dutch Colonials with their gables to the street such as the one at the southeast corner of Hazel and Grand, are also present. A gable-front turn-of-the century-looking Colonial house at 222 Elm stands out among the neighborhood's dwellings because of its tripartite, with arched center, Palladian-inspired window in the front gable.

Most houses in River Point occupy narrow-fronted and deep lots and thus embody similarly narrow and deep forms. Elm Street presents virtually the only exceptions to this general pattern. A stuccoed, hip-roof, two-family house of Arts-and-Crafts inspiration—the only building constructed as a two family house noted in the neighborhood, at the southwest corner of S. Grand—and a broad-fronted gambrel-roof Dutch Colonial with shed dormer, located on Elm's north side between Grand and Platt, are highly visible buildings because of this broad-fronted orientation.

The neighborhood's only church building stands at the south end of the area on South Street between Grand and Platt. It is a cross-gable, early twentieth-century, auditorium-type church building with a square-plan tower near the façade's midpoint. Simple bargeboards mark the eaves.

The short east-west streets west of Washington retain few buildings. The most notable of them—really one of the outstanding buildings of the neighborhood—stands at 117 S. South. This two-story, symmetrical-front building, presumably once an apartment house, sports an Arts-and-Crafts façade of brick of various hues from red orange to brown that is divided into three vertical bays by boldly projecting piers, the central ones rising well above the tiled pent roofs that top the bays. The central bay's entry and broad windows in either side bay, set within segmental arches and panels of header brick outlined by stretcher brick (itself a reversal of the typical panel treatment), separates the first-floor openings from those above. Another pent-roof building, a smaller one-story commercial building with an arched central entry, stands next door to the west at 121.

River Point today all but turns its back to the river. Although some streets and houses stand close to the Grand and Red Cedar, steep, thickly wooded banks conceal the water from view. The city has developed the small River Point Park at the actual confluence of the Grand and Red Cedar, but, it seems, more could be done to make the rivers' proximity a community asset.



UPDATING PREVIOUS SURVEYS

Areas may require re-surveying because the existing data has become outdated, a higher level of survey is required (an intensive-level survey will replace an old reconnaissance-level one), or the quality of the old survey is unreliable. Whatever the reason, past survey activity may provide information useful for the present project, including:

- Existing site-specific records (inventory cards, forms, or database records);
- Research that can contribute to the current research effort;
- Recommendations regarding eligibility;
- Districting proposals.

The new survey should build upon the old one. The old thematic narratives should not be used as is, but the new survey should be seen as an opportunity to revise and expand them. The aim of a new survey should be to provide survey materials meeting current standards for all properties in the survey area that have previously been surveyed and that meet the survey criteria developed for the re-survey project. A re-survey project should generally be performed at the intensive level; it usually makes little sense to re-survey previously surveyed properties unless the survey will generate additional information. Old surveys often omitted features of complex properties such as carriage house/stable buildings and agricultural outbuildings that would be included in current intensive-level surveys. The new survey provides an opportunity to obtain complete survey data that should not be missed.

The new survey report should include all of the standard products as well as any newly surveyed properties within the re-survey area.



THEMATIC SURVEYS AND CONTEXT STUDIES

Thematic survey is the survey of properties relating to a specific property type or historic theme. Thematic surveys of industrial and engineering sites, highway bridges, post offices, and state parks have been carried out at the statewide level, and myriad other property types or themes such as vernacular log buildings, outdoor sculpture, designed historic landscapes, and the automobile industry could be the subjects of statewide thematic surveys. Thematic surveys within single counties or larger cities are equally feasible.

A survey project in Grand Rapids included thematic surveys of city parks, public school buildings, and cemeteries. Surveys of public schools, apartment buildings, and banks in the city of Detroit have been completed. The Michigan SHPO has undertaken these context studies as a way to better assist planning efforts in these regions. Thematic surveys could involve important aspects of local history, such as the struggle for Civil Rights in Detroit or Detroit's rich twentieth-century heritage as a center for jazz and other forms of popular music. A survey of sites associated with the history of popular music in Detroit, for example, might seek to identify birthplaces and homes of musicians, recording studios, and clubs, ballrooms, and other places where locally and nationally important performers and groups played. The possibilities for thematic surveys and context studies are endless.

Thematic surveys differ from other survey types by requiring an initial property-specific research phase to identify the specific properties to be surveyed or to locate the areas likely to produce resources that merit survey. Standard sources of information such as published histories, typically used for surveys, may not be as useful in thematic surveys, and research in specialized sources of information appropriate to the project will be needed. A statewide survey of historic railroad bridges might require a search for railroad company records, engineering and railroad journals and bridge company records and catalogs that might provide information on specific structures, and a review of maps to locate likely points for major bridges. Surveys of Civil Rights struggle-related sites or popular music-related sites in Detroit would probably require numerous oral history interviews. A survey of the Finnish farmsteads in the Upper Peninsula would likely require research in old maps and census records to determine where the concentrations of Finnish settlements were located.

Surveyors will need to devise research strategies appropriate for identifying and documenting the resources to be surveyed. Persons with specialized knowledge of the survey's subject matter should be involved in the project at the earliest planning stage. In carrying out a thematic survey, the general instructions for intensive-level survey provided here should be followed. However, a thematic survey must begin with a research phase both to document the theme itself and to identify and document the associated properties. The thematic research will lead to the preparation of a single thematic narrative that includes discussion of associated property types.

Many thematic surveys are done under contract with SHPO. These projects often involve the preparation of inventory forms and a Multiple Resource Documentation Form for the National Park Service. In addition to this form, these surveys must include a separate survey report following the guidelines outlined in this document. Consultants should utilize site forms following the example in Appendix D for the creation of their inventory forms. These items must also be entered in the MiSHPO system as outlined in this document.



SURVEY AND SECTION 106

As a part of their compliance with Section 106 of the National Historic Preservation Act, federal agencies and their designees have the responsibility to identify historic properties that may be affected by an undertaking. An undertaking is a federally assisted or licensed project, such as housing rehabilitation and demolition, streetscape improvements, new road construction and road reconstruction or realignment, airport expansions and renovations, water and sewer projects, new bank branches, railroad line abandonments, and communication towers. Under Section 106, federal funding or licensing agencies (or their designees when permitted under federal regulations) must provide SHPO with data on historic properties that might be affected by their proposed projects along with substantive comments on the eligibility of those properties. The submission of this information is a prerequisite to obtaining comments from SHPO on the effects of the projects on historic above-ground resources. Projects that involve both above-ground and below-ground disturbances should also contact the State Archaeologist to conduct appropriate file reviews of below-ground sites in the project area.

The APE for a project should be defined in consultation with SHPO. **Please note that the area of potential effects (APE) is not simply the project's physical boundaries or right of way.** It is important to understand this. The APE is defined as the geographic area or areas within which an undertaking may directly, or indirectly, cause changes in the character or use of historic properties. The area of potential effects is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by an undertaking. In defining the APE, you must consider not only physical effects but also visual, auditory, and sociocultural (i.e. land use, traffic patterns, public access) effects.

The potential National Register of Historic Places eligibility of properties that may be affected by a federally assisted or licensed project must be reviewed in the context of the neighborhood or area in which they are located. The agency requesting SHPO's review must provide sufficient information to answer the question, "What are the historic properties either listed in or eligible for listing in the National Register of Historic Places within the area of potential effect (APE) for the project?" This includes determining not only whether affected properties may be individually eligible for the National Register, but also whether they may contribute to the historic character of a larger area or district that as a whole meets the National Register criteria. Competent professionals meeting the federal professional qualifications for historian and architectural historian should perform the work.

WORK PROGRAM

Federal agencies or their federally delegated designees ("Responsible entities" for HUD-funded projects) must perform the following in order to provide the basic information SHPO requires. This information will be used to make informed determinations of eligibility and effect for properties in the APE:

1. A visual inspection of the exterior of each property in the APE and of the surrounding neighborhood to
    a. Evaluate the architectural character and integrity
    b. Determine if properties in the APE may be part of a National Register-eligible district and if so, to define the district's boundaries.
2. Contact SHPO to
    a. Review National Register listings for the community
    b. Determine whether SHPO has previously established firm boundaries for a National Register-eligible district in the area.
3. Research the properties in the APE and document their histories, using standard sources such as
    a. Historic atlases and plat books
    b. Directories and published sources such as county and local histories
    c. Tax records
    d. Interviews with current and past property owners, local historians, and long-term residents



APPENDIX A

HISTORIC ARCHITECTURE SURVEY GLOSSARY OF TERMS

These definitions were obtained from the National Park Service National Register Bulletins 15, 24, and 16a.

ARCHITECTURE CLASSIFICATION – Item on the National Register form calling for the entry of an architectural style or other term by which the property can be identified.

BUILDINGS – A building, such as a house, barn, church, hotel or similar construction is created to shelter any form of human activity. Building may also refer to a historically and functionally related unit, such as a courthouse and jail or a house and barn. Examples include stables, sheds, garages, courthouses, city halls, social halls, commercial buildings, libraries, factories, mills, train depots, stationary mobile homes, theaters, schools, and stores.

DISTRICT – A district possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development. Examples include college campuses, central business districts or other commercial areas, residential areas, industrial complexes, civic centers, rural villages, large farms, ranches or estates, and large landscaped parks.

FORM CLASSIFICATION – the item on the National Register form calling for the architectural form or other term by which the property can be identified.

HISTORIC CONTEXT – An organizing structure for interpreting history that groups information about historic properties that share a common theme, common geographical area, and a common time period. The development of historic context is a foundation for decisions about the planning, identification, evaluation, registration, and treatment of historic properties, based upon comparative historic significance.

HISTORIC INTEGRITY – the unimpaired ability of a property to convey its historical significance.

HISTORIC RESOURCE – a building, site, district, object, or structure evaluated as historically significant.

IDENTIFICATION – the process through which information is gathered about historic properties.

LANDSCAPE – A landscape is a collection of organized features that can range from something as small as a birdbath to large fields or orchards. The U.S. Secretary of the Interior has defined the following six components of a landscape that must be identified and documented if the character of the landscape property is to be understood: spatial organization and land patterns; topography; vegetation; circulation; water features; and structures, site furnishings, and objects.

OBJECT – The term object is used to distinguish from buildings and structures those constructions that are primarily artistic in nature or are relatively small in scale and similarly constructed. Although it may be, by nature or design, movable, an object is associated with a specific setting or environment, such as statuary in a designed landscape. Examples include sculpture and statuary, monuments, fountains, fences and streetlights.

PROPERTY TYPE – a grouping of individual properties characterized by common physical and/or associated attributes.

RESOURCE – any building, structure, site or object that is part of or constitutes a historic property.

RESOURCE TYPE – the general category of property – building, structure, site, district, or object – that may be listed in the National Register.

SETTING – quality of integrity applying to the physical environment of a historic property.

SIGNIFICANCE – Importance of a historic property as defined by the National Register criteria in one or more areas of significance.

SITE – A site is the location of a significant event, a prehistoric or historic occupation or activity, or a building or structure, whether standing, ruined, or vanished, where the location itself possesses historic, cultural, or archaeological value regardless of the value of an existing structure. Examples commonly encountered in above-ground surveys include estate and other grounds, gardens, ruins of historic buildings and structures, cemeteries, parks, and designed landscapes.

STRUCTURE – The term structure is used to distinguish from buildings those functional constructions made usually for purposes other than creating shelter. Examples include bridges, tunnels, dredges, fire towers, canals, dams, power plants, water purification and sewage treatment plants, water towers, corncribs, silos, roadways, windmills, grain elevators, kilns, railroad grades, systems of roadways and paths, boats and ships, railroad locomotives and cars, carousels, bandstands, gazebos, and aircraft.

STYLE – in this case, it is the architectural style that is not on the list of the pre-defined NPS-acceptable terms for the National Register Form. If “other” is selected for the Architectural Classification field, then Style should indicate what the “other” is.

SURVEY – A survey is a systematic search for properties that possess or appear to possess significance to national, state, or local history. Survey is the process of identifying and gathering data on properties that may be historic. It includes field survey, the physical search for and recordation of basic information about historic and potentially historic properties; background research to establish the historic context for the properties within the project area; and historical research on surveyed properties.

THEME – a trend or pattern in history or prehistory relating to a particular aspect of cultural development, such as dairy farming or silver mining.



APPENDIX B

FARMSTEAD AND HISTORIC LANDSCAPE SURVEY STANDARDS

Urban, suburban, and rural survey areas may contain properties and areas that possess significance as historic landscapes. The U.S. Secretary of the Interior has defined the following six components of a landscape that must be identified and documented if the character of the landscape property is to be understood: spatial organization and land patterns; topography; vegetation; circulation; water features; structures; site furnishings; and objects. The degree of importance of any of these features depends on the landscape and its use.

The most likely types of historic landscapes encountered in the field are the Historic Designed Landscape and the Rural Historic Landscape. Before beginning work, surveyors should review *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes*; National Register Bulletin 18, *How to Evaluate and Nominate Designed Historic Landscapes;* and National Register Bulletin 30, *Guidelines for Evaluating and Documenting Rural Historic Landscapes*, for insights into identifying and documenting these important historic resources.

A Historic Designed Landscape is defined in Bulletin 18 as a landscape:

- Significant as a design or work of art
- Consciously designed and laid out either by a master gardener, landscape architect, architect, or horticulturalist to a design principle, or by an owner or other amateur according to a recognized style or tradition, or
- That has a historical association with a significant person, trend, or movement in landscape gardening or architecture, or a significant relationship to the theory or practice of landscape architecture

Historic designed landscapes may include parks, squares and other public spaces, cemeteries, parkway or boulevard systems, small residential grounds, estates, campus or institutional grounds, gardens, golf courses, and planned subdivisions and communities, including mobile-home parks/manufactured housing developments.

A Rural Historic Landscape is defined in Bulletin 30 as:

- A geographic area that historically has been used by people, or shaped or modified by human activity, occupancy, or intervention, and that possesses a significant concentration, linkage, or continuity of areas of land use, vegetation, buildings and structures, roads and waterways, and natural features. Rural landscapes often reflect the day-to-day occupational activities of people engaged in traditional work activities such as mining, fishing, and various types of agriculture. Often, they have developed and evolved in response to both the forces of nature and the pragmatic need to make a living.

Rural historic landscapes often contain large acreage and proportionally small numbers of buildings and structures compared to other types of historic properties. Examples of rural historic landscapes in Michigan include: agricultural districts, industrial districts of a series of mine complexes or remnants, a fishing village or complex, and a district of recreational camps.

SURVEYING HISTORIC LANDSCAPES

Survey forms should be customized in consultation with SHPO for a historic landscape depending on whether the landscape forms a single complex property, such as a park, cemetery, residential grounds, an estate, or a number of complex properties. For single complex property surveys, any feature that appears several times on the landscape such as a fence or wall system, should be recorded on a single form with the quantity included. For cemeteries, records should be created for all public monuments and memorials, such as veteran memorials. Private monuments and memorials should be surveyed when they mark the resting place of historically significant individuals, when they possess special artistic

merit or unique design, or when they are rare examples of a type (e.g. iron cross markers from old Catholic cemeteries).

For multiple complex properties forming a historic landscape, each property should have its own site form. Examples include the following:

- A Rural Historic Landscape that is a rural agricultural district consisting of a group of farms, each of which contains historic features that require survey;
- A Designed Historic Landscape that is a planned residential district in which each individual property contains historic features that require survey.

Survey data for a Rural Historic Landscape should be captured on both a survey form and in the description field as appropriate. Some of the items collected could include:

- Land uses and activities
- Patterns of spatial organization
- Response to the natural environment
- Cultural traditions
- Circulation networks
- Boundary demarcations
- Vegetation related to land use
- Buildings, structures, and objects
- Clusters
- Archaeological sites
- Small-scale elements

Survey data for Designed Historic Landscapes should be captured on both a survey form and in the description field as appropriate. Some of the items collected could include:

- Overall form and plan of the landscape.
- Approximate size of the landscape—Convey the scale of the landscape in terms of acres or square miles, as appropriate.
- Topography—Describe whether the land is flat, rolling, hilly, or varied in relief.
- Natural features—Describe natural features, such as rivers, lakes, hills, or bluffs that help define the landscape.
- Circulation systems of roads, paths, trails, etc.
- Spatial relationships and orientation, such as symmetry, asymmetry, and axial alignment.
- Views and vistas in to and out of the landscape.
- Vegetation—Ideally, describe the common name with caliper for trees and heights for shrubs (and put this information onto maps). At the least, describe the primary types and locations of vegetation. Mention the extent of tree cover, using appropriate terms such as grove, scattered trees, forest, wooded area, and specimen tree. If possible, name the species of trees or describe whether trees are coniferous (evergreen) or deciduous. Include the general maturity of trees. Use a similar approach to describing shrubs and their arrangement on the landscape. Flowers and other low-growing plants should be described in terms of their placement on the landscape: in beds, naturalistic plantings, planters, or specialty gardens.
- Bodies of water such as pools, fountains, lakes, streams, and cascades.

- Number and general character and location of buildings, structures, and objects present.

Photography should include an appropriate number of images to thoroughly document the entire district and individual complexes or features. The views should be taken from different directions and include one or more that illustrate the street frontage.

A single survey map should be prepared for each surveyed complex in accordance with the general survey mapping instructions. The map should include the entire district, not just areas containing the buildings. All surveyed resources should be plotted and labeled. The survey map should also illustrate those important features not surveyed but included on the survey form for the entire property.

SURVEYING FARM PROPERTIES

Farm properties commonly consist of farmstead areas containing houses, barns and other outbuildings plus the remainder of the farm properties, which may include a combination of features such as crop and pasture areas, woodlots, orchards and gardens, lanes, windbreaks, and ponds. Additional buildings such as hay barns and migrant housing clusters may stand outside of the main farmstead area. Small-scale features such as fencing, windmills, wells, and bridges may also be present. These human-built and natural elements plus the overall features of land use and circulation patterns define the character of farm properties.

A survey of farm properties should provide information on the entire property, including a comparison of the current historic patterns of land use and the physical layout as far as it can be determined. It should provide information on all buildings, structures, and other component features.

The surveyor must complete survey forms for the entire property and also individual survey forms for each of the buildings, structures, and objects regardless of age. Survey forms must also be made to cover all examples of any features that appear several times on the landscape such as fencing or wall systems. Historic vegetation associated with human occupation and use—such as windbreaks, tree lines along roads or drives, specimen trees, garden beds, and sugarbushes—should be included on survey forms, when historic information on the origins and uses of these features can be obtained. If information on the origin and use of the features is not found then they should be described and mentioned in the survey form for the larger farmstead.

Photography will include an appropriate number of images to thoroughly document the entire farm and individual features. The views should be taken from different directions and include one or more that illustrate the street frontage.

A single survey map must be prepared for each surveyed farm in accordance with the general survey mapping instructions. The map must include the entire property, not just the area containing the buildings. All surveyed resources must be plotted and labeled. The survey map should also illustrate those important features not surveyed but included on the survey form for the entire farm.



APPENDIX C

CONTRACTING SURVEYS

Survey Sponsors seeking consultants for survey work should develop a Request for Proposal (RFP) for the project. A clear RFP, with work and work products explicitly stated, helps consultants prepare more accurate budgets. If the work program is vague, consultants may have to compensate by pricing for unknown or unclear aspects of the work, and disagreement over the expected products may result at the end of the project. It is a good idea to request that the SHPO Survey Coordinator review the RFP before it is sent out to consultants.

The RFP should define the work program and products as fully as possible. It should clearly and thoroughly define:

- The work the consultant is expected to perform;
- The products—including the number of copies—to provide at the end of the project;
- The boundaries of the survey area, clearly defined in writing and illustrated by a map or series of maps;
- The expectations for the level of property-specific research, including what sources of information the consultant will be expected to use for all properties, and what additional research will be required for a specific number of apparently more significant properties, if that information is available;
- The total number of properties to be surveyed and a breakdown of the numbers by level of research, if possible;
- The time frame within which the project must be completed;
- Services or materials that may be provided to the consultant at the consultant's request; and
- Expectations for meetings the consultant will be expected to attend or presentations the consultant will be expected to make.

The RFP should clearly define the information that consultants must submit in their proposals, including:

- A thorough description of the work to be performed and the final products to indicate whether or not consultants have a clear understanding of what will be required;
- A plan of action for accomplishing the work. This should include a breakdown of the work by components and personnel and a schedule with time frames for each component;
- Educational background and related work experience of the personnel working on the project;
- Writing samples for personnel involved in preparing the report;
- Professional References.

Finally, the RFP should specifically list the criteria against which proposals will be evaluated. The criteria should award points to proposals that demonstrate:

- A solid understanding of the work and products required;
- An adequate program and realistic time frames for successful completion of the project; and
- Personnel with the necessary educational background, work experience, and proven track record of successfully completed projects.

Cost is obviously an important consideration, but no proposal should be considered unless it fully meets the evaluation criteria set forth above.



APPENDIX D

MICHIGAN HISTORY/ARCHITECTURAL SURVEY SITE FORM

NAME
Historic Name

STREET ADDRESS
Street Address

MUNICIPAL UNIT, COUNTY
City/Township, County

DISTRICT NAMES
District Name (if applicable)

Photo

YEAR BUILT
Date of Construction

PROPERTY TYPE
Resource Type

ARCHITECTURAL CLASSIFICATION
Architectural Classification
Architectural Classification Other

PLAN FOUNDATION WALLS
Plan

Foundation Materials

Wall Materials

ROOF FORM ROOF OTHER MATERIALS
Roof Form

Roof Materials

Other Materials

CONDITION INTEGRITY ARCHITECT
Condition

Integrity

Architect

HISTORIC USE CURRENT USE BUILDER
Historic Use

Current Use

Builder

OUTBUILDINGS Outbuildings

AREAS OF SIGNIFICANCE Areas of Significance

NARRATIVE DESCRIPTION
Narrative Description

STATEMENT OF SIGNIFICANCE
Statement of Significance

ELIGIBILITY RECOMMENDATION NR CRITERIA NR EXCEPTIONS
Eligibility Recommendation

NR Criteria

NR Exceptions

DISTRICT NAME
Related District Name

SOURCES
Sources

Surveyor Date Surveyed
Surveyor

Date Surveyed

Historic Name	Address	SHPO Survey Number
Common Name	Township/City	Surveyor
District Name (if applicable)	County	Date Surveyed

MICHIGAN HISTORY/ARCHITECTURAL SURVEY SITE FORM **Michigan State Historic Preservation Office**

Ownership: □ Private □ Public Local □ Public State □ Public Federal

Visible from ROW: □ Yes □ No

Endangered: □ Yes □ No Explain:

Category

□ Building
□ District
□ Site
□ Structure
□ Object
□ Landscape Feature

Condition

□ Excellent
□ Good
□ Fair
□ Deteriorated
□ Demolished
□ Ruins

Integrity

□ Unaltered
□ Slightly Altered
□ Moderately Altered
□ Severely Altered
□ Moved → → → →

Removals

Date Moved

Replacement

□ Roof
□ Porch
□ Windows - Some
□ Windows - All
□ Door
□ Other:

Additions

□ Siding
□ Wings
□ Other:

Plan

□ Rectangular
□ L
□ T
□ X
□ U
□ Irregular
□ Polygonal
□ Other:

Roof Form

□ Side-gable
□ Front-gable
□ Cross-gable
□ Hip
□ Pyramidal
□ Mansard
□ Flat
□ Other:

Roof Features

Porches
□ Front
□ Side
□ Rear

Retains Integrity of:

□ Association
□ Design
□ Feeling
□ Location
□ Material
□ Setting
□ Workmanship

Historic Use

Current Use

Foundation Materials	Wall Materials	Roof Materials	Other Materials

Architectural Classification	Builder/Architect	Significant Person(s)

Outbuildings

□ Barn
□ Carriage House
□ Chicken Coop
□ Corncrib
□ Garage
□ Granary
□ Hog House
□ Livestock Barn
□ Machine Shed
□ Milk House
□ Privy/Outhouse
□ Pumphouse
□ Shed
□ Silo
□ Smokehouse
□ Spring House
□ Stable
□ Summer Kitchen
□ Tool Shed
□ Wash House
□ Windmill
□ Wood Shed
□ Workshop
□ Other:

Descriptions:

Date Built

Areas of Significance

□ Agriculture
□ Archaeology
□ Architecture
□ Art
□ Commerce
□ Communications
□ Community Planning and Development
□ Conservation
□ Contact Period
□ Economics
□ Education
□ Engineering
□ Entertainment/ Recreation
□ Ethnic Heritage
□ Exploration/ Settlement
□ Health/Medicine
□ Industry
□ Invention
□ Landscape Architecture
□ Law
□ Literature
□ Maritime History
□ Military
□ Performing Arts
□ Philosophy
□ Politics
□ Religion
□ Science
□ Social History
□ Transportation
□ Other:

Historic Context(s)/Statement of Significance/Additional Description:

Site Plan

↑

N

Information Sources:

Photo Numbers

Eligibility Recommendation

□ Previously listed □ Individually eligible □ Contributing to district □ Non-contributing to district □ Not eligible
□ More research needed

If Eligible, Criteria Met: □ A □ B □ C □ D **Criteria Considerations:** □ a □ b □ c □ d □ e □ f □ g

Parcel Number:

Lat/Long:



APPENDIX E

MISHPO TERMS LIST

Below is a list of some of the acceptable MiSHPO terms.

OWNER TYPE:

- Private
- Public-Local
- Public-State
- Public-Federal

PROPERTY TYPE:

- Apartment building
- Bridge
- Commercial district
- Duplex
- Farm
- Lighthouse
- Railroad depot
- Residential district
- Rowhouse
- Service station
- Ship

FORMS

BUILDING FORMS

- A-frame Building
- Octagon Building
- Polygon Building
- Quonset Building – use for Quonset or other arch-rafter structure with semi-cylindrical roof and non-existent side walls
- Round Building

HOUSE FORMS

- American Foursquare
- Basilica Plan House – use in place of Hen and Chicks
- Bungalow
- Cruciform House
- Cup and Saucer House
- Front-gabled House
- Gabled Ell
- Half Basilica House
- Hall and Parlor House
- Hen and Chicks – use Basilica Plan

- I-House
- New England Large House
- New England 1½ Cottage
- Pyramidal Cottage
- Ranch House
- Upright and Double Wing House
- Upright and Wing
- Basement Barn
- English Barn
- Pennsylvania Barn
- Pole Barn
- Southwestern Michigan Dutch Barn

COMMERCIAL BUILDING FORMS: Use the following terms as appropriate. See Richard Longstreth's *The Buildings of Main Street* (Walnut Creek, CA: AltaMira Press, 2000).

- Arcaded Block
- Enframed Block
- Enframed Window Wall
- One-part Commercial Block
- Stacked Vertical Block
- Temple Front
- Three-part Vertical Block
- Two-part Vertical Block
- Vault (Architecture)

INDUSTRIAL BUILDING FORMS: Use the following terms as appropriate. See Betsy Hunter Bradley's *The Works: The Industrial Architecture of the United States* (NY: Oxford University Press, 1999)

- Industrial Loft
- Production Shed

MATERIALS

Foundation

- Brick
- Concrete
- Stone
- Stone: Granite
- Stone: Limestone
- Stone: Marble
- Stone: Sandstone
- Other

Walls

- Asbestos
- Asphalt
- Brick
- Ceramic Tile
- Cloth/Canvas
- Concrete
- Earth
- Glass
- Metal
- Metal: Aluminum
- Metal: Bronze
- Metal: Cast Iron
- Metal: Copper
- Metal: Iron
- Metal: Lead
- Metal: Nickel
- Metal: Steel
- Metal: Tin
- Stone
- Stone: Granite
- Stone: Limestone
- Stone: Marble
- Stone: Sandstone
- Stone: Slate
- Stucco
- Synthetics: Fiberglass
- Synthetics: Rubber
- Synthetics: Vinyl
- Terra Cotta
- Wood
- Wood: Log
- Wood: Plywood/Particle Board
- Wood: Shingle
- Wood: Weatherboard
- Other

Roof

- Asbestos
- Asphalt
- Metal: Copper
- Meta: Iron
- Metal: Steel
- Metal: Tin
- Stone: Slate
- Vitrified Clay Tile
- Wood: Shingle
- Wood: Shake
- Other

NATIONAL REGISTER ELIGIBILITY

- NR Eligible
- Not NR Eligible
- More information needed

STATUS IN A CURRENT OR POTENTIAL DISTRICT

- Contributing Site
- Non-Contributing Site
- More information needed


INTERNATIONAL TRANSPORTATION CENTER
SWEET SOO
OF THE NORTH
LAKE SUPERIOR
STATE COLLEGE
NO
LEFT
TURN

APPENDIX F

REPORT TEMPLATE

SECTION ONE

- Cover or Title Page
- Acknowledgment/Funding Credit
- Executive Summary
- Table of Contents
- Credits and Credentials
- Project Objectives and Methodology
- Data Location
- Evaluation Results
- Planning Needs and Recommendations
- Preservation Issues and Threats
- Survey Maps

SECTION TWO

- Descriptive Overview of Survey Area
- Historical Context
- Bibliography

SECTION THREE

- Index of Surveyed Properties
- Inventory Forms
- Survey Photos



APPENDIX G

PROPERTY INDEX TEMPLATE

SHPO will provide a copy of the excel document upon request but below are the headers that are required.

Name			**Street Address**	
Municipal Unit	**County**	**District Name**	**Year Built**	**Property Type**
Architectural Classification			**Architectural Classification - Other**	
Plan	**Foundation**		**Walls**	**Roof Form**
Roof	**Other Materials**			
Condition	**Integrity**	**Architect**	**Historic Use**	
Builder	**Outbuilding**		**Areas of Significance**	
Narrative Description		**Statement of Significance**		
Eligibility Recommendation				
NR Criteria	**NR Exceptions**		**Sources**	
Surveyor	**Date Surveyed**		**Parcel Number**	
Ownership	**Geographical Coordinates**			



VISIT US AT WWW.MICHIGAN.GOV/SHPO

MSHDA
MICHIGAN STATE HOUSING DEVELOPMENT AUTHORITY

MICHIGAN
SHPO
STATE HISTORIC PRESERVATION OFFICE

Appendix D – *Federal Curation Regulations (36 CFR 79)*

while it is in the possession of the Commission or its staff. After completing its review of the supplemental information, the Commission or its staff will return or destroy it, if the Registrant complies with the procedures outlined in Rule 418 under the Securities Act [17 CFR 230.418].

7. Each exhibit identified in the exhibit index (other than an exhibit filed in eXtensible Business Reporting Language) must include an active link to an exhibit that is filed with the registration statement or, if the exhibit is incorporated by reference, an active hyperlink to the exhibit separately filed on EDGAR. If the registration statement is amended, each amendment must include active hyperlinks to the exhibits required with the amendment."

* * * * *

Note: The text of Form N–3 does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 13. Amend Form N–3 (referenced in §§ 239.17a and 274.11b), Cover Page, by adding a new paragraph immediately after the sentence ["t]he Commission also may use the information provided on Form N–3 in its regulatory, disclosure review, inspection, and policy making roles" To read as follows:

* * * * *

A Registrant is required to disclose the information specified by Form N–3, and the Commission will make this information public. A Registrant is not required to respond to the collection of information contained in Form N–3 unless the Form displays a currently valid Office of Management and Budget ("OMB") control number. Please direct comments concerning the accuracy of the information collection burden estimate and any suggestions for reducing the burden to Secretary, Securities and Exchange Commission, 100 F Street NE, Washington, DC 20549. The OMB has reviewed this collection of information under the clearance requirements of 44 U.S.C. 3507.

* * * * *

Note: The text of Form N–CEN does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 14. Amend Form N–CEN (referenced in § 274.101) by replacing the Instruction following Item F.3 and replacing Item F.18 to read as follows:

* * * * *

Part F: Additional Questions for Unit Investment Trusts

* * * * *

Item F.3. * * *

Instruction. If the answer to Item F.3 is yes, respond to Item F.12 through Item F.19. If the answer to Item F.3 is no, respond to Item F.4 through Item F.11, and Item F.17 through Item F.19.

* * * * *

Item F. 18. Reliance on rule 12d1–4. Did the Registrant rely on rule 12d1–4 under the Act (17 CFR 270.12d1–4) during the reporting period? [Y/N]

* * * * *

Note: The text of Form N–PX does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 15. Amend Form N–PX (referenced in § 274.129), Cover Page by removing "§§ 239.24 and 274.5 of this chapter" and adding, in its place, "17 CFR 239.24 and 274.5".

Note: The text of Form N–MFP does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 16. Amend Form N–MFP (referenced in § 274.201), in Item A.14.c. by removing the term "A.14.a–c." and adding, in its place, the term "A.14.a–b."

PART 275—RULES AND REGULATIONS, INVESTMENT ADVISERS ACT OF 1940

■ 17. The authority for part 275 continues to read, in part, as follows:

Authority: 15 U.S.C. 80b–2(a)(11)(G), 80b–2(a)(11)(H), 80b–2(a)(17), 80b–3, 80b–4, 80b–4a, 80b–6(4), 80b–6a, and 80b–11, unless otherwise noted.

* * * * *

Section 275.204–2 is also issued under 15 U.S.C. 80b–6.

* * * * *

Section 275.204–5 is also issued under sec. 913, Public Law 111–203, sec. 124 Stat. 1827–28 (2010).

* * * * *

§ 275.204–2 [Amended]

■ 18. In § 275.204–2 amend paragraph (a)(15)(ii) by removing "." and adding, in its place, "; and".

§ 275.204–3 [Amended]

■ 19. In § 275.204–3 amend paragraph (b) by removing "Subject to paragraph (g), you" and adding, in its place, "You".

§ 275.204–5 [Amended]

■ 20. In § 275.204–5 amend paragraph (e)(1) by removing "§ 275.204–1(b)(3)" and adding, in its place "§ 275.204–1(b)".

§ 275.206(4)–1 [Amended]

■ 21. In § 275.206(4)–1 amend paragraph (b)(2)(i) by removing "," and adding in its place ";".

PART 279—FORMS PRESCRIBED UNDER THE INVESTMENT ADVISERS ACT OF 1940

■ 22. The authority for part 279 continues to read, in part, as follows:

Authority: The Investment Advisers Act of 1940, 15 U.S.C. 80b–1, *et seq.*, Public Law 111–203, 124 Stat. 1376.

Note: The text of Form ADV does not, and these amendments will not, appear in the *Code of Federal Regulations.*

■ 23. Amend Form ADV (referenced in § 279.1) by:

■ a. In General Instruction 4 to Form ADV removing "Section 10 of Schedule R" and adding, in its place, "Section 4 of Schedule R"; and

■ b. In the Instruction to Section 4.B.7 of Schedule R removing "pre-fill Schedule B with the same indirect owners you have provided in Schedule B" and adding, in its place, "pre-fill the chart below with the same indirect owners you have provided in Schedule B for your *filing adviser*".

* * * * *

Dated: March 29, 2022.

Vanessa A. Countryman,

Secretary.

[FR Doc. 2022–06972 Filed 4–14–22; 8:45 am]

BILLING CODE 8011–01–P

DEPARTMENT OF THE INTERIOR

National Park Service

36 CFR Part 79

Office of the Secretary of the Interior

43 CFR Part 3

[NPS–WASO–CR–33054; PPWOCRADI0, PCU00RP14R50000]

RIN 1024–AE58

Curation of Federally Owned or Administered Archeological Collections

AGENCY: National Park Service, Interior.

ACTION: Final rule.

SUMMARY: The National Park Service amends regulations governing the curation of federally owned or administered archeological collections to establish definitions, standards, and procedures to dispose of material remains that have insufficient archeological interest. This rule promotes more efficient and effective curation of archeological collections.

DATES: This rule is effective May 16, 2022.

FOR FURTHER INFORMATION CONTACT: Karen Mudar, Archeology Program, National Park Service, 1849 C Street NW, Washington, DC 20005, 202–354–2103, email: *karen_mudar@nps.gov.* Individuals in the United States who are deaf, deafblind, hard of hearing, or have a speech disability may dial 711 (TTY, TDD, or TeleBraille) to access telecommunications relay services. Individuals outside the United States should use the relay services offered within their country to make international calls to the point-of-contact in the United States.

SUPPLEMENTARY INFORMATION:

Background

Authority To Promulgate Regulations

The Archaeological Resources Protection Act (ARPA; 16 U.S.C. 470aa–mm) authorizes the Secretary of the Interior (the Secretary) to promulgate regulations for the disposition of archeological and other resources recovered under the authority of ARPA, the Reservoir Salvage Act (RSA; 54 U.S.C. 312501–312508), and the Antiquities Act (54 U.S.C. 320301–320303). 36 CFR part 79's disposition process for resources recovered under ARPA, RSA, and the Antiquities Act is authorized thereunder. In addition, the National Historic Preservation Act (NHPA; 54 U.S.C. 302107 and 306131) authorizes the Secretary to promulgate regulations for the proper curation of archeological collections created under ARPA, RSA, and NHPA. 36 CFR part 79's curation requirements for resources recovered under ARPA, RSA, and NHPA are authorized thereunder. The Department of the Interior's Departmental Manual entitled ''Protection of the Cultural Environment'' (519 DM 2.3D) requires the Departmental Consulting Archeologist (DCA), located within the National Park Service (NPS), to develop regulations concerning the preservation of prehistoric and historic material remains of archeological interest under ARPA.

Regulatory History

The regulations at 36 CFR part 79 establish definitions, standards, procedures, and guidelines to be followed by Federal agencies to preserve collections of prehistoric and historic material remains and associated records that generally include those resulting from a prehistoric or historic resource survey, excavation, or other study conducted in connection with a Federal action, assistance, license, or permit.

As currently written, 36 CFR part 79 does not discuss processes for Federal agencies to dispose of particular material remains from archeological collections. It is important for Federal agencies to establish appropriate methods of disposal because prehistoric or historic material remains improperly disposed of could later be rediscovered and misinterpreted by archeologists or others as evidence of activity in the distant past. A proposed rule to establish procedures for discarding particular material remains from Federal collections was published in the **Federal Register** in 1990 (55 FR 37670, September 12, 1990). A final rule was never published. Instead, the DCA focused on the proper curation of federally owned or administered collections and left the subject of disposal of material remains for a future rulemaking.

In recent years, renewed interest from Federal agencies to address the issue of deaccessioning certain material remains has led to the promulgation of this rule. Specifically, Federal agencies such as the Department of Defense asked the DCA to help them find solutions to the growing costs of managing archeological collections. The NPS published a proposed rule in the **Federal Register** on November 18, 2014 (79 FR 68640).

Final Rule

This rule establishes procedures for the disposal of particular material remains of insufficient archeological interest that are held in federally owned or administered archeological collections. The procedures are not intended to apply to entire collections. Material remains refers to artifacts, objects, specimens, and other physical evidence, including human remains, of a historic or prehistoric resource. Federal agencies are responsible for ensuring that disposition of material remains is conducted in accordance with this rule and 36 CFR 79.7 ''Methods to fund curatorial services.'' This rule does not affect any material remains defined as ''cultural items'' by the Native American Graves Protection and Repatriation Act (NAGPRA; 25 U.S.C. 3001 *et seq.*) and subject to that statute. NAGPRA cultural items include Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony.

In addition to providing a mechanism for appropriate and carefully considered disposition, this rule will improve the curation of federally owned or administered archeological collections, such as by promoting more effective space and cost management. This rule addresses many of the comments submitted in 1990 by incorporating independent advice and opinions supplied by numerous experts that were consulted between 2005 and 2013. The NPS stresses that the disposition process laid out in this rule must be employed as part of a comprehensive collection management program that emphasizes collection stewardship and responsible accessioning practices. The best deaccession policy is a good accession policy. This rule provides measures to allow for deaccessioning only as a last resort. The NPS recommends that, in addition to proposing deaccession, agencies implement carefully designed field collection policies and create and implement clear and thoughtful scope of collections statements. Consistent with the Secretary's authority to promulgate regulations for ultimate disposition of certain material remains, this rule uses the term disposition throughout. The NPS acknowledges the museum practice of deaccessioning will be an integral and parallel part of the disposition process described in this rule.

In addition to adding a new Subpart E—Disposition of Particular Material Remains (Sections 79.12–79.18), this rule organizes existing sections 79.1–79.11 into Subparts A (Administrative Provisions), B (Archeological Collections Management), C (Public Access to and Use of Collections), and D (Inspections and Inventories of Collections). This rule also revises sections 79.1–79.4 to update legal citations, removes paragraph designations for defined terms in section 79.4 as recommended by the Office of the Federal Register's Document Drafting Handbook, and adds two defined terms that are used in Subpart E. A section-by-section analysis of the rule can be found in the Background section of the proposed rule.

Summary of Public Comments

The NPS published a proposed rule in the **Federal Register** on November 18, 2014 (79 FR 68640). The NPS accepted comments on the proposed rule through the mail, hand delivery, and through the Federal eRulemaking Portal at *http://www.regulations.gov.* Comments were accepted through February 17, 2015. The NPS received comments from individuals, federally recognized tribes, state and local government agencies, public institutions, and professional organizations. Summaries of the issues raised in the comments and responses from the NPS are provided below.

Disposition Process

1. Comment: Several commenters addressed the notification and consultation requirements in the

proposed rule. Commenters requested more time be given to interested parties to comment on a proposed disposition, and that additional direct notice be given to interested parties during the disposition process. Commenters asked that the Federal Agency Official (FAO) take additional steps to engage with public stakeholders during the disposition process.

NPS Response: The NPS made several changes in the final rule to ensure there is sufficient notice provided to interested parties during the disposition process. The NPS added a requirement that the FAO provide at least 60 days for notified entities to comment on a proposed disposition. The NPS increased the time allowed for objecting to a final determination of disposition from 30 to 60 days. The NPS added to the list of parties who must receive notice of proposed dispositions by including state archeologists, certain private landowners, broader categories of Indian tribes with cultural relationships to material remains in the collections, and organizations and institutions for which the agency has an existing relationship for research, excavation, curation, education, or other partnership in the state and region from which the material remains to be disposed were recovered. The NPS believes these notice requirements will sufficiently involve the relevant stakeholders in the disposition process prior to any determination of disposition published in the **Federal Register**.

2. Comment: Two commenters recommended that the rule limit the amount of time given to the FAO to choose a method of disposition.

NPS Response: The NPS declines to adopt this recommendation because it is important to preserve flexibility in this part of the disposition process, so that the most appropriate method is chosen. Time limits are required in other phases of the process such as during the periods for commenting on and objecting to determinations of disposition. A time limit at this stage would not further the purpose of the rule because agencies could be motivated to forego considered deliberation in order to select a method of disposition merely to meet a time limit.

3. Comment: One commenter argued that judgements other than those of the Indian Claims Court, as well as other types of documentation, should be allowed to determine aboriginal occupancy of land for purposes of whether an Indian tribe may receive deaccessioned materials excavated from lands other than Indian lands. Another commenter argued that culturally affiliated tribes that request deaccessioned material remains should be allowed to receive them.

NPS Response: The NPS has added two methods of disposition in paragraph 79.13(b) to accommodate these requests. Aboriginal occupation of lands where material remains were removed can now be documented by any type of evidence. The final rule allows material remains to be conveyed to federally recognized Indian tribes for the purposes of traditional, cultural, educational, or religious practices.

4. Comment: One commenter asked whether deaccessioned materials could be reused for educational or interpretive purposes (*i.e.,* adaptive reuse).

NPS Response: Deaccessioned materials may be used for educational or interpretive purposes. The methods of disposition in section 79.13 allow for such reuse. The rule is therefore sufficiently flexible to allow adaptive reuse after material remains have been deaccessioned.

5. Comment: One commenter argued that all methods of disposition are unacceptable because disposition is not a preservation activity.

NPS Response: ARPA section 5 (16 U.S.C. 470dd) specifically authorizes the Secretary of the Interior to promulgate regulations providing for the ultimate disposition of archeological resources. A requirement for specific disposition methods to constitute a preservation activity has no basis in the statutory authority.

6. Comment: Two commenters requested that the NPS list the methods of disposition in priority order for material remains excavated from public lands. One commenter requested that the rule provide a clear step-by-step process.

NPS Response: The NPS declines to impose a priority order on the methods of disposition because this would unduly restrict the discretion given to FAOs to dispose of deaccessioned material remains in the manner most appropriate to the situation. With the goal of making the disposition process as clear as possible, the NPS has provided a step-by-step process for an FAO to follow.

Federal Agency Official (FAO)

7. Comment: One commenter asked the NPS to identify the level of government where the FAO is located.

NPS Response: The FAO is defined in section 79.4 to mean ''any officer, employee or agent officially representing the secretary of the department or the head of any other agency or instrumentality of the United States having primary management authority over a collection that is subject to this part.'' In practice, the FAO is typically situated at the departmental, national, headquarters, or equivalent level of the agency, unless the agency has a different policy.

Collections Advisory Committee

8. Comment: Several commenters asked that individuals from outside of the Federal government be invited to participate on the collections advisory committee. One commenter proposed that any disposition should be contingent on a consensus recommendation from the collections advisory committee. Another commenter suggested that the DCA should not be eligible to serve on a collections advisory committee. Several commenters recommended that qualified experts be given more influence on the committee, while one commenter argued that the collections advisory committee should be made up of individuals who are professionally disinterested or distanced from the material remains being considered for disposition.

NPS Response: The NPS has revised the rule to clarify the qualifications necessary to serve on a collections advisory committee. The NPS added a requirement that the committee make consensus recommendations to the FAO about proposed dispositions. The NPS also added a provision stating that the DCA may not participate on the committee, because the DCA may be called upon to make recommendations in the case of a dispute. With the exception of certain Tribal officials specified in paragraph 79.15(e)(3), the NPS declines to delegate the responsibilities of Federal agencies for federally owned or administered property to non-Federal employees through an expansion of the composition of the committee. In order to increase the transparency of the committee, the final rule requires the collections advisory committee to prepare a written report for the FAO that contains, at a minimum, the following:

- The information required for the **Federal Register** notice of determination of disposition identified in paragraphs (i)(1)(i) through (iii) of section 79.15;
- The membership of the committee and their role and expertise pertinent to the deliberations;
- The committee's recommendations, including any conditions of transfer or conveyance; and
- An explanation of why the committee determined other methods of disposition were of lesser public benefit.

9. Comment: Several commenters asked the NPS to include specific procedures in the rule that collections advisory committee members must follow in order to make recommendations to the FAO about proposed dispositions, rather than allowing the committee to determine their own rules. One commenter recommended that the committee have clearly written procedures, including timelines and opportunities for public consultation and input. Another argued that the rule should identify the specific tasks and procedures of the collections advisory committee. One commenter proposed that the regulations establish a single committee to review every proposed disposition.

NPS Response: The rule supports the need for flexibility in the disposition process, including in the formation and operation of collection advisory committees. The NPS believes these committees must address the unique circumstances of each proposed disposition, as well as reflect the unique needs, capacities, and operating environments of the responsible Federal agencies, which a single central committee could not do. However, the rule also establishes some basic requirements about the composition and operation of the committees to enable appropriate recommendations. In order to strike a balance between fostering flexibility and imposing standard requirements, the rule establishes qualifications for committee membership and requires written procedures to be approved by the FAO. The NPS believes this is sufficient to ensure all recommendations are fair, open, timely, and in the best interest of the public. Mandating specific rules of procedure for each committee would be unduly rigid and make the work of the committees more difficult because they would be forced to apply strict rules to the unique situations and capacities of each committee. Although the regulations require that the composition of the committees be tailored to the characteristics of each disposition, nothing in the regulations prevents the same committee from reviewing more than one disposition of a similar nature. Under these circumstances, the Federal agency would not need to form a new committee for each proposed disposition provided the members of the committee meet the requirements in the regulations with respect to the particular collection under review.

Insufficient Archeological Interest

10. Comment: One commenter argued that a determination of insufficient archeological interest should be made on the basis of independent peer review that includes experts outside of the Federal government.

NPS Response: The NPS added a requirement in the final rule that the FAO must consult with qualified museum professionals at non-Federal repositories about the appropriateness of a proposed disposal. The NPS acknowledges that the perspective of qualified museum professionals responsible for the care and curation of the subject materials is necessary for the FAO to make an informed determination. FAOs must use appropriate judgment and base determinations of disposition on appropriate supporting information. Because the rule regulates federally owned or administered collections, however, it remains appropriate that Federal agency staff and officials, with verifiable knowledge of the materials, make decisions regarding the disposition of material remains in those collections.

11. Comment: One commenter argued that a lack of original records should not be sufficient to presume a determination of insufficient archeological interest if provenience can be reconstructed through other means.

NPS Response: The loss or destruction of associated records is one factor in determining whether there is a lack of provenience information. Under section 79.12, a qualified archeological or museum professional must determine that a disposition will not negatively impact the overall value of the collection in order to make a finding of insufficient archeological interest. In doing so, the professional must make a concerted effort to research all records, including museum records, associated with a collection. In addition, the FAO must determine that disposition of the material remains will not negatively impact the overall integrity of the original collection.

12. Comment: One commenter stated that it is unclear who makes the determination of insufficient archeological interest and what that individual's qualifications should be.

NPS Response: At least one qualified archeological or museum professional with verifiable knowledge of and experience in the type of material remains being evaluated makes a determination of insufficient archeological interest. The FAO determines whether the professional is qualified, using the Professional Qualification Standards set by the Secretary of the Interior as a benchmark, and considering the professional's verifiable knowledge of the material remains. The FAO then determines, under section 79.15, whether the material remains are eligible for disposition under this subpart.

13. Comment: Two commenters requested that the rule define the following terms related to insufficient archeological interest: Material remains, physical integrity, irreparable damage, overly abundant, and representative sample.

NPS Response: Existing regulations define material remains as ''artifacts, objects, specimens and other physical evidence that are excavated or removed in connection with efforts to locate, evaluate, document, study, preserve or recover a prehistoric or historic resource.'' This definition goes on to provide illustrative examples of different classes of material remains. The NPS declines to define the other terms requested by the commenters. These terms are commonly used by the archeological community and must be applied in context using the professional judgement of qualified personnel. For example, the amount sampled and sampling method for a representative sample must be determined on a case-by-case basis, using the professional discretion of subject matter experts and best available information. The rule requires subject matter experts to have verifiable knowledge of the material remains to be examined.

14. Comment: One commenter questioned whether material remains could possess increasing archeological interest over time.

NPS Response: For material remains that are overly redundant and not useful for research, the rule requires that a sampling strategy be developed and implemented in order that the retained samples may be subjected to new or improved analytical technologies in the future that could demonstrate those materials remains have greater archeological interest than previously known. The NPS has revised the rule to clarify that samples of material remains determined to be overly redundant and not useful for research must be representative of the population as a whole from which the sample was taken. This will help ensure the integrity and potential future worth of samples that are retained.

15. Comment: One commenter suggested that the criterion ''overly redundant and not useful for research'' be split into two separate criteria, each of which could support a determination of insufficient archeological interest.

NPS Response: The NPS declines to split this criterion into separate criteria because both elements of this criterion are necessary to establish insufficient

archeological interest. Fulfilling only one of these two elements (overly redundant or not useful for research) could not result in a determination of insufficient archeological interest. A redundant set of material remains that is still useful for research could have sufficient archeological interest. For instance, two sets of similar material remains derived from different archeological contexts are likely, by virtue of their spatial disparity, to provide some information about the past, even though those material remains may seem similar or identical in a museum setting. Alternatively, material remains not useful for research but not overly redundant could still have archeological interest because: (1) Their uniqueness may render them inherently informative about the past and (2) they may become useful for research in the future as new technologies are developed. Thus, to meet this test, material remains must be both overly redundant and not useful for research.

16. Comment: One commenter suggested that the NPS establish a hierarchy of levels of archeological interest and provide a range of disposition options for each level.

NPS Response: The rule only addresses the ultimate disposition of certain materials that have insufficient archeological interest. Identifying different degrees or levels of insufficient archeological interest and assigning different disposal options for each level would unnecessarily complicate the process.

Costs

17. Comment: Several commenters addressed the costs for Federal agencies and recipient entities of complying with the disposition process under the rule. Several commenters were concerned that the rule would place financial strain on repositories for retaining materials during the disposition process without addressing a general shortfall of personnel and funding. One commenter expressed concern that several methods of disposition (*e.g.,* conveyance to suitable repositories or institutions) would impose unfair financial burdens on recipients of deaccessioned material remains.

NPS Response: The rule will impose little or no direct cost upon the public. Section 79.7 makes Federal agencies responsible for funding the curation of material remains. This includes costs associated with deaccessioning material remains in federally owned or administered collections, including costs borne by repositories that retain materials during the disposition process. Federal agencies must accession and catalog material remains before deaccessioning, and must follow relevant law and agency policy in ensuring that funding decisions address all aspects of collection stewardship, not just deaccessioning. The rule provides a series of options for disposition and does not require any group or individual to accept material remains that are eligible for disposal. The rule does not impose unfair financial burdens on recipients of deaccessioned material remains because those recipients are under no obligation to accept the material remains. A recipient must independently choose to accept deaccessioned material, thus it will have an opportunity in advance to consider the financial impact of its participation in the disposition process. The NPS believes the disposition process in the rule is financially achievable for Federal agencies.

18. Comment: Two commenters inquired about the costs of deaccessioning material remains of insufficient archeological interest. They were concerned that resources, which could be used to catalog and curate collections, might be diverted to deaccessioning instead.

NPS Response: To limit the possibility that Federal agencies allocate resources to deaccessioning rather than to curating collections, the rule provides controls, under section 79.12, on the disposition process, intended to limit its use only to appropriate circumstances. Deaccessioning is one part of a comprehensive curation methodology. In order to be eligible for disposition, material remains must be part of a Federal collection, and thus have undergone appropriate intake and accessioning procedures, which must be documented in accordance with agency protocols. Agency staff responsible for determining whether particular material remains lack archeological interest must consider the relationship of the material remains to the collection as a whole. Any effort to determine the archeological interest of material remains must include a review of the overall collection, along with associated documentation, from which those material remains are derived. For these reasons, the NPS does not believe that the disposition process will divert funds from curation because deaccessioning is part of a responsible curation program.

19. Comment: One commenter suggested that the disposition process will impose new costs for excavation because allowing for disposition will force archeologists to perform a more thorough analysis of material remains prior to curating them in a repository.

NPS Response: The NPS does not consider this scenario as likely to occur. However, a more thorough analysis of collections during an initial excavation project could be a desirable outcome because it means that the documentation concerning material remains will provide a better understanding of the archeological interest and improve the value of the resulting curated collections to the public. Any increase in the initial cost of analysis would be voluntary.

Compliance

20. Comment: Several commenters discussed ways that implementation of the rule will support and interplay with compliance regimes for laws such as the NHPA and the National Environmental Policy Act (NEPA).

NPS Response: Under section 106 of the NHPA, Federal agencies must consider the effect of an undertaking on any historic property that is included in or eligible for inclusion in the National Register. Museum collections, including archeology collections, are not generally considered historic properties (see National Register Bulletin 15). Further, material remains determined to be of insufficient archeological interest are not likely to be included in or eligible for inclusion in the National Register because, characteristically, they would not be worthy of preservation. NEPA requires Federal agencies to fully consider the impacts of proposals that would affect the human environment prior to deciding to take an action. The disposal of material remains under this rule will generally not constitute a Federal action under NEPA that would have a significant effect on the human environment. Nevertheless, FAOs must consider the context related to each proposed disposal of material remains and comply with all applicable laws, including the NHPA and NEPA, before making a final determination. The FAO must consider the opinions, as appropriate, of the collections advisory committee, Indian Tribes, and other available experts in making disposition decisions to ensure compliance with Federal law. In cases where collections are held under a compliance agreement, such as a Memorandum of Agreement under section 106 of NHPA, the FAO must consider the context and the terms of the agreement to determine whether disposal is appropriate.

Administrative Record

21. Comment: Several commenters focused on the creation and preservation of the administrative record of the disposition process. One commenter asked that the

administrative record be provided to tribes and SHPOs, particularly when they possess additional data about the site or collection. Other commenters asked the NPS to clarify the requirement in paragraph 79.15(i)(2)(i) to prepare a detailed list of material remains to be deaccessioned and better define when photographic documentation would be considered appropriate.

NPS Response: Section 79.18 requires Federal agencies to include in their administrative record specific documentation of the determination of disposition. Consistent with these requirements, Federal agencies should follow their own procedures for preparing, preserving, and distributing administrative records. The FAO should follow existing practices that comply with applicable state and Federal standards for recording material remains in archeological collections when preparing the detailed list of material remains required by paragraph 79.15(i)(2)(i). This paragraph specifies that the list must include a description of each object, or lot of objects if there are multiples of a particular type, and photograph(s) of the objects when appropriate. The FAO should also consider standard practices to determine when photographic documentation is appropriate.

Authority and Applicability of Regulations

22. Comment: Two commenters questioned whether the authorities cited in section 79.2 authorize the NPS to allow the disposition of material remains. Two commenters questioned the applicability of the rule to material remains excavated under the Antiquities Act and the interplay with prior regulations.

NPS Response: Section 5 of ARPA (16 U.S.C. 470dd) gives the Secretary the explicit and sole authority to promulgate regulations providing for ''the ultimate disposition'' of ARPA archeological resources and other resources removed pursuant to the Antiquities Act and the RSA. These authorities are cited in paragraph 79.2(b)(2) which, except for updated citations, is not changed by this rule. The explicit statutory authority to promulgate this rule supersedes any preceding regulatory requirements regarding similar subject matter, in particular, 43 CFR 3.17. This more recent statutory authority thus makes it appropriate to include those resources excavated under the Antiquities Act and eligible for disposal via the process described in the new Subpart E as subject to this rule. For clarity, this rule adds a note to 43 CFR 3.17 stating that resources excavated under the Antiquities Act are eligible for disposal via Subpart E of 36 CFR 79.

23. Comment: Several commenters requested clarification about the term ''practical management authority'' and the meaning of ''indirect'' practical management authority.

NPS Response: Part 79 applies to federally owned or administered collections. Section 79.3(a) uses the term ''practical management authority'' to further explain the circumstances under which collections that are owned by the United States are subject to Part 79. Federal agencies have ownership of collections due to specific laws, activities on Federal lands, or other circumstances, and these collections are managed in a variety of ways. In order for those collections to be subject to Part 79, a Federal agency that owns a collection also must have ''practical management authority'' over that collection, either directly or indirectly. Otherwise, Federal agencies would be responsible for curating collections that they do not control. Direct practical management authority generally includes situations where a Federal agency is directly administering collections at Federal facilities. Indirect practical management authority includes situations in which a Federal agency has legal responsibility and control over collections but a non-Federal entity has responsibility for curating the collection. This is usually documented through the terms of an agreement, contract, permit, or authorized expenditures.

24. Comment: One commenter stated that the rule should only apply to federally owned collections and that there should be no question about who has legal title over material remains that are proposed for disposal.

NPS Response: The FAO should be able to discern the ownership of material remains when determining if those remains are eligible for disposal under paragraph 79.12(a) and when reviewing the provenience information to determine if those remains have insufficient archeological interest under paragraph 79.12(e)(2)(i). Directions from ascertainable owners or questions regarding ownership must inform the FAO's proposed disposition determination. Clear legal ownership by the United States is not a prerequisite for disposal of material remains under Part 79; the rule also applies to material remains that are not owned by the United States but that are managed or controlled by a Federal agency pursuant to the Antiquities Act, NHPA, RSA and ARPA. Other provisions of the rule explicitly ensure that certain owners of federally administered collections, such as Indian individuals or tribes under 79.13(a), have an opportunity to receive them or to object to a proposed disposition. This aspect of the rule is intended to ensure that the government cares for archeological collections in its possession in accordance with applicable laws.

25. Comment: Based on established practices that allow for the re-interment of human remains not subject to NAGPRA, several commenters suggested that this rule should apply to human remains not subject to NAGPRA and identify reburial as a method of disposition. One commenter suggested that the rule establish a disposition process for human remains that are not subject to NAGPRA.

NPS Response: During consultation for the proposed rule, Federal agencies, Tribes, and professional organizations suggested that excluding all human remains from the disposition process for materials of insufficient archeological interest described in this subpart would simplify the rule and avoid confusion with NAGPRA and its implementing regulations. As a result, the proposed rule excluded all human remains from disposition and, in doing so, did not distinguish between human remains subject to NAGPRA and other human remains. The final rule clarifies in paragraph 7.12(b)(1) that Native American cultural items under NAGPRA, which can include human remains, are not eligible for disposition under this rule. Native American human remains are subject to disposition or repatriation under NAGPRA. In paragraph 7.12(b)(2), the final rule also states that other human remains not subject to NAGPRA are ineligible for disposition under Subpart E. The NPS does not intend for this subpart to affect established practices that otherwise allow for the disposition and re-interment of human remains not subject to NAGPRA. The final rule clarifies that human remains not subject to NAGPRA are excluded only from the process described in Subpart E. The NPS is reserving section 79.14 to address this issue in the future if necessary.

Disputes

26. Comment: Several commenters addressed the procedures for objecting to determinations of disposition. One commenter asked that the public have 90 days to dispute a determination of disposition, and that the requirement for submission of documentation be removed. Another commenter recommended that those objecting to a disposition should be responsible for finding a new repository. One

commenter suggested that the DCA should make binding decisions for all objections instead of non-binding recommendations to the FAO. Another commenter requested that the rule require the DCA to thoroughly explain their recommendation to the FAO. Two commenters asked that the rule include a dispute resolution process in section 79.16 to help resolve disagreements over which tribes should receive material remains that have been determined to be eligible for disposal. One commenter specifically recommended adopting the dispute resolution language from NAGPRA.

NPS Response: The NPS made several changes in section 79.16 of the final rule to provide a more effective and inclusive process for objecting to a determination of disposition. The NPS lengthened the timeframe to object to a determination of disposition from 30 to 60 days. The NPS believes this will provide sufficient time for interested parties to file an objection, in part because the list of those notified and consulted with prior to the determination of disposition is comprehensive. It is important that the objecting party document the reasons for the objection so that the DCA and the FAO are able to evaluate the merits of the objection. While objecting parties may suggest a different repository, they are not required to as a condition to filing an objection. The NPS also shortened the timeframe for the FAO to respond to the DCA's non-binding recommendation from 60 to 30 days and added a requirement that the DCA forward a copy of the objection to the FAO within 5 days of receipt of the objection. The final rule also requires the DCA to consult with the objecting party and the FAO with the aim of resolving the objection. This will ensure that the DCA plays a significant role in the resolution of disputes over determinations of disposition. The final rule requires that the DCA explain their recommendation to the FAO.

The NPS declines to make the DCA's decision binding because the DCA's role to other government agencies is advisory in nature. The DCA has no authority to broker binding arbitration with other Federal agencies, nor does the DCA have the authority to make decisions on their behalf. Similarly, the NPS declines to outline a dispute resolution process specifically for tribes because such a process would be duplicative of the appeal process in section 79.16. In addition, the NPS notes that the dispute resolution process in NAGPRA is specifically authorized in 25 U.S.C. 3006(c); no such authorization exists in ARPA or the other applicable authorities for this rule.

Rulemaking Process

27. Comment: Several commenters stated that the rulemaking process was inadequate because of insufficient opportunities for public comment. One commenter asked for an extension of the public comment period.

NPS Response: The NPS consulted widely with Tribes and interest groups before publishing the proposed rule. The proposed rule was open for public comment for 90 days, from November 18, 2014, through February 17, 2015. This is 30 days longer that the standard comment period of 60 days that is identified in Department of the Interior Policy (318 Departmental Manual, section 5.3). The NPS received a substantial number of comments and has worked to address or respond to all issues raised by those comments in this final rule.

Impacts to Federal Collections

28. Comment: Two commenters stated that many collections were made with the understanding that they would be held in perpetuity by the government for future study, and that perpetual curation might be required by agreements entered into for purposes of complying with section 106 of the NHPA.

NPS Response: Legal instruments for the curation of materials, including those created under the section 106 consultation process, such as memoranda of agreement or programmatic agreements, may contain provisions requiring curation of materials beyond what otherwise would be required by this rule. When considering the potential disposal of materials covered by any such agreement, the FAO must review the terms of the agreement to determine whether the agreement and section 79.12 can be reconciled to allow disposal. Legally binding requirements for the perpetual curation of materials that appear in an agreement or other written instrument will not be affected by the disposition process established in this rule.

29. Comment: One commenter argued that deaccessioning would greatly reduce the volume of material remains available for study, which would lead to increased excavation.

NPS Response: The disposition process established in this rule applies narrowly to material remains of insufficient archeological interest. The rule does not compel the wholesale divestment by the government of its collections, but instead allows for small reductions in the size of some collections under specific circumstances. Samples of material remains to be deaccessioned under this rule must be retained when those materials are deemed overly redundant and not useful for research. The cautious approach to disposition required by this rule makes it unlikely that the rule will result in a steep reduction in the amount of materials available for study in Federal collections, and a consequential need for additional excavations.

NAGPRA Consultation

30. Comment: Two commenters sought stronger requirements to consult with Tribes regarding the determination that material remains are not subject to NAGPRA. One commenter asked the NPS to clarify the FAO's responsibilities to consider NAGPRA compliance.

NPS Response: Federal agencies have separate procedural requirements under NAGPRA to ensure that NAGPRA cultural items in their collections are included in inventories and summaries. Extensive consultation is required during the inventory and summary process under 43 CFR 10.8 and 10.9. In general, Federal agencies were required to complete their NAGPRA summaries by November 16, 1993, and their NAGPRA inventories by November 16, 1995, so, in most cases, Federal agencies will have already determined which items in their collections are NAGPRA cultural items. Section 79.12 provides an additional measure to ensure NAGPRA cultural items are handled pursuant to NAGPRA and not subject to disposition under this rule. Prior to making a final determination of disposition, the FAO must determine that the material remains are not NAGPRA cultural items. The rule further states that, when Native American material remains are proposed for disposition, the collections advisory committee must include one or more elected officers (or their designees) of federally recognized Indian Tribes that are regularly consulted by the Federal agency. The rule also contains robust notification requirements that will help ensure that interested Tribes are aware of proposed dispositions. Further, any Tribe may object to determinations of disposition if it believes the materials are NAGPRA cultural items. The NPS believes that these requirements are sufficient to ensure that Native American cultural items subject to NAGPRA will not be disposed of under this rule.

Use of Deaccessioned Material Remains

31. Comment: One commenter argued that enforcing the restrictions on disposition of material remains in the proposed rule would constitute a taking of property under the Fifth Amendment of the Constitution, specifically for material remains excavated and removed from Indian lands and returned to the Indian individual or Indian tribe having rights of ownership over the resources. Commenters sought to ensure that deaccessioned material remains may not be sold in the future. Another commenter questioned the ability of the FAO to enforce prohibitions on government employees receiving deaccessioned material remains.

NPS Response: The NPS has clarified in paragraph 79.13(b) that, as a condition of disposal, the FAO will reasonably ensure that material remains from public lands that are not Indian lands may not be traded, sold, bought, or bartered after disposal is completed. This condition will not apply to material remains from Indian lands. The NPS has removed the prohibition on government employees receiving deaccessioned material remains because it is redundant with government-wide ethics requirements that address the concerns originally underlying this proposed restriction. Indian individuals who are also Federal employees must work with their agency's ethics officials to determine a course of action in the event that they wish to receive deaccessioned material remains.

General Support and Opposition

32. Comment: Some commenters expressed general support for the rule, praising its clear language and stringent and rigorous disposition process. Commenters recognized the need for the rule and its potential to improve the value of collections and reduce careless accession of material remains. Other commenters expressed general opposition to the rule, citing their belief that material remains should not be deaccessioned and that the rule will not provide a complete solution to the curation crisis.

NPS Response: Responsible deaccessioning is a necessary tool for maintaining the scientific value of collections. Several Federal agencies requested this rule, which supports the proper curation of Federal collections. This rule establishes a rigorous and deliberative disposition process that, when properly implemented, will prevent the careless deaccessioning of material remains. Supporting agency stewardship of archeological collections is the foundational goal of 36 CFR 79.

Changes in the Final Rule

After considering the public comments and after additional review, the NPS made the following substantive changes in the final rule. The NPS made other non-substantive, editorial changes for clarity and ease of reading. In many places, the NPS replaced outdated citations to Title 16 of the U.S. Code with correct citations to Title 54. The NPS also removed the paragraph designations in section 79.4 and organized the defined terms alphabetically, as recommended in the Office of the Federal Register's Document Drafting Handbook. In order to make these changes, the entire section 79.4 appears below in the regulatory text even though the only changes to that section are to add definitions of ''Departmental Consulting Archeologist'' and ''provenience information.''

Final rule section or paragraph	Change	Reason for change
79.4	Added definitions of the terms ''Departmental Consulting Archeologist'' and ''provenience information''.	Clarifies the meaning of these terms for non-specialists.
79.12(b)(2)	Specified that the term ''human remains'' refers to human remains that are not ''cultural items'' under NAGPRA.	Clarifies that no human remains may be disposed of under this rule, whether or not they are subject to NAGPRA.
79.12(c)	Clarified that only persons who meet the applicable Professional Qualification Standards set by the Secretary may propose the disposal of material remains.	Helps ensure that only qualified experts may initiate the disposition process. Ensures that disposition is not undertaken casually or as a matter of convenience. The professional standards are available here: *https://www.nps.gov/articles/sec-standards-prof-quals.htm.*
79.12(c)(1)	Added a requirement that Federal agency staff members must have verifiable knowledge of the particular material remains that are proposed for disposal.	Helps ensure that disposition is not undertaken improperly because qualified experts were not involved.
79.12(e)	Added a requirement that archeological or museum professionals must have verifiable knowledge of the particular material remains in order to determine whether those material remains have insufficient archeological interest.	Helps ensure that disposition is not undertaken improperly because qualified experts were not involved.
79.12(e)(2)(i)(C)	Clarified that a lack of provenience information may be established if associated records never existed, have been lost, or have been destroyed.	Addresses a legitimate circumstance where there is no existing provenience information.
79.12(e)(2)(iii)	Clarified that representative samples of material remains that are overly redundant and not useful for research must be representative of the population as a whole from which the sample was taken.	Helps ensure that a statistically valid sample is retained in the event that new analytical techniques are developed that allow the sample to generate useful information about the past.
79.13(a)(2)	Clarified that the FAO must receive written consent and relinquishment of ownership from the Indian individual or tribe having rights of ownership before otherwise disposing of material remains excavated from Indian lands.	Helps ensure that the FAO will not dispose of material remains owned by Indian individuals or tribes without their consent.
79.13(b)(5)	Added the following method of disposal for material remains excavated or removed from public lands: Convey to a federally recognized Indian tribe for the purpose of traditional cultural, educational, or religious practices.	Responds to public comment and improves consistency between the acceptable methods of disposition for materials removed from Indian and public lands.

Final rule section or paragraph	Change	Reason for change
79.15(d)	Added a requirement that the FAO consult with qualified museum professionals located in the repository that provides curatorial services for material remains proposed for disposal when those museum professionals did not propose the disposal.	Helps ensure that appropriate experts are involved in the disposition process.
79.15(e)	Added a requirement that the collections advisory committee make consensus recommendations to the FAO about proposed dispositions.	Responds to public comment and helps ensure that disposition is not undertaken lightly or improperly.
79.15(e)(1)	Added a provision stating that the DCA may not participate on a collections advisory committee.	Helps maintain the impartiality of the DCA, who serves as the arbiter of disputes about proposed dispositions.
79.15(e)(3)	Clarified that the requirement that collections advisory committees include at least one representative of an Indian tribe only applies if there are Native American material remains proposed for disposal.	Ensures the appropriate inclusion of tribal viewpoints in considering a disposition of Native American material remains.
79.15(e)(5)	Added a requirement that the collections advisory committee submit a written report to the FAO about any proposed disposition.	Responds to public comments and improves the administrative record of a disposition.
79.15(g)	Added a requirement that, for material remains excavated from Indian land, the FAO provide a copy of the associated records to the appropriate Tribal Historic Preservation Officer or tribal official.	Responds to public comments and improves accountability to tribal governments.
79.15(h)	Added a minimum duration of 60 days for the public comment period for a proposed disposition. Made the FAO responsible for responding only to relevant, substantive comments.	Responds to public comments to improve timeliness and public accountability. Reduces the administrative burden on the FAO during the comment review period.
79.15(h)(1)	Added a requirement that the FAO must give notice of proposed dispositions to the State Archeologist if there is one.	Improves coordination with state officials and improves the administrative record.
79.15(h)(3)	Added a requirement that the FAO must give notice of proposed dispositions to private landowners from whose lands the objects to be disposed were removed.	Responds to public comments to provide additional information to landowners.
79.15(h)(5)	Removed the requirement that the FAO must give notice to organizations and institutions with an active department of or program in archeology or anthropology pertaining to the archeology of the state or region from which the material remains to be disposed of were recovered. Clarified that the FAO must give notice of proposed dispositions to organizations and institutions for which the agency has an existing relationship pursuant to a written instrument (*e.g.,* permit, agreement) for research, excavation, curation, education, or other partnership in the state and region from which the objects to be disposed were recovered.	Removes ambiguity about which institutions and organizations must receive notice of proposed dispositions. Reduces the burden of compliance for the FAO by requiring only notification of those entities that have a formal relationship. Improves communication about proposed disposition actions with interested researchers.
79.16	Lengthened the timeframe to object to a determination of disposition from 30 to 60 days after publication of the notice of determination of disposition in the **Federal Register**.	Responds to public comments and provides more opportunity for the public to object to a proposed disposition.
79.16(a)	Added a requirement that the DCA forward a copy of objections to the FAO within 5 days of receipt.	Improves accountability from the DCA to the FAO and streamlines the objection process.
79.16(c)	Added a requirement that the DCA consult with the objecting party and the FAO with the aim of resolving the objection.	Responds to public comments to improve the fairness of the objection process by providing another opportunity for discussion between the objecting party and the FAO.
79.16(d)	Added a requirement that the DCA must thoroughly explain their non- binding recommendation to the FAO.	Responds to public comment to provide a more effective and inclusive disputes process.
79.16(e)	Shortened the timeframe for the FAO to respond to the DCA and the objector with a final determination from 60 to 30 days.	Streamlines the objection process and encourages timely resolution to objections.
79.16(f)	Clarified that notice of a decision on an objection is a final agency action under the Administrative Procedure Act.	Responds to public comment to make procedures clear to the public.
79.17	Added a requirement that disposition after an objection will occur no sooner than 30 days after the FAO publishes the notice of decision on the objection and any amendments in the **Federal Register**.	Responds to public comment to make procedures clear to the public.
43 CFR 3.17	Added a note that resources excavated under the Antiquities Act may be eligible for disposal under Subpart E of 36 CFR 79.	Responds to public comments questioning the applicability of the rule to material remains excavated under the Antiquities Act.

Compliance With Other Laws, Executive Orders and Department Policy. Regulatory Planning and Review (Executive Orders 12866 and 13563)

Executive Order 12866 provides that the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget will review all significant rules. OIRA has determined that this rule is not significant.

Executive Order 13563 reaffirms the principles of Executive Order 12866 while calling for improvements in the nation's regulatory system to promote predictability, to reduce uncertainty, and to use the best, most innovative, and least burdensome tools for achieving regulatory ends. Executive Order 13563 directs agencies to consider regulatory approaches that reduce burdens and maintain flexibility and freedom of choice for the public where these approaches are relevant, feasible, and consistent with regulatory objectives. Executive Order 13563 emphasizes further that regulations must be based on the best available science and that the rulemaking process must allow for public participation and an open exchange of ideas. The NPS has developed this rule in a manner consistent with these requirements.

Regulatory Flexibility Act

This rule will not have a significant economic effect on a substantial number of small entities under the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*). This certification is based on information contained in the economic analyses found in the report entitled ''Cost-Benefit and Regulatory Flexibility Analyses: Proposed Regulations on the Curation of Federally-Owned or Administered Archeological Collections'' that is available online at the following URL: *https://www.nps.gov/orgs/1187/upload/Regulatory_Analyses_36_CFR_Part_79_12.pdf.*

Congressional Review Act (CRA)

This rule is not a major rule under 5 U.S.C. 804(2), the CRA. This rule:

(a) Does not have an annual effect on the economy of $100 million or more.

(b) Will not cause a major increase in costs or prices for consumers, individual industries, Federal, state, or local government agencies, or geographic regions.

(c) Does not have significant adverse effects on competition, employment, investment, productivity, innovation, or the ability of U.S.-based enterprises to compete with foreign-based enterprises.

The rule relates to internal administrative procedures and management of government function. It does not regulate external entities, impose any costs on them, or eliminate any procedures or functions that would result in a loss of employment or income on the part of the private sector.

Unfunded Mandates Reform Act

This rule does not impose an unfunded mandate on state, local, or tribal governments or the private sector of more than $100 million per year. This rule does not have a significant or unique effect on state, local or tribal governments, or the private sector. A statement containing the information required by the Unfunded Mandates Reform Act (2 U.S.C. 1531 *et seq.*) is not required.

Takings (Executive Order 12630)

This rule does not affect a taking of private property or otherwise have taking implications under Executive Order 12630. A takings implication assessment is not required.

Federalism (Executive Order 13132)

Under the criteria in section 1 of Executive Order 13132, this rule does not have sufficient federalism implications to warrant the preparation of a federalism summary impact statement. This rule does not regulate, change, or otherwise affect the relationship between Federal and state governments. A federalism summary impact statement is not required.

Civil Justice Reform (Executive Order 12988)

This rule complies with the requirements of Executive Order 12988. Specifically, this rule:

(a) Meets the criteria of section 3(a) requiring that all regulations be reviewed to eliminate errors and ambiguity and be written to minimize litigation; and

(b) Meets the criteria of section 3(b)(2) requiring that all regulations be written in clear language and contain clear legal standards.

Paperwork Reduction Act (44 U.S.C. 3501 *et seq.*)

This rule does not contain information collection requirements, and a submission to the Office of Management and Budget under the Paperwork Reduction Act is not required. The NPS may not conduct or sponsor and you are not required to respond to a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act

This rule does not constitute a major Federal action significantly affecting the quality of the human environment. A detailed statement under the NEPA is not required because this rule is covered by a categorical exclusion. This rule is excluded from the requirement to prepare a detailed statement because it qualifies as a regulation of an administrative and procedural nature. (For further information see 43 CFR 46.210(i)). This rule does not involve any of the extraordinary circumstances listed in 43 CFR 46.215 that would require further analysis under NEPA.

Federal Advisory Committee Act

Intergovernmental consultation recommended under this rule is exempt from the Federal Advisory Committee Act (FACA). This rule requires that consultation with Indian tribes be conducted between Federal officials and elected tribal officers or their designated employees acting in their official capacities, who meet solely for the purpose of exchanging views, information, or advice related to the management or implementation of this rule. Consultation with Tribes under this rule thus meets the two-part test for an exemption from the FACA set out in the Unfunded Mandates Reform Act of 1995, Public Law 104–4.

Consultation With Indian Tribes (E.O. 13175 and Departmental Policy)

The Department of the Interior strives to strengthen its government-to-government relationship with Indian Tribes through a commitment to consult with Indian Tribes and recognition of their right to self-governance and tribal sovereignty. The NPS has evaluated this rule under the criteria in Executive Order 13175 and under the Department's tribal consultation policy and has determined that tribal consultation is not required because the rule will have no substantial direct effect on federally recognized Indian tribes. Nevertheless, the NPS conducted outreach to tribes and Native Hawaiian Organizations, initiated consultation through two letters to tribal leaders, and conducted face-to-face consultation on this rule upon request. Additional information regarding the identified effects on Indian Tribes and these outreach and consultation efforts is contained in a document entitled ''Consultation with Indian Tribes (E.O. 13175) regarding the proposed 36 CFR 79.12,'' which is available at the following URL: *https://www.nps.gov/orgs/1187/upload/Tribal_Consultation_36_CFR_Part_79_12.pdf.*

Effects on the Energy Supply (E.O. 13211)

This rulemaking is not a significant energy action under the definition in Executive Order 13211; the rule is not likely to have a significant adverse effect on the supply, distribution, or use of energy, and the rule has not otherwise been designated by the Administrator of OIRA as a significant energy action. A Statement of Energy Effects is not required.

Drafting Information

This rule was written with the cooperation and consultation of the following Federal agencies and bureaus: U.S. Bureau of Indian Affairs, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Air Force, U.S. Army Corps of Engineers, U.S. Navy, and U.S. Forest Service. Each agency and bureau provided a specialist in the curation of archeological collections to participate in an informal interagency working group to provide expert advice during the drafting of this rule.

List of Subjects

36 CFR Part 79

Archives and records, Historic preservation, Indians—lands, Museums, Public lands.

43 CFR Part 3

Agriculture Department, Army Department, Historic preservation, Smithsonian Institution.

In consideration of the foregoing, the National Park Service and Department of the Interior amend 36 CFR part 79, and 43 CFR part 2, as set forth below:

PART 79—CURATION OF FEDERALLY OWNED OR ADMINISTERED ARCHEOLOGICAL COLLECTIONS

■ 1. The authority citation for part 79 is revised to read as follows:

Authority: 16 U.S.C. 470aa–mm, 54 U.S.C. 300101 *et seq.*

■ 2. Revise the part heading to read as shown above.

§§ 79.1 through 79.4 [Designated as Subpart A]

■ 3. Designate §§ 79.1 through 79.4 as subpart A and add a heading for subpart A to read as follows:

Subpart A—Administrative Provisions

§ 79.1 [Amended]

■ 4. In § 79.1 amend paragraph (a) by:
■ a. Removing ''(16 U.S.C. 431–433)'' and adding, in its place, ''(54 U.S.C. 320301–320303)'';
■ b. Removing ''(16 U.S.C. 469–469c)'' and adding, in its place, ''(54 U.S.C. 312501–312508)''; and
■ c. Removing ''(16 U.S.C. 470h-2)'' and adding, in its place, ''(54 U.S.C. 306101–306114)''.

■ 5. In § 79.2:
■ a. Revise paragraph (a).
■ b. In paragraph (b)(2), remove ''(16 U.S.C. 431–433)'' and add, in its place, ''(54 U.S.C. 320301–320303)'' and remove ''(16 U.S.C. 469–469c)'' and add, its place, ''(54 U.S.C. 312501–312508)''.

The revision reads as follows:

§ 79.2 Authority

(a) The regulations in this part are promulgated under 54 U.S.C. 302107 which requires that the Secretary of the Interior issue regulations ensuring that significant prehistoric and historic artifacts and associated records are deposited in an institution with adequate long-term curatorial capabilities. This requirement applies to artifacts and associated records subject to the National Historic Preservation Act (54 U.S.C. 300101 *et seq.*), the Reservoir Salvage Act (54 U.S.C. 312501–312508), and the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm).

* * * * *

■ 6. In § 79.3, revise paragraph (a) to read as follows:

§ 79.3 Applicability.

(a) Except as otherwise stated in this section, the regulations in this part apply to collections, as defined in § 79.4 of this part, that are excavated or removed under the authority of the Antiquities Act (54 U.S.C. 320301–320303), the Reservoir Salvage Act (54 U.S.C. 312501–312508), section 110 of the National Historic Preservation Act (54 U.S.C. 306101–306114) or the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm). Such collections generally include those that are the result of a prehistoric or historic resource survey, excavation or other study conducted in connection with a Federal action, assistance, license, or permit. Such collections include those that are owned by the United States and for which a Federal agency has practical management authority, either directly or indirectly, as a result of that ownership; and those collections that are not owned by the United States but that are managed or controlled by a Federal agency pursuant to the laws cited in this paragraph (a).

* * * * *

■ 7. Revise § 79.4 to read as follows:

§ 79.4 Definitions.

As used for purposes of this part:

Associated records means original records (or copies thereof) that are prepared, assembled and document efforts to locate, evaluate, record, study, preserve or recover a prehistoric or historic resource. Some records such as field notes, artifact inventories and oral histories may be originals that are prepared as a result of the field work, analysis, and report preparation. Other records such as deeds, survey plats, historical maps and diaries may be copies of original public or archival documents that are assembled and studied as a result of historical research. Classes of associated records (and illustrative examples) that may be in a collection include, but are not limited to:

(1) Records relating to the identification, evaluation, documentation, study, preservation, or recovery of a resource (such as site forms, field notes, drawings, maps, photographs, slides, negatives, films, video and audio cassette tapes, oral histories, artifact inventories, laboratory reports, computer cards and tapes, computer disks and diskettes, printouts of computerized data, manuscripts, reports, and accession, catalog, and inventory records);

(2) Records relating to the identification of a resource using remote sensing methods and equipment (such as satellite and aerial photography and imagery, side scan sonar, magnetometers, subbottom profilers, radar, and fathometers);

(3) Public records essential to understanding the resource (such as deeds, survey plats, military and census records, birth, marriage and death certificates, immigration and naturalization papers, tax forms and reports);

(4) Archival records essential to understanding the resource (such as historical maps, drawings and photographs, manuscripts, architectural and landscape plans, correspondence, diaries, ledgers, catalogs, and receipts); and

(5) Administrative records relating to the survey, excavation, or other study of the resource (such as scopes of work, requests for proposals, research proposals, contracts, antiquities permits, reports, documents relating to compliance with section 106 of the National Historic Preservation Act (16 U.S.C. 470f), and National Register of Historic Places nomination and determination of eligibility forms).

Collection means material remains that are excavated or removed during a survey, excavation, or other study of a prehistoric or historic resource, and associated records that are prepared or

assembled in connection with the survey, excavation, or other study.

Curatorial services means managing and preserving a collection according to professional museum and archival practices, including, but not limited to:

(1) Inventorying, accessioning, labeling, and cataloging a collection;

(2) Identifying, evaluating, and documenting a collection;

(3) Storing and maintaining a collection using appropriate methods and containers, and under appropriate environmental conditions and physically secure controls;

(4) Periodically inspecting a collection and taking such actions as may be necessary to preserve it;

(5) Providing access and facilities to study a collection; and

(6) Handling, cleaning, stabilizing, and conserving a collection in such a manner to preserve it.

Departmental Consulting Archeologist means the individual serving as the agent of the Secretary of the Interior in overseeing and coordinating the Department's archeological activities.

Federal Agency Official means any officer, employee or agent officially representing the secretary of the department or the head of any other agency or instrumentality of the United States having primary management authority over a collection that is subject to this part.

Indian lands has the same meaning as in § -.3(e) of uniform regulations 43 CFR part 7, 36 CFR part 296, 18 CFR part 1312, and 32 CFR part 229.

Indian tribe has the same meaning as in § -.3(f) of uniform regulations 43 CFR part 7, 36 CFR part 296, 18 CFR part 1312, and 32 CFR part 229.

Material remains means artifacts, objects, specimens, and other physical evidence that are excavated or removed in connection with efforts to locate, evaluate, document, study, preserve or recover a prehistoric or historic resource. Classes of material remains (and illustrative examples) that may be in a collection include, but are not limited to:

(1) Components of structures and features (such as houses, mills, piers, fortifications, raceways, earthworks, and mounds);

(2) Intact or fragmentary artifacts of human manufacture (such as tools, weapons, pottery, basketry, and textiles);

(3) Intact or fragmentary natural objects used by humans (such as rock crystals, feathers, and pigments);

(4) By-products, waste products or debris resulting from the manufacture or use of man-made or natural materials (such as slag, dumps, cores and debitage);

(5) Organic material (such as vegetable and animal remains, and coprolites);

(6) Human remains (such as bone, teeth, mummified flesh, burials, and cremations);

(7) Components of petroglyphs, pictographs, intaglios, or other works of artistic or symbolic representation;

(8) Components of shipwrecks (such as pieces of the ship's hull, rigging, armaments, apparel, tackle, contents, and cargo);

(9) Environmental and chronometric specimens (such as pollen, seeds, wood, shell, bone, charcoal, tree core samples, soil, sediment cores, obsidian, volcanic ash, and baked clay); and

(10) Paleontological specimens that are found in direct physical relationship with a prehistoric or historic resource.

Personal property has the same meaning as in 41 CFR 100–43.001–14. Collections, equipment (*e.g.,* a specimen cabinet or exhibit case), materials and supplies are classes of personal property.

Provenience information means recorded data about the physical location of an object as it was found during a survey, excavation, or other study of a prehistoric or historic resource.

Public lands has the same meaning as in § -.3(d) of uniform regulations 43 CFR part 7, 36 CFR part 296, 18 CFR part 1312, and 32 CFR part 229.

Qualified museum professional means a person who possesses knowledge, experience and demonstrable competence in museum methods and techniques appropriate to the nature and content of the collection under the person's management and care, and commensurate with the person's duties and responsibilities. Standards that may be used, as appropriate, for classifying positions and for evaluating a person's qualifications include, but are not limited to, the following:

(1) The Office of Personnel Management's ''Position Classification Standards for Positions under the General Schedule Classification System'' (U.S. Government Printing Office, stock No. 906—028–00000–0 (1981)) are used by Federal agencies to determine appropriate occupational series and grade levels for positions in the Federal service. Occupational series most commonly associated with museum work are the museum curator series (GS/GM–1015) and the museum technician and specialist series (GS/GM–1016). Other scientific and professional series that may have collateral museum duties include, but are not limited to, the archivist series (GS/GM–1420), the archeologist series (GS/GM–193), the anthropologist series (GS/GM–190), and the historian series (GS/GM–170). In general, grades GS–9 and below are assistants and trainees while grades GS–11 and above are professionals at the full performance level. Grades GS–11 and above are determined according to the level of independent professional responsibility, degree of specialization and scholarship, and the nature, variety, complexity, type, and scope of the work.

(2) The Office of Personnel Management's ''Qualification Standards for Positions under the General Schedule (Handbook X–118)'' (U.S. Government Printing Office, stock No. 906–030–00000–4 (1986)) establish educational, experience and training requirements for employment with the Federal Government under the various occupational series. A graduate degree in museum science or applicable subject matter, or equivalent training and experience, and three years of professional experience are required for museum positions at grades GS–11 and above.

(3) The ''Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation'' (48 FR 44716, Sept. 29, 1983) provide technical advice about archeological and historic preservation activities and methods for use by Federal, State, and local Governments and others. One section presents qualification standards for a number of historic preservation professions. While no standards are presented for collections managers, museum curators or technicians, standards are presented for other professions (*i.e.,* historians, archeologists, architectural historians, architects, and historic architects) that may have collateral museum duties.

(4) Copies of the Office of Personnel Management's standards, including subscriptions for subsequent updates, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Copies may be inspected at the Office of Personnel Management's Library, 1900 E Street NW, Washington, DC, at any regional or area office of the Office of Personnel Management, at any Federal Job Information Center, and at any personnel office of any Federal agency. Copies of the ''Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation'' are available at no charge from the Interagency Resources Division, National Park Service, P.O. Box 37127, Washington, DC 20013–7127.

Religious remains means material remains that the Federal Agency Official

has determined are of traditional religious or sacred importance to an Indian tribe or other group because of customary use in religious rituals or spiritual activities. The Federal Agency Official makes this determination in consultation with appropriate Indian tribes or other groups.

Repository means a facility such as a museum, archeological center, laboratory, or storage facility managed by a university, college, museum, other educational or scientific institution, a Federal, State, or local Government agency or Indian tribe that can provide professional, systematic, and accountable curatorial services on a long-term basis.

Repository Official means any officer, employee or agent officially representing the repository that is providing curatorial services for a collection that is subject to this part.

Tribal Official means the chief executive officer or any officer, employee or agent officially representing the Indian tribe.

§§ 79.5 through 79.9 [Designated as Subpart B]

■ 8. Designate §§ 79.5 through 79.9 as subpart B and add a heading for subpart B to read as follows:

Subpart B—Archeological Collections Management

§ 79.10 [Designated as Subpart C]

■ 9. Designate § 79.10 as subpart C and add a heading for subpart C to read as follows:

Subpart C—Public Access to and Use of Collections

§ 79.11 [Designated as Subpart D]

■ 10. Designate § 79.11 as subpart D and add a heading for subpart D to read as follows:

Subpart D—Inspections and Inventories of Collections

■ 11. Add subpart E to read as follows:

Subpart E—Disposition of Particular Material Remains

Sec.

79.12 Determining which particular material remains are eligible for disposal.
79.13 Acceptable methods for disposition of particular material remains.
79.14 [Reserved].
79.15 Final determination of disposition of particular material remains.
79.16 Objecting to a determination of disposition of particular material remains.
79.17 Timing of disposition.
79.18 Administrative record of disposition.

§ 79.12 Determining which particular material remains are eligible for disposal.

(a) *Which material remains are eligible for disposal under this subpart?* In order to be eligible for disposal under this subpart, material remains from collections must be:

(1) Archaeological resources, as defined in the Archaeological Resources Protection Act (16 U.S.C. 470bb(1)), or other resources excavated and removed under the Reservoir Salvage Act (54 U.S.C. 312501–312508) or the Antiquities Act (54 U.S.C. 320301–320303); and

(2) Considered to be of insufficient archeological interest under the criteria in paragraph (e) of this section, based on the definition of ''of archaeological interest'' in 43 CFR 7.3(a)(1).

(b) *Which material remains are not eligible for disposal under this subpart?* The following material remains from collections are not eligible for disposal under this subpart:

(1) Native American ''cultural items'' as defined in the Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001(3)), because disposition is governed by that Act and its implementing regulations (43 CFR part 10);

(2) Other human remains not subject to the Native American Graves Protection and Repatriation Act of 1990;

(3) Material remains excavated and removed from Indian lands on or before the enactment of the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm) on October 31, 1979; and

(4) Material remains excavated and removed from Indian lands under the Antiquities Act (54 U.S.C. 320301–320303).

(c) *Who may propose the disposal of particular material remains?* The following individuals who meet the applicable Professional Qualification Standards set by the Secretary of the Interior may propose the disposal of particular material remains from a collection:

(1) Federal agency staff members with verifiable knowledge of the particular material remains, including archeologists, curators, and conservators; and

(2) Qualified museum professionals located in a repository that provides curatorial services for a collection held in that repository.

(d) *Who is responsible for the disposal of particular material remains?* The Federal Agency Official is responsible for ensuring that particular material remains are disposed of according to the requirements of this subpart.

(e) *When are particular material remains considered to be of insufficient archeological interest?* Particular material remains are considered to be of insufficient archeological interest when, on a case-by-case basis, at least one qualified archeological or museum professional who meets the Professional Qualification Standards set by the Secretary of the Interior and possesses verifiable knowledge of and experience in the type of material remains being evaluated makes a determination. The determination must follow the process established in § 79.15 and document that:

(1) Disposition of the material remains will not negatively impact the overall integrity of the original collection recovered during the survey, excavation, or other study of a prehistoric or historic resource; and

(2) At least one of the following three requirements—lack of provenience information; lack of physical integrity; or overly redundant and not useful for research—are met:

(i) *Lack of provenience information.* Lack of provenience information may be established after a concerted effort to recover the information in the related associated records is performed and documented and by one or more of the following circumstances:

(A) The labels on the material remains or the labels on the containers that hold the material remains do not provide adequate information to reliably establish meaningful archeological context for the material remains;

(B) The labels on the material remains or the labels on the containers that hold the material remains have been lost or destroyed over time and cannot be reconstructed through the associated records; or

(C) The associated records of the material remains never existed, have been lost, or have been destroyed.

(ii) *Lack of physical integrity.* Material remains lack physical integrity when, subsequent to recovery during the survey, excavation, or other study of a prehistoric or historic resource, the material remains were irreparably damaged through decay, decomposition, or inadvertent loss. Examples may include human-caused incidents, exposure to elements, or natural disaster.

(iii) *Overly redundant and not useful for research.* Material remains are overly redundant and not useful for research in light of the collection's archeological context, research questions, and research potential. These considerations may vary based on geography, time and culture period, scientific or cultural significance, prior analysis, and other factors. Because it is difficult to predict if future analytical methods will yield

useful information about the material remains proposed for disposal, a sample of the material remains deemed to be overly redundant and not useful for research must be retained for curation, as required by § 79.15(f).

§ 79.13 Acceptable methods for disposition of particular material remains.

(a) *Indian lands.* This paragraph applies to material remains that are determined to be of insufficient archeological interest under § 79.12(e) and that were excavated or removed from Indian lands after October 31, 1979. Under the Archaeological Resources Protection Act (16 U.S.C. 470aa–mm), these material remains are the property of the Indian individual or Indian tribe having rights of ownership over the resources. Under the authority of 16 U.S.C. 470dd, disposition of these material remains is subject to the consent of the Indian individual or Indian tribe. The Federal Agency Official must use the following methods of disposal for these material remains in the following order:

(1) Return them to the Indian individual or Indian tribe having rights of ownership under the Archaeological Resources Protection Act's custody regulations, 43 CFR 7.13(b), 36 CFR 296.13(b), 32 CFR 229.13(b), and 18 CFR 1312.13(b).

(2) If the Indian individual or Indian tribe having rights of ownership does not wish to accept and take physical custody of the material remains, the Federal Agency Official may otherwise dispose of the material remains using the disposition methods in paragraph (b) of this section after receiving written consent and relinquishment of ownership from the Indian individual or Indian tribe having rights of ownership.

(b) *Public lands.* This paragraph applies to material remains that are determined to be of insufficient archeological interest under § 79.12(e) and that were excavated or removed from public lands that are not Indian lands. As a condition of disposal, the Federal Agency Official will reasonably ensure that material remains from such lands may not be traded, sold, bought, or bartered after disposal. The Federal Agency Official must consider the following methods for disposal of the material remains:

(1) Transfer to another Federal agency.

(2) Convey to a suitable public or tribal scientific or professional repository as defined in § 79.4(k) of this part.

(3) Convey to a federally recognized Indian tribe if the material remains were excavated or removed from lands of religious or cultural importance to that tribe and were identified and documented by a Federal land manager under 43 CFR 7.7(b)(1), 36 CFR 296.7(b)(1), 32 CFR 229.7(b)(1), or 18 CFR 1312.7(b)(1).

(4) Convey to a federally recognized Indian tribe from whose aboriginal lands the material remains were removed. Aboriginal occupation may be documented by evidence including, but not limited to, a final judgment of the Indian Claims Commission or the United States Court of Claims, or a treaty, Act of Congress, or Executive Order.

(5) Convey to a federally recognized Indian tribe for the purpose of traditional cultural, educational, or religious practices.

(6) Transfer within the Federal agency for the purpose of education or interpretation, or convey to a suitable institution to be used for public benefit and education including, but not limited to, local historical societies, museums, university or college departments, and schools.

(7) If the Federal Agency Official considers each of these prior methods carefully and is still unable to find an acceptable method of disposition, then the material remains may be destroyed. The Federal Agency Official or their designee must witness and document the destruction, including through photography or video as practicable.

§ 79.14 [Reserved]

§ 79.15 Final determination of disposition of particular material remains.

The Federal Agency Official is responsible for ensuring that the agency disposes of material remains according to the requirements of this subpart. A determination made under this subpart in no way affects a Federal land manager's obligations under other applicable laws or regulations. The Federal Agency Official must take all the following actions before making a final determination that it is appropriate to dispose of material remains.

(a) The Federal Agency Official must determine that the material remains are eligible for disposal under the criteria in § 79.12(a).

(b) The Federal Agency Official must verify in writing that none of the material remains proposed for disposal meet the criteria in § 79.12(b).

(c) The Federal Agency Official must verify that the material remains proposed for disposal are appropriately documented through a professional procedure approved by the Federal agency that is consistent with curatorial services, including accessioning and cataloging, as defined in § 79.4(b).

(d) The Federal Agency Official must consult with qualified museum professionals located in the repository that provides curatorial services for the material remains proposed for disposal if those museum professionals did not propose the disposal under § 79.12(c)(2). This consultation with the qualified museum professionals must address the appropriateness of the proposed disposal.

(e) The Federal Agency Official must establish a collections advisory committee of at least five members to review proposed dispositions of material remains. The committee must make a consensus recommendation to the Federal Agency Official about each proposed disposition based on the adequacy of the documentation addressing the requirements in paragraphs (a) and (b) of this section and the appropriateness of the proposed disposition based on the criteria in § 79.12(e).

(1) The collections advisory committee must consist of qualified employees from Federal agencies who meet appropriate Professional Qualification Standards set by the Secretary of the Interior, and must include the curator and the principal archeologist of the Federal agency that owns or administers the material remains if either or both of these two positions exist. The Departmental Consulting Archeologist may not participate on the collections advisory committee. If the Departmental Consulting Archeologist is the principal archeologist, then the Federal Agency Official must designate another qualified archeologist at the agency instead.

(2) Collections advisory committee members must include Federal employees with subject matter or technical expertise in the object types, cultural period, and culture area of the proposed disposition. These employees may include archeologists, anthropologists, curators, and conservators with expertise in historic, prehistoric, or underwater material remains.

(3) If the material remains being proposed for disposal are Native American, then collections advisory committee members must also include at least one or more individuals who are Tribal Officials acting in their official capacities representing their respective federally recognized Indian tribes that are regularly consulted by the Federal agency regarding the collection containing the material remains being proposed for disposal.

(4) The collections advisory committee must have written

procedures and governing rules, including terms of member appointments and the duration of the committee, approved by the Federal Agency Official, to ensure all recommendations about the appropriateness of disposal are fair, open, timely, and in the best interests of the public.

(5) The collections advisory committee must submit a written report to the Federal Agency Official for each proposed disposition that, at a minimum, documents the information required for the **Federal Register** notice identified in paragraphs (i)(1)(i) through (iii) of this section; membership of the committee and each member's role and expertise pertinent to the proposed disposition; a summary of any comments received on the proposed disposition under paragraph (h) of this section; the recommendations for disposition, including any conditions of transfer or conveyance; and the reasons why other methods of disposal would be of lesser public benefit.

(6) Federal employees or qualified members of federally recognized Indian tribes may be temporarily added to the committee if its existing members determine that specific expertise, including archeological knowledge of the cultural period and cultural area, is needed on a case-by-case basis.

(7) Collections advisory committee members, whether permanent or temporary, and their family members may not benefit financially or in any other way from a disposition of material remains, except to the extent that members of a federally recognized Indian Tribe, when that Indian Tribe is being considered as a potential recipient of material remains, may participate in the collections advisory committee as described in § 79.15(e)(3).

(f) The Federal Agency Official must retain in the curated collection a sample of those material remains determined to be overly redundant and not useful for research that is representative of the population as a whole from which the sample was taken.

(1) The size of the representative sample must be large enough to permit future analysis for research purposes.

(2) The method for establishing a representative sample, including sample size and typology, must be determined by a qualified museum or archeological professional with expertise in the type of prehistoric or historic material remains being sampled.

(3) The sampling method must be documented and consistent with professional prehistoric or historic archeological practice.

(g) The Federal Agency Official must retain all associated records in the archeological collection as defined in § 79.4(a)(2). A copy of the original associated records must be given to the recipient of any transferred or conveyed items subject to the restrictions stipulated in the Archaeological Resources Protection Act (16 U.S.C. 470hh(a)). For material remains excavated and removed from Indian land, a copy of the original associated records must be given to the Tribal Historic Preservation Officer (or other designated tribal representative) from the tribal land where the material remains were recovered.

(h) The Federal Agency Official must notify the entities listed in this paragraph of the proposed disposition and solicit comments on the proposal. Notifications must be made in writing, and must include a deadline for submitting comments that is at least 60 days after notice is issued, in accordance with procedures established by the Federal agency. All written comments must be reviewed by the Federal Agency Official and the collections advisory committee. The Federal Agency Official will respond to all relevant, substantive comments received. Notice must be given to the following:

(1) The State Historic Preservation Officer and, where established, the State Archeologist, from the state(s) where the material remains to be disposed of were recovered.

(2) The Tribal Historic Preservation Officer (or other designated tribal representative) from the Indian land(s) where the material remains to be disposed of were recovered.

(3) Federal, state, tribal, or local agencies that were involved in the recovery of the material remains to be disposed of.

(4) Private landowners from whose lands the material remains to be disposed of were removed, but only in such cases where the Federal agency obtained practical management authority over the material remains as the result of activities conducted in connection with a Federal action, assistance, license, or permit, on those private lands.

(5) Universities, museums, scientific institutions, and educational institutions with which the agency has an existing relationship pursuant to a written instrument (*e.g.,* permit, agreement) for research, excavation, curation, education, or other partnership in the state and region from which the material remains to be disposed of were recovered.

(6) Indian tribes that consider the land to have religious or cultural importance, if the material remains are from a site on public lands that has religious or cultural importance to Indian tribes under 43 CFR 7.7(b)(1).

(7) Indian tribes from whose aboriginal lands the material remains were removed, if aboriginal occupation has been documented by a final judgment of the Indian Claims Commission or the United States Court of Claims, treaty, Act of Congress, or Executive Order.

(i) The Federal Agency Official must, after the comment period described in paragraph (h) of this section has expired and the Federal Agency Official has responded to all relevant, substantive comments received, publish a notice of determination of disposition in the **Federal Register**.

(1) The notice published in the **Federal Register** must include the following:

(i) A general description of the material remains to be disposed.

(ii) The criteria used to determine that the material remains are of insufficient archeological interest under § 79.12(e).

(iii) The method of disposal.

(iv) The name of the Federal Agency Official or their designee as a point of contact.

(v) An explanation of a person's right to object to the determination of disposition under § 79.16 and the name, email, and physical address of the Departmental Consulting Archeologist.

(2) The Federal Agency Official must also prepare a determination of disposition that includes the following:

(i) A detailed list of the material remains to be disposed, including a description of each object, or lot of objects if there are multiples of a particular type, and photograph(s) of the objects when appropriate.

(ii) The report of the collections advisory committee as stipulated in paragraph (e)(5) of this section.

(iii) Documentation that all of the procedures in § 79.15 have been met.

(iv) The name of the recipient entity or method of disposal, as appropriate.

(v) Justification of the method to be used to dispose of the material remains under § 79.13.

(vi) The name of the Federal Agency Official or their designee as a point of contact.

(vii) Other conditions of transfer or conveyance, as appropriate.

(viii) A statement that the determination is a final agency action under the Administrative Procedure Act (5 U.S.C. 704) unless an objection is filed in accordance with § 79.16.

§ 79.16 Objecting to a determination of disposition of particular material remains.

Anyone may object to and request in writing that the Departmental Consulting Archeologist review a Federal Agency Official's determination to dispose of material remains within 60 days of publication of the notice of determination of disposition in the **Federal Register**. The objection must document why the objector disagrees with the Federal Agency Official's decision regarding the disposal. The procedure for objecting to a determination of disposition is as follows:

(a) The objection must be sent to the Departmental Consulting Archeologist. The Departmental Consulting Archeologist must forward a copy of the objection within 5 days of receipt to the Federal Agency Official who made the determination under objection. The Federal Agency Official must halt the planned disposition until the Departmental Consulting Archeologist completes the requested review.

(b) The Departmental Consulting Archeologist must review the objection, and the Federal Agency Official's determination of disposition in § 79.15(i)(2).

(c) The Departmental Consulting Archeologist must consult with the objecting party or parties and the Federal Agency Official with the aim of resolving the objection.

(d) Within 60 days of receipt of the objection, whether or not a formal resolution has been agreed upon, the Departmental Consulting Archeologist must transmit to the Federal Agency Official a non-binding recommendation, including a thorough explanation, for further consideration.

(e) The Federal Agency Official must consider the recommendation of the Departmental Consulting Archeologist prior to making a decision on the objection. Within 30 days of receipt of the recommendation, the Federal Agency Official must respond to the Departmental Consulting Archeologist and the objector with a decision on the objection and a justification for that decision. The decision document must include any information about administrative appeal rights required by internal agency appeal procedures or a statement that the decision document is a final agency action under the Administrative Procedure Act, as appropriate.

(f) The Federal Agency Official must publish notice of the decision on the objection and any amendments made to the determination of disposition in the **Federal Register**. This may only be done after the objector exhausts any internal appeal procedures identified in the decision document sent to the objector under § 79.16(e). Publication of the notice of the decision on the objection constitutes a final agency action under the Administrative Procedure Act (5 U.S.C. 704).

§ 79.17 Timing of disposition.

Disposition will occur no sooner than 60 days after the notice of determination of disposition is published in the **Federal Register** under § 79.15(i). If the Federal agency receives an objection under § 79.16, then disposition will occur no sooner than 30 days after the notice of decision on the objection and any amendments are published in the **Federal Register** under § 79.16(f).

§ 79.18 Administrative record of disposition.

(a) After the Federal Agency Official has made a determination of disposition, he or she must document the determination and retain the administrative record as part of the associated records as defined in § 79.4(a)(2), which must include:

(1) The professional evaluation of the material remains conducted under §§ 79.12(e) and 79.15(b).

(2) The report of the collections advisory committee provided under § 79.15(e)(5).

(3) Notifications of the proposed disposition under § 79.15(h); consent of Indian individuals or tribes, if applicable, under § 79.13(a)(2); and comments received from the parties notified under § 79.15(h).

(4) Objections received by the Departmental Consulting Archeologist, the non-binding recommendation of the Departmental Consulting Archeologist, and the decision on the objection and any amendments made to the determination of disposition, if applicable, under § 79.16.

(5) The disposition action with specific information, including a description and evaluation of objects; the method of disposition and the reason for the method chosen; names and titles of persons initiating and approving the disposition; date of disposition; relevant accession and catalog numbers; evidence of the receipt for the return, transfer, or conveyance of the material remains by the recipient tribe, agency, repository, or institution, including the title to the received material remains, as appropriate; photographic documentation, as appropriate; and the name and location of the recipient institution or entity, as appropriate.

(6) A detailed inventory of the representative sample of material remains retained, when the larger proportion is disposed of because it is overly redundant and not useful for research.

(7) Other activities and decisions pertaining to the disposition of the material remains, such as conditions of use after the disposition is completed, as appropriate.

(b) The administrative record must be made available to the public upon request, unless the information or a portion of it must be withheld under the terms of the Freedom of Information Act (5 U.S.C. 552) or the Archaeological Resources Protection Act (16 U.S.C. 470hh). The latter restricts the government's ability to make sensitive information, such as archeological site location data, available to the public.

(c) After disposition, the accession and catalog records must be reviewed and amended through a procedure established by the Federal agency. The amendments must identify the material remains that were deaccessioned and disposed of, the date of disposition, and the manner in which they were disposed. The documentation prepared under § 79.15, § 79.16, and paragraph (a) of this section must be retained in accordance with Federal agency policy.

TITLE 43: PUBLIC LANDS: INTERIOR

SUBTITLE A—OFFICE OF THE SECRETARY OF THE INTERIOR

PART 3—PRESERVATION OF AMERICAN ANTIQUITIES

■ 12. The authority citation for part 3 is revised to read as follows:

Authority: 54 U.S.C. 320302–320303.

■ 13. Amend § 3.17 by adding a note at the end of the section to read as follows:

§ 3.17 Preservation of Collection

* * * * *

Note to § 3.17: Regulations concerning curation of federally owned or administered archeological collections are found in 36 CFR part 79. Objects excavated under the Antiquities Act may be eligible for disposal under subpart E of 36 CFR part 79.

Shannon A. Estenoz,

Assistant Secretary for Fish and Wildlife and Parks.

[FR Doc. 2022–07471 Filed 4–14–22; 8:45 am]

BILLING CODE 4312–52–P

INTRODUCTION

The following appendix describes the Inadvertent Discovery Plan for Cultural Resources or Human Remains for the "*Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project*." The procedure outlined below conforms to MI-NRCS general Procedure for Construction Discovery but in this instance covers only items of cultural resource not attributable to the architecture of the low-head dams. Any discovered human remains are subject to this Inadvertent Discovery Plan.

RECOGNIZING CULTURAL RESOURCES

A cultural resource discovery is an item of presumed human manufacture and likely to be greater than 50 years of age. Examples include but are not limited to:

- Stone tools or debitage (i.e., arrow head or chipped stone waste flakes),
- Clusters of tin cans, ceramics, bottles, logging implements, agricultural equipment etc., that appears older than 50 years

UPON DISCOVERING CULTURAL RESOURCES

In the event that any NRCS staff, consultant, local agency representative, contractor, landowner, etc. discover a cultural resource during removal of the low-head dams, they must immediately notify the construction manager, who will, in response: 1. cease operations in that location and 2. notify the NRCS Cultural Resources Specialist.

If the action affecting the resource is not halted, continuing to affect the resource may result in withdrawal of NRCS assistance. Pursuant to Section 110(k) of the National Historic Preservation Act and the NRCS National Cultural Resources Procedures Handbook, Subpart C, Section 601.27, the NRCS must ensure that Federal assistance is NOT used to cause or further an adverse impact to a cultural resource.

UPON DISCOVERING HUMAN REMAINS

The following steps will be implemented if human remains and/or materials subject to NAGPRA are inadvertently discovered during this Project. This largely follows the steps set forward in Michigan Attorney General Opinion No. 6585 of 1989, *Cemeteries and Dead Bodies*, those recommended by the State Historic Preservation Office, and those recommended by the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (Gun Lake Tribe) who reviewed and commented on this permit application.

If the action affecting the remains is not halted, continuing to affect the remains may result in withdrawal of NRCS assistance.

Human Remains and Associated Materials

1. Upon the discovery of human remains and any associated materials, excavation in the immediate vicinity is halted. Cover and secure the area and do not handle finds. All Project personnel shall treat any discovery as confidential.

2. The local police authority is immediately notified so that they may evaluate the site.

3. Immediately notify the NRCS, who will then notify the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians THPO, SHPO archaeologists and any additional tribes who requested consultation with NRCS.

4. If the police determine that human remains represent evidence of a crime or missing person, they will complete their investigation.

5. If the police determine that human remains do not represent evidence of a crime or missing person, the burial will be adequately documented and preserved in place or relocated as determined through appropriate consultation. It is preferred that burial sites be preserved and maintained in place. If this is not possible, the remains and any associated materials would need to be moved for their protection.

The following sequence of steps will be employed if it is not possible to preserve and maintain an inadvertently discovered burial in place:

1. Excavations shall be respectful and conducted out of public view, to the extent possible.

2. A qualified archaeologist experienced in human remains recovery shall recover the remains and any related materials that may be present. Archaeological expertise is important in documenting the discovery context and evaluating whether the remains are isolated or if additional remains may be immediately present. Archaeological recovery may be done under the auspices of law enforcement. If law enforcement chooses not to be involved, a permit for disinterment must be obtained from the local Department of Public Health, or through a court order.

3. As soon as possible, the remains shall be examined by a physical anthropologist using standard non-invasive methods and procedures to create a basic biological profile and estimate ethnicity.

4. Draft and final archaeological reports, with related physical anthropological reports and law enforcement case documentation appended, will be submitted to the NRCS, Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians THPO, and SHPO archaeologists.

Discoveries of Native American Ancestors and/or Other Materials Subject to NAGPRA

1. If it can be determined immediately that a discovery is, or has the potential to be, a Native American Ancestor and/or other materials subject to NAGPRA (i.e., associated or unassociated funerary objects, sacred objects, and objects of cultural patrimony), the Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (and any other consulting Tribes) will be notified within 72 hours of discovery and potential identification. Tribal notification and consultation will be coordinated by the NRCS and SHPO archaeologists. After notification and initial consultation, consulting Tribes may request that all federally recognized Tribes likely to be culturally affiliated with the discovery be notified in writing by mail or email and further consultation initiated regarding the cultural affiliation, care, handling, excavation (if necessary), and/or disposition per NAGPRA.

2. Known or suspected Native American Ancestors or other materials subject to NAGPRA will not be moved, touched, or further disturbed after discovery until completion of Tribal consultation or emergent circumstances arise.

3. Accommodations will be made for traditional or ceremonial practices in association with discoveries.

4. Photographs shall not be taken, except when necessary for identification and documentation. Tribes may request that any photographs of Native American Ancestors or other materials subject to NAGPRA be destroyed or repatriated at the end of the Project.

5. Pending consultations, documentation of the discovery will include a written description, mapping and sketching, and precise GPS coordinates. This documentation will be curated with other Project records and not be published or made publicly available in any way.

6. To ensure the protection, preservation, and proper respectful treatment of any discovered materials, pursuant to applicable law, the nature and location of any discovery shall remain confidential as best as reasonably possible given the circumstances and location. Only those persons and entities identified in this plan shall be notified of the discovery or given information about the discovery. The Permittee, NRCS, SHPO, and related contractors will ensure all staff and consulting personnel are appropriately trained for their respective roles in implementing this plan.

7. Consulting Tribes will be afforded opportunities to employ proper traditional cultural practices and treatments during periods of non-Tribal holding of discoveries.

8. The permanent care of Native American Ancestors and materials subject to NAGPRA will be determined by the appropriate Tribe or Tribes in consultation with the SHPO.

9. Draft and final archaeological reports, with related physical anthropological reports and law enforcement case documentation appended, will be submitted to the appropriate Tribes for review and comment.

Additional Notes
The Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (Gun Lake Tribe) has notified the NRCS and SHPO that they wish to consult if Native American Ancestors or cultural materials are found. This Tribe will be consulted in addition to those who requested consultation with the NRCS.

Contacts

Local Police
Grand Rapids Police Department
Non-emergency phone number: (616)456-3400
GRPDinfo@grcity.us

Natural Resources Conservation Service - Michigan
E.W. Duane Quates, State Cultural Resources Specialist / Senior Archaeologist
(517)324-5261
Edward.Quates@usda.gov

Michigan State Historic Preservation Office
Sarah Surface-Evans, Senior Archaeologist
(517)282-7959
Surfaceevanss1@michigan.gov

Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians (Gun Lake Tribe)
Lakota Pochedley, Tribal Historic Preservation Officer
(269)525-8125 / (269)397-1780
Lakota.pochedley@glt-nsn.gov
Mbpi_thpo@glt-nsn.gov

Michigan Anishinaabek Cultural Preservation and Repatriation Alliance
William Johnson, Chairman
(989)775-4730
wjohnson@sagchip.org

Appendix F - *Contact Information*

The following contact information is to be used for the purposes of this agreement and is the responsibility of each organization to submit updates as information changes.

Natural Resources Conservation Service *3001 Coolidge Rd, Suite 250* *East Lansing, MI 48823-6321* *www.mi.nrcs.usda.gov* *(517) 324-5270*	*Duane Quates* *State Cultural Resources Specialist* *Edward.quates@usda.gov* *(517) 324-5261* *Chris Valvano* *Archaeologist* *Christopher.valvano@usda.gov* *(517) 324-5349* *Melissa Gutierrez* *Cultural Resources Coordinator* *Melissa.gutierrez@usda.gov* *(517) 324-5251*
State Historic Preservation Office *300 North Washington Square* *Lansing, MI 48913* *miplace.org/historic-preservation/* *(517) 335-9840*	*Scott Slagor* Cultural Resource Protection Manager *SlagorS2@michigan.gov* *(517) 285-5120*
City of Grand Rapids *300 Monroe Avenue NW* *Grand Rapids, MI 49503* *grandrapidsmi.gov*	*Mike Staal* *Acting Project Manager* *Engineering Department* *mstaal@grcity.us* *Office: (616) 456-4182* *Cell: (616) 481-2214*
Grand Rapids Whitewater *120 Lyon Street NW* *Grand Rapids, MI 49503* *grandrapidswhitewater.org*	*Matt Chapman* *Project Manager* *matt@grandrapidswhitewater.org* *(616) 608-6922*
Grand Valley Metropolitan Council *Lower Grand River Organization of Watersheds* *678 Front Avenue, NW, Suite 200* *Grand Rapids, MI 49504* *www.gvmc.org*	*Wendy Ogilvie* *Director of Environmental Programs* *Wendy.ogilvie@gvmc.org* *Office: (616) 776-7605* *Cell: (616) 901-8172*

Appendix

Grand Rapids Public Museum *272 Pearl St. NW* *Grand Rapids, MI 49504* *www.grpm.org*	*Alex Forist* *Chief Curator* *aforist@grpm.org* *(616) 929-1700*

Appendix G – *Glossary of Terms*

ACHP – Advisory Council on Historic Preservation is an independent federal agency created solely to address historic preservation issues. It promotes the preservation, enhancement, and sustainable use of our nation's historic resources. The ACHP advises and guides federal agencies and participants through the Section 106 review process.

City – The City of Grand Rapids, Michigan is the sponsoring local organization, EGLE permit applicant and responsible for establishing contracts for demolition work. The City is an invited signatory.

GRPM – Grand Rapids Public Museum, a concurring party.

GRWW – Grand Rapids Whitewater, Inc. is leading the design and engineering of the Project and will closely coordinate with the City and other partners to accomplish the intent of the design. GRWW is an invited signatory.

GVMC – Grand Valley Metropolitan Council is the applicant for federal assistance through the RCPP and is responsible for ensuring habitat restoration work and requirements of the RCPP agreement are met. GVMC is an invited signatory.

MOA – Memorandum of Agreement. This MOA serves to document steps that will be taken to mitigate the adverse effects caused by the removal of the four low-head dams in the Grand River in downtown Grand Rapids as part of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project.

MSF – Michigan Strategic Fund, a signatory.

NHPA – National Historic Preservation Act

NRCS – Natural Resources Conservation Service, a federal agency of the U.S. Department of Agriculture. NRCS is the lead federal agency for this MOA and is a signatory.

SHPO – State Historic Preservation Office, a signatory.

Signatory Status – Parties who may sign a MOA fall into 1 of 3 categories:
(from: https://www.achp.gov/executing_agreement_documents)

1. **Signatory** – In accordance with 36 CFR Part 800.6(c)(1), a signatory has the sole authority to execute, amend, or terminate the agreement. The federal agency and the SHPO/THPO are signatories. The ACHP is a signatory when it chooses to participate. A THPO or tribal representative is a required signatory when the undertaking occurs on or affects historic properties on tribal lands.

2. **Invited Signatory** - In accordance with 36 CFR Part 800.6(c)(2), an invited signatory, upon signing, has the authority to amend and terminate the agreement. The federal agency official may invite additional parties to sign the agreement such

as an Indian tribe who attaches religious and cultural significance to historic properties affected by the undertaking (off tribal lands), or any party that assumes a responsibility under the agreement.

3. **Concurring Party** – In accordance with 36 CFR Part 800.6(c)(3), a concurring party is a consulting party invited to concur in the agreement document but who does not have the authority to amend or terminate the agreement. A concurring signature is essentially an endorsement of the agreement.

Consulting Party – Consulting Party status entitles the person or group to share their views, receive and review pertinent information, offer ideas, and consider possible solutions together with the federal agency and other consulting parties. Each party can decide how active a role they wish to play in consultation.

APPENDIX E

Other Supporting Information

NRHP Evaluation
Grand River
Beautification Dams
GRWW



NRHP Evaluation of Four Beautification Dams in the Grand River, Grand Rapids, Kent County, Michigan

February 18, 2021

Project No: 0476625

The business of sustainability

ERM

Signature page

February 18, 2021

NRHP EVALUATION OF FOUR BEAUTIFICATION DAMS IN THE GRAND RIVER, GRAND RAPIDS, KENT COUNTY, MICHIGAN



Jeffrey L. Holland
Historian



Emily Tucker-Laird
Architectural Historian

ERM
3352 128th Avenue
Holland MI 49424

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ABSTRACT

The Michigan State Historic Preservation Office (MI SHPO) has requested a National Register of Historic Places (NRHP) evaluation of the eligibility of four low-head dams in the Grand River in Grand Rapids, Michigan that would be affected by the Grand Rapids Whitewater Project (Project), which proposes the removal of these dams. With the support of the City of Grand Rapids and Grand Rapids Whitewater (GRWW), Environmental Resources Management (ERM) prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are eligible for the NRHP, and if so, whether the Project may result in adverse effects to these cultural resources. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) is the lead federal agency with funding authority over the undertaking.

The Project spans approximately 0.7 miles along the downtown portion of the Grand River, and includes the removal of four low-head, historic-aged dams associated with the early industrial and commercial growth of Grand Rapids, as well as other changes in the river. Another dam in the Grand River upstream of the Project, the Sixth Street Dam and Fish Passage, has already been recommended eligible for the NRHP, and has been addressed as a separate undertaking. This report evaluates the four dams located from just north of Bridge Street to just north of Pearl Street. In order to evaluate the significance of the dams, ERM collected information on the dams and their context within the history of Grand Rapids from experts knowledgeable in local history, city planning, and historical public works. Documents, maps, and photographs were collected from the Grand Rapids City Archive and Record Center, the Grand Rapids Public Museum, the Grand Rapids Public Library, and the Grand Rapids Historical Commission.

Based on the information gathered, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are potentially eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. ERM also recommends that the Project would have an adverse effect on the properties. The Project plan as currently proposed requires removal of all the dams and does not allow for avoidance or minimization of adverse effects. ERM recommends that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project on the four low-head dams.

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Acronyms and Abbreviations

Name	Description
ACHP	Advisory Council on Historic Preservation
APE	Area of Potential Effects
Ca.	Circa
CFR	Code of Federal Regulations
ERM	Environmental Resources Management
GRCARC	Grand Rapids City Archive and Record Center
GRHC	Grand Rapids Historical Commission
GRPL	Grand Rapids Public Library
GRPM	Grand Rapids Public Museum
GRWW	Grand Rapids Whitewater
MI SHPO	Michigan State Historic Preservation Office
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
Project	Grand Rapids Whitewater Project
USGS	United States Geological Survey

1. INTRODUCTION

1.1 Overview

Michigan State Historic Preservation Office (MI SHPO), in the course of consultation regarding the Project, has requested an evaluation of National Register of Historic Places (NRHP) eligibility of four low-head dams in the Grand River in Grand Rapids that would be affected by the Project, which proposes the removal of these dams in an effort to restore the river to a more natural state. With the support City of Grand Rapids and Grand Rapids Whitewater (GRWW), Environmental Resources Management (ERM) prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are potentially eligible for the NRHP, and if so, whether the Project may result in adverse effects to these cultural resources.

The Project requires funding authorization from the NRCS, and must comply with the provisions of the National Environmental Policy Act (NEPA) of 1970 and the National Historic Preservation Act (NHPA) of 1966. The need for federal authorization requires Project review under Section 106 of the NHPA, as amended. Section 106 of the NHPA (54 United States Code § 306108) requires federal agencies, including NRCS, to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment. Historic properties are defined as cultural resources that are listed or eligible for listing in the NRHP (36 Code of Federal Regulations [CFR] 60). GRWW, as a non-federal party, is assisting the Natural Resources Conservation Service (NRCS) in meeting its obligations under Section 106 by preparing the necessary information, analyses, and recommendations as authorized by 36 CFR § 800.2(a)(3).

On December 20, 2018, ERM, on behalf of NRCS, submitted a request for initial consultation regarding the Lower Grand River Watershed Habitat Restoration Project. On June 18, 2020, NRCS submitted an update to that submittal. MI SHPO responded on June 29, 2020 with a request for more information regarding the four low-head dams to be removed as part of the river restoration. Additional information was provided on November 2, 2020, to which MI SHPO responded with a request for further information regarding the known history and current condition of the four low-head dams (December 17, 2020, ER20-876). MI SHPO requested that additional information be provided about the dams to be removed by the Project, along with historical context that would help frame their potential eligibility for the NRHP. The current report was prepared to satisfy that request.

The Project includes the following:

- The Construction Area—the area within the wetted channel of the Grand River from approximately 130 feet upstream of the Bridge Street Bridge to the upstream edge of the Fulton Street Bridge
- The Project Area—the areas where Project activities would occur:
  - Portions of the land on both sides of the Grand River from the 6th Street Dam to Fulton Street (where construction access or staging areas would occur)
  - The wetted channel of the river from 130 feet upstream of the Bridge Street Bridge to the upstream face of the Fulton Street Bridge (the Construction Area)
  - Three recipient sites in the river for the placement of relocated unionid mussels. The three recipient sites are mussel beds near Ada, Michigan; at Riverside Park just upstream of Grand Rapids; and between Plaster Creek and the M-11 (28th Street) Bridge.

The Project's Area of Potential Effect (APE) is defined for direct effects as the Construction Area and Project Area, and for indirect effects as areas immediately adjacent to the Construction Area. Direct effects on the four low-head dams scheduled for removal are the subject of this report. Proposed earth

disturbance is not planned beyond the confines of the active river channel except for construction access points and temporary staging areas on the banks.

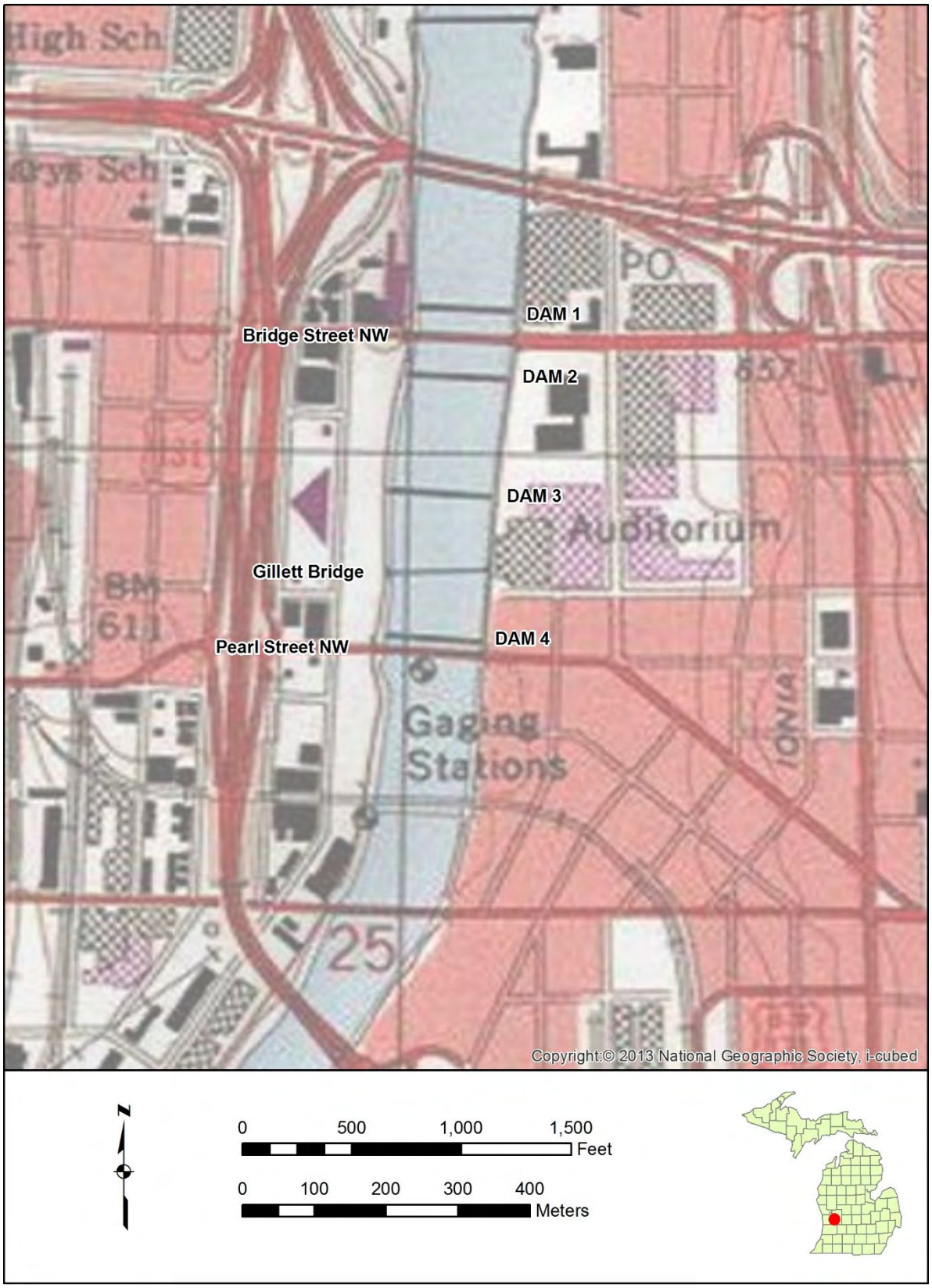

Figure 1.1-1: Topographic Map Showing Location of Dams



Figure 1.1-2: Current Aerial Imagery of Beautification Dams

The Project spans approximately 0.7 miles along the downtown portion of the Grand River, and includes the removal of four low-head, historic-aged dams associated with the twentieth century commercial growth of Grand Rapids, as well as other changes in and near the river (Figures 1.1-1 and 1.1-2). Another dam in the river at Grand Rapids, the Sixth Street Dam and Fish Passage, was constructed earlier than the other four, and was originally intended for water power. It was repaired and improved in 1926 as part of the planned improvements to the river recommended by city planner Harland Bartholomew. This dam has already been determined eligible for the NRHP (Robinson et al. 2020; B. Grennell to C. Sedlacek, letter dated 6 October, 2020). The current report evaluates the four dams located from just north of Bridge Street to just north of Pearl Street. In order to evaluate the significance of the dams, ERM collected information on the dams and their context from online sources and experts knowledgeable in local history, city planning, and historical public works. Documents, maps, and photographs were collected from the Grand Rapids City Archive and Record Center (GRCARC), the Grand Rapids Public Museum (GRPM), the Grand Rapids Public Library (GRPL), and the Grand Rapids Historical Commission (GRHC).

The four dams were constructed in 1927 as part of a plan to beautify the river through downtown. The creation of canals on both sides of the river for power and industrial use had led to low water levels in the river during dry periods, creating fetid pools and the growth of brush in the channel. The construction of low-head dams to create run-of-the-river pools had been recommended by Harlan Bartholomew as part of the 1925 City Plan (Bartholomew 1925). The proposed undertaking would entail removal of all four dams to reinstitute rapids in the riverbed, improving aquatic habitat diversity, improving public health and safety, expanding use of the river, and improving recreational use of the river. This report will evaluate the potential NRHP eligibility of the four Beautification Dams proposed for removal as part of the Project.

1.2 Management Recommendations

Based on the information gathered, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. ERM also recommends that the Project would have an adverse effect on the properties. The Project as currently proposed requires removal of all the dams and does not allow for avoidance or minimization of adverse effects. ERM recommends that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project

2. HISTORIC CONTEXT

When settlers began to congregate around the Baptist Mission on the west bank of the Grand River and the trading post established by Louis Campau on the east side of the river at what is now Grand Rapids in the 1820s, the river was described as a mile-long cascade of rapids that was 300 yards wide and dropped a total of 10 to 15 feet. A map made in 1830 (Grand Rapids Public Library 1830) shows the rapids that spanned the length of the city's street grid (Figure 2.0-1). The potential water power that the river could provide was immediately recognized, and by at least 1833, the river was being used for power. In 1835, the first dam was constructed on the river. The stone wing dam was located near Eleventh Street to the north of the Project area, and diverted water into the East Side Power Canal to provide waterpower to a sawmill and gristmill. The canal was extended for a mile along the river and was completed in 1842, providing power to a number of industries until it was abandoned in 1925. In 1849, a log and stone dam was constructed across the width of the river in an attempt to expand the canal for navigation. The canal project was a failure, but the horseshoe-shaped dam near Sixth Street remained until after 1878 (Figure 2.0-2) (Biolchini 2019; Robinson, et al. 2020).



Figure 2.0-1: Map of Grand Rapids in 1830 Showing the Rapids through the City (North is to the right) (GRPL)

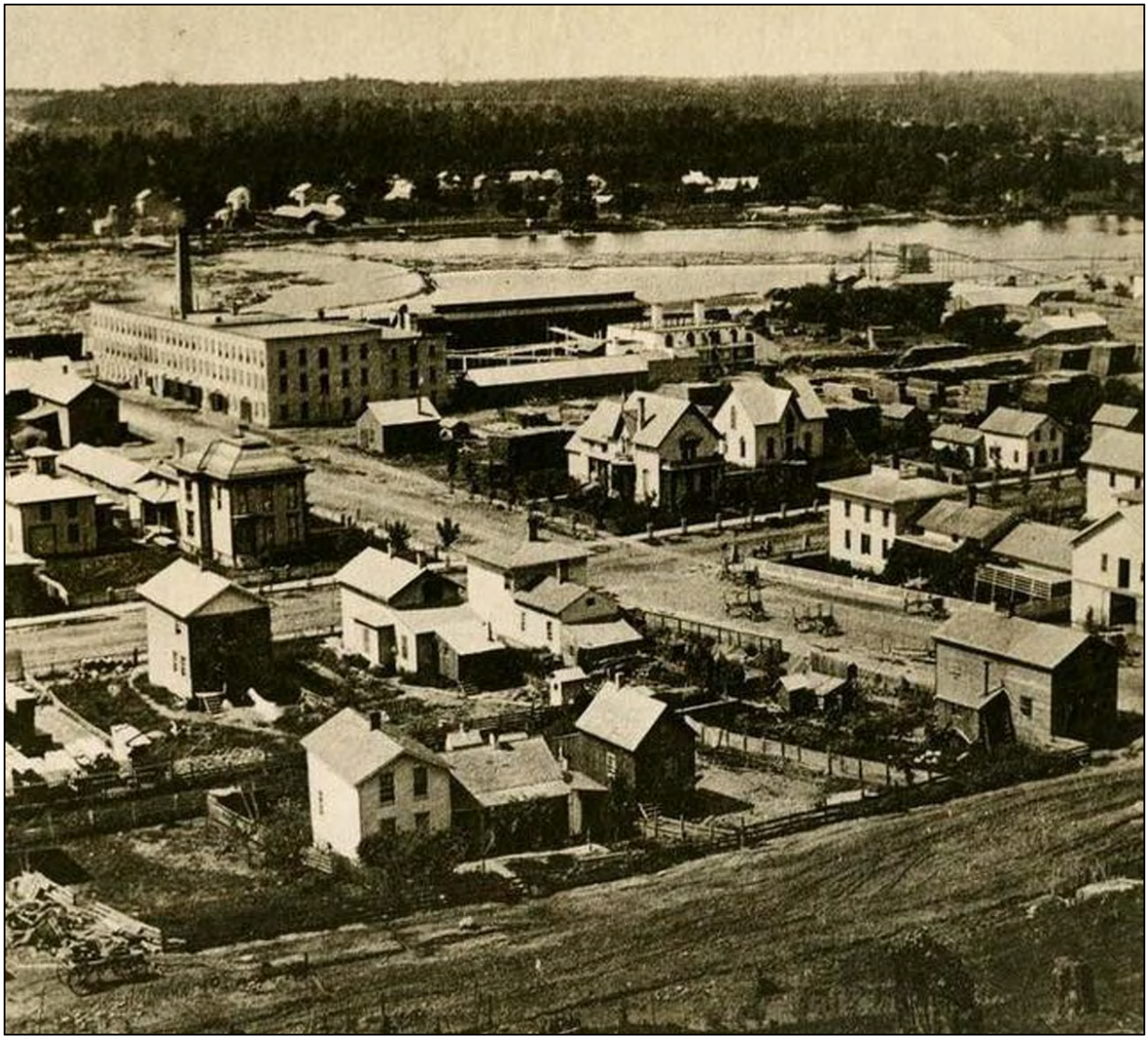

Figure 2.0-2: View of Grand Rapids in 1865 with the 1849 Horseshoe Dam in the Background (GRPL)

In 1866, the West Side Water Power Association began construction on the West Side Canal. Through an agreement with the East Side Water Power Company, the water rights would be split between the two companies, and a new, more permanent timber crib dam would be constructed across the river at Fourth Street that would serve both canals. This was known as the water power dam, or Fourth Street Dam (Figure 2.0-3). It was located a few blocks south of the earlier horseshoe dam, which remained in place until at least 1878 but was gone by 1888 (GRCARC 1873, 2019; Sanborn Map Company 1888). The Fourth Street Dam was later known as the Sixth Street Dam (Robinson et al. 2020).

In the early twentieth century, Grand Rapids experienced a series of disastrous floods. The first of these in 1904 damaged a 150-foot section of the Fourth Street Dam. At that time, it was suggested that a concrete dam replace the 1866 timber crib dam, although it appears that the dam was simply repaired (*Grand Rapids Herald* 1904). The city hired Lyman E. Cooley, an engineer from Chicago, to make recommendations regarding flood control and improving water power. Cooley proposed in 1904 that flood

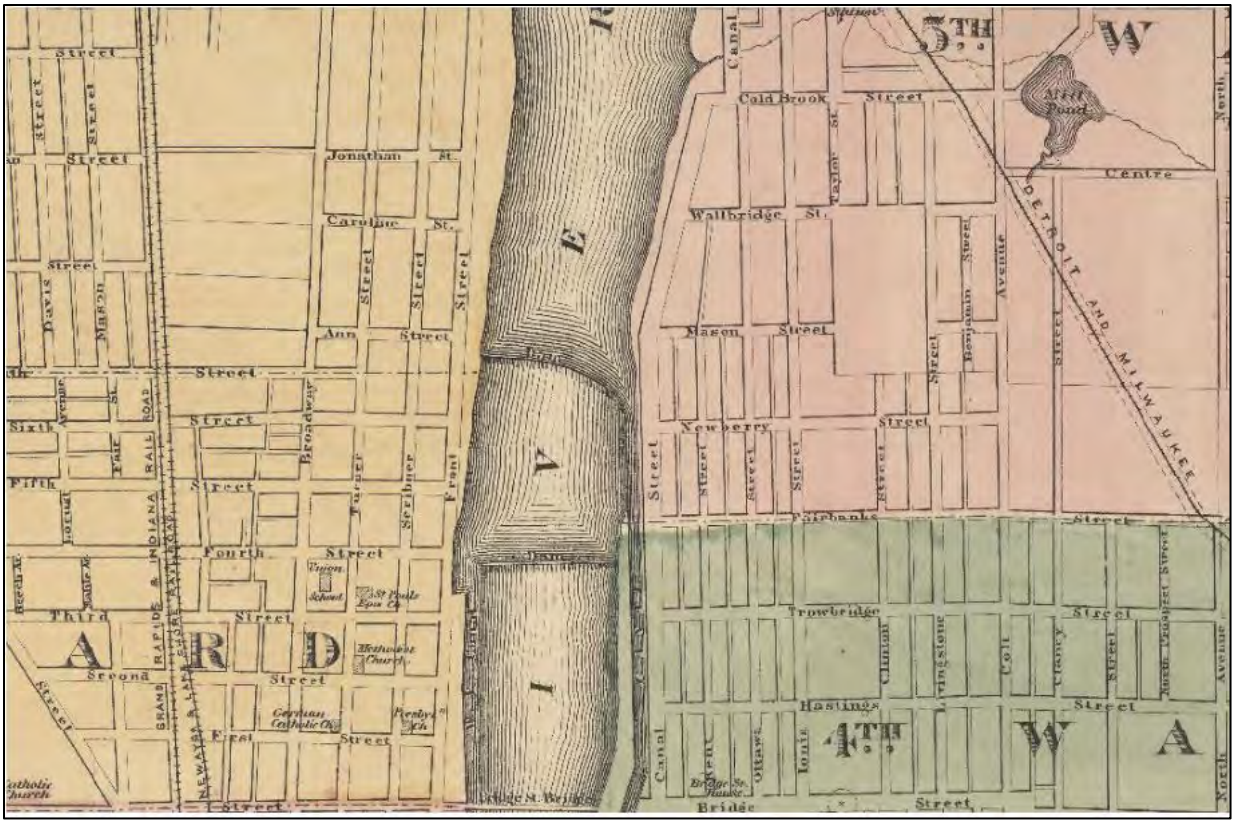

Figure 2.0-3: Map of Grand Rapids in 1873 Showing the 1866 Fourth Street Dam, the 1849 Horseshoe Dam, and the East and West Side Canals (GRCARC)

walls be constructed through the city, and work on these was begun soon after (Figure 2.0-4; Lydens 1966:122). In 1909, Cooley proposed that a new dam be constructed 300 feet north of Bridge Street. This dam was apparently not constructed (Biolchini 2019; Cooley 1909; Forist and Gleisner 2015).

In 1915, another major flood took out a 100-foot section of the western part of the Fourth Street Dam. Plans were proposed for the repair of the dam, with both a timber crib replacement and an upgrade to concrete being considered. The design of the concrete section is nearly identical to the plans later used for the Beautification Dams downstream. It appears from later plans that the damaged section was replaced with concrete, and the remaining timber crib section was replaced in 1926 when the beautification project was undertaken (GRCARC 2019).

The idea of a series of low-head dams on the Grand River in order to maintain water in the river bed and prevent the accumulation of trash and brush in the river was proposed by city planner Harland Bartholomew, whose firm was hired by the Grand Rapids Planning Department in the early 1920s to develop a master plan for the city (GRPL 2017). The diversion of water for the East and West Side Canals and city water works had resulted in the river often lacking a constant flow, resulting in the accumulation of trash and brush in the riverbed (Figure 2.0-5). The low-head dams would maintain the flow of the river and would “add greatly to the appearance and provide ample water surface for boating,” according to Bartholomew (Bartholomew 1925; Biolchini 2019; GRPM ca. 1926). An appropriation was approved for the beautification project in March 1926, but it was not until May 1927 that a bid of $24,112 was accepted from a Grand Rapids firm for the construction, with an expected completion date of

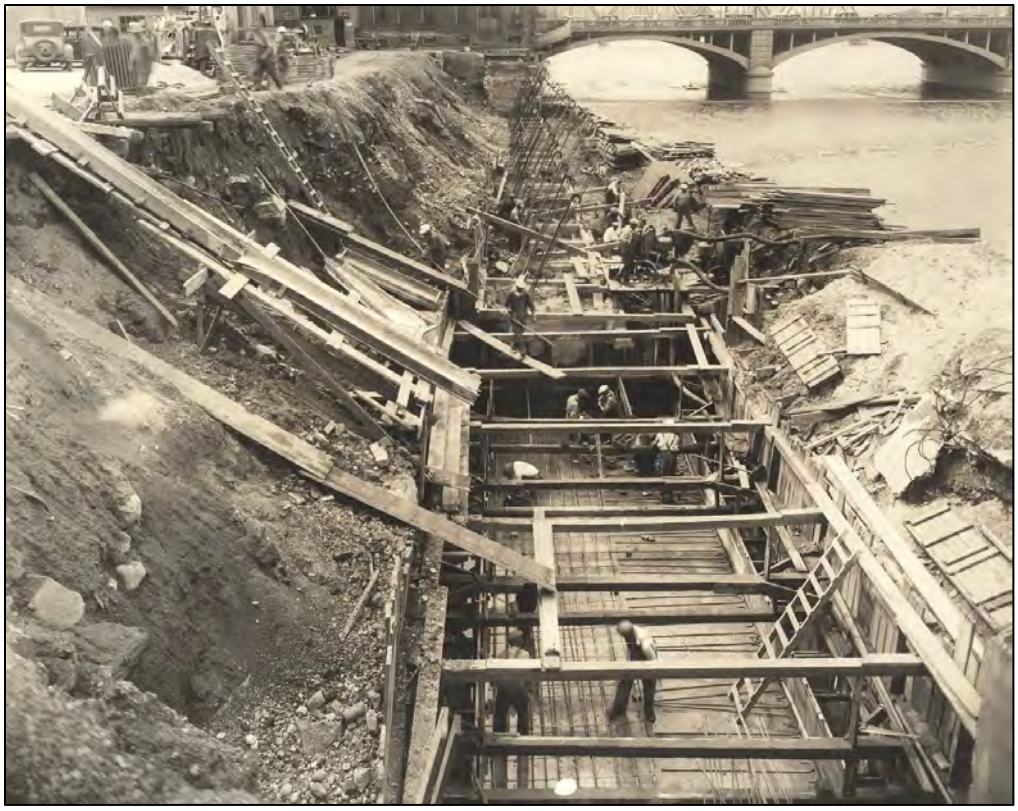

Figure 2.0-4: Construction of Flood Walls on the East Side of the River above the Pearl Street Bridge (GRCARC)



Figure 2.0-5: View of Downtown and the River Showing Brush Growing in the Riverbed Downstream of the Fourth Street Dam (GRPM)

January 1, 1928. The *Grand Rapids Press* praised the city for approving the plan, which would help the river "take on some of the beauty which existed before drought and the west side canal removed all liquid attractions" (*Grand Rapids Press* 1927a, 1927b).

The dams were constructed by diverting water using a coffer dam, leaving the riverbed dry (Figure 2.0-6) (*Grand Rapids Herald* 1927). They were completed by January 2, 1928, when a report of the Engineers' Office noted that it had overseen the placement of the dams at a cost of $37,000. In April 1928, the mayor remarked that the dams had "improved the appearance of the river 100 percent." In July 1928, the *Grand Rapids Press* remarked, "By expenditure on a series of carefully placed dams Grand Rapids has succeeded, without increasing its flood hazard in restoring some of the beauty of Grand river between the main dam at Fourth street and a point two or three hundred feet north of Pearl Street bridge" (*Grand Rapids Press* 1928a, 1928b).

The dams have remained in place to the present, with no known significant changes. The purposes of the dam construction project were well realized, as the water level was maintained, and public and private development became more focused on the river in the twentieth century. Numerous parks and public and private attractions have been established on both sides of the river, including the Gerald R. Ford Presidential Museum, Grand Rapids Public Museum, the Civic Auditorium (now part of the DeVos Place Convention Center), Ah-Nab-Awen Park, and Sixth Street Park.

Details related to the conception, design and construction of the Beautification Dams, as well as their place within the context of city planning in general and the work of Harland Bartholomew in particular, are discussed in greater detail in Section 4.



Figure 2.0-6: Dry Bed of the Grand River during Construction of Beautification Dams, View to the South from Bridge Street Bridge; Dam #2 is in the Foreground (GRCARC)

3. METHODS

3.1 Survey Methods

The current investigation was prompted by a request from the MI SHPO for additional information about the four low-head dams and their historical context to assist in a determination of eligibility. In a comment letter dated December 17, 2020, MI SHPO requested survey information about the nature and condition of the dams and a discussion of their potential NRHP eligibility within a proper historical context.

Because of accessibility issues due to the COVID-19 pandemic and the fact that the dams are currently covered by water, ERM architectural historians undertook a remote survey of the properties based on historical plans and historical and current photographs from a variety of sources including the GRCARC, GRWW, GRPL, Google Earth, and previous site visits. The photographs were used to record the structures' overall appearance and details. Topographic maps and aerial photographs were used to record the relationship of the structures to each other and the surrounding landscape features and infrastructure.

A Michigan State Architectural Properties Identification Form was completed as part of the recordation process, which is attached in Appendix A.

3.2 Documentary Research

In order to assess the significance of the dams, ERM collected information from knowledgeable experts in local history, city planning, and historical public works. ERM conducted online research to identify historic themes, events, and patterns important in the development of local, regional, and national significance. Local government records and information provided by knowledgeable local organizations also were examined to establish a context for the development of the water control systems in Grand Rapids, as well as specific details relating to the system as built and as it exists today. Documents, maps, and photographs were collected from the GRCARC, the GRPM, the GRPL, and the GRHC.

3.3 NRHP and Effects Evaluation

The four dams were evaluated with respect to their eligibility for listing on the NRHP using published guidance from the National Park Service. According to 36 CFR 60.4 (Andrus and Shrimpton 2002), cultural resources eligible for listing on the NRHP are defined as buildings, structures, objects, sites, and districts that have "integrity" and that meet one or more of the criteria outlined below. Criterion D is typically relevant to archaeological sites. Historic resources are generally evaluated in relation to Criteria A, B, and C. Criterion C is typically applicable to architectural resources but also may be relevant in the case of resources that are associated with landscape architecture (like cemeteries or battlefields) or engineering (like dams, bridges, railroads, and mines).

- Criterion A (Event). Association with one or more events that have made a significant contribution to the broad patterns of national, state, or local history
- Criterion B (Person). Association with the lives of persons significant in the past
- Criterion C (Design/Construction). Embodiment of distinctive characteristics of a type, period, or method of construction; or representation of the work of a master; or possession of high artistic values; or representation of a significant and distinguishable entity whose components may lack individual distinction
- Criterion D (Information Potential). Properties that yield, or are likely to yield, information important in prehistory or history. Criterion D is most often (but not exclusively) associated with archaeological resources. To be considered eligible under Criterion D, sites must be associated with specific or

general patterns in the development of the region. Therefore, sites become significant when they are seen within the larger framework of local or regional development.

"Integrity" is perhaps the paramount qualification of NRHP eligibility, and can be related to any or all of the following (Andrus and Shrimpton 2002):

- Location: the place where the historic property (or properties) was/were constructed or where the historic event(s) occurred
- Design: the combination of elements that create the form, plan, space, structure, and style of a property (or properties)
- Setting: the physical environment of the historic property (or properties)
- Materials: the physical elements that were combined to create the property (or properties) during the associated period of significance
- Workmanship: the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory
- Feeling: the property's (or properties') expression of the aesthetic or historic sense of the period of significance
- Association: the direct link between the important historic event(s) or person(s) and the historic property (or properties).

The four dams were evaluated in relation to these criteria and attributes, and then the criteria of adverse effect were applied for the proposed undertaking in accordance with ACHP regulations at 36 CFR 800.5. Specifically,

> An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the National Register. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative.

4. SURVEY RESULTS

This section presents the findings of the historic architectural investigation carried out for the Project. One resource, consisting of four low-head dams in the Grand River at Grand Rapids, known as Beautification Dams, was evaluated as part of the Section 106 review for the Project. The dams would be removed as part of the Project, and thus would be subject to direct effects from the Project.

4.1 Previous Investigations

A literature review of previously recorded resources determined that the Beautification Dams had not been previously recorded as historic resources. An Architectural Properties Identification Form was completed as part of the current investigations (Appendix A).

4.2 Current Survey Findings

The Beautification Dams consist of four low-head concrete dams ranging from 1.5 to 3 feet in height and approximately 425 to 440 feet in length, located in the Grand River between the Interstate 196 Bridge and the Pearl Street Bridge. The four dams together constitute the evaluated resource, and are collectively referred to as the Beautification Dams in the Grand River. They are recommended eligible for the NRHP and are summarized in Table 4.2-1. A view of each dam is shown in Figures 4.2-1 through 4.2-4.

Table 4.2-1: Summary of Beautification Dams in the Grand River

Number	Location	Length*	Height†
Dam #1	135–155 feet north of the center of the Bridge Street Bridge	437 feet	3 feet
Dam #2	148–175 feet south of the center of the Bridge Street Bridge	440 feet	1.5 feet
Dam #3	336–373 feet north of the center of the Gillette Pedestrian Bridge (Interurban Bridge)	440 feet	2 feet
Dam #4	85 feet north of the center of the Pearl Street Bridge	425 feet	1.5 feet

* Estimated length based on aerial photographs

† Based on ca. 1927 profile drawings



Figure 4.2-1: Dam #1, View to the Northeast



Figure 4.2-2: Dam #2, View to the East



Figure 4.2-3: Dam #3, View to the East



Figure 4.2-4: Dam #4, View to the West

4.2.1 Beautification Dams History

Low-head or low-stage dams typically run the width of a river or stream and allow the water flow to pass over all or most of its length. They can be as high as 15 feet, but are more commonly just a few feet in height. These types of dams are common throughout the United States and are usually constructed to raise the water level for civic, industrial, or agricultural use. They also enhance recreational opportunities. Many low-head dams were constructed across the U.S. in the eighteenth and nineteenth centuries to power gristmills and small industries (Tschantz and Wright 2011:8).

The use of low-head dams for beautification and recreation, rather than commercial and industrial uses, coincided with the emergence of city planning as a professional pursuit in the early twentieth century, and a shift in public attitudes toward the environment and the revitalization of urban areas through public improvement projects and regulatory policy (Hill 2000:153). Harland Bartholomew was a prominent city planner from the 1920s to the 1980s, known for advocating for zoning laws and creating the concept of the “City Efficient.” His firm, Harland Bartholomew & Associates (HB&A) developed more than 500 city plans and more than 300 zoning proposals for cities in the U.S. and internationally (Barone 2018:438).

Bartholomew began working on a plan for Grand Rapids as early as 1921 (GRPL 2017). His plan for Grand Rapids was based on similar principles to those he applied in other cities, both large and small. The plans were based on zoning, a concept that was being recognized by city leaders as the most efficient way to maintain property values and grow their cities in a controlled manner. Bartholomew’s zoning classes were based on variations on three factors: use, building height, and lot size. Industrial uses were zoned to the outskirts of the city, along rail lines and waterways, while the downtown area was designated for commercial use. Planning firms worked with city planning commissions to develop a plan that the commission could promote to city officials, civic groups, and business leaders. The planning commissions also worked to build public support for the plans. The goal was to get buy-in from a variety of interests in the city by highlighting the economic advantages that would accrue from a comprehensive zoning plan. In Grand Rapids, the City Planning Commission presented their early planning work at a municipal fair called “City Show” in 1920 (Moskowitz 1998:308–309).

Bartholomew produced a number of documents for the City of Grand Rapids between 1921 and 1927. His overall vision was presented to the public in 1924 through the *Grand Rapids Press* (1924a), which published a rendering of the “Future Grand Rapids” produced by Bartholomew (Figure 4.2-5). The Grand River occupied the prominent spot in the oblique aerial view and was flanked by a tree-lined esplanade on the east bank and a park with trees, open spaces, and walkways on the west bank. The bridge at the bottom of the drawing is the Bridge Street Bridge, with the next two bridges being the interurban rail bridge (Gillette Pedestrian Bridge) and the Pearl Street Bridge. No dams are evident in the view, but the river is full from bank to bank, with no obstructions. Eventually, the esplanade along the river was constructed in the form of the Riveredge Trail, and parks were established along the west side of the river, as envisioned in the plan. The changes proposed in the plan, including a “beautiful river front,” were praised by the paper as “outstanding” (Grand River Press 1924b).

Bartholomew’s City Plan for Grand Rapids included a section on riverfront improvement (Bartholomew 1925:100–103). He stated that the river was the city’s “raison d’etre,” but had fallen into insignificance in the commercial age. However, Bartholomew maintained that opportunities for development were available, and that the city should purchase as much of the riverfront property as possible. The flood walls in place along portions of the river were seen as a positive influence that would permit linear parks adjacent to the river. He recommended the construction of additional walls and the reclaiming land adjacent to the east side of the river that was occupied by the East Side Canal and constructing a road alongside the river. This would separate the buildings from the riverside docks and encourage more aesthetic architecture. The improvements would not interfere with the commercial or industrial activities of

the city, because the river no longer had value to those interests. The plan for the river was plainly laid out, including improving the appearance below the existing 6th Street dam:

> Grand Rapids must complete its flood wall as a protective measure. It would seem that this work would offer the best opportunity to carry out a more thorough riverfront improvement program. Not only should the banks be improved by the use of wall, terraces, small parks and plazas, but the appearance of the river below the dam should be improved. During the dry seasons certain stretches of the rapids have the appearance of an abandoned stone quarry overgrown with weeds and littered with tin cans, crates and rubbish. Several low-stage dams could be constructed at intervals which would maintain water constantly in the river. This would add greatly to the appearance and provide ample water surface for boating [Bartholomew 1925:102].

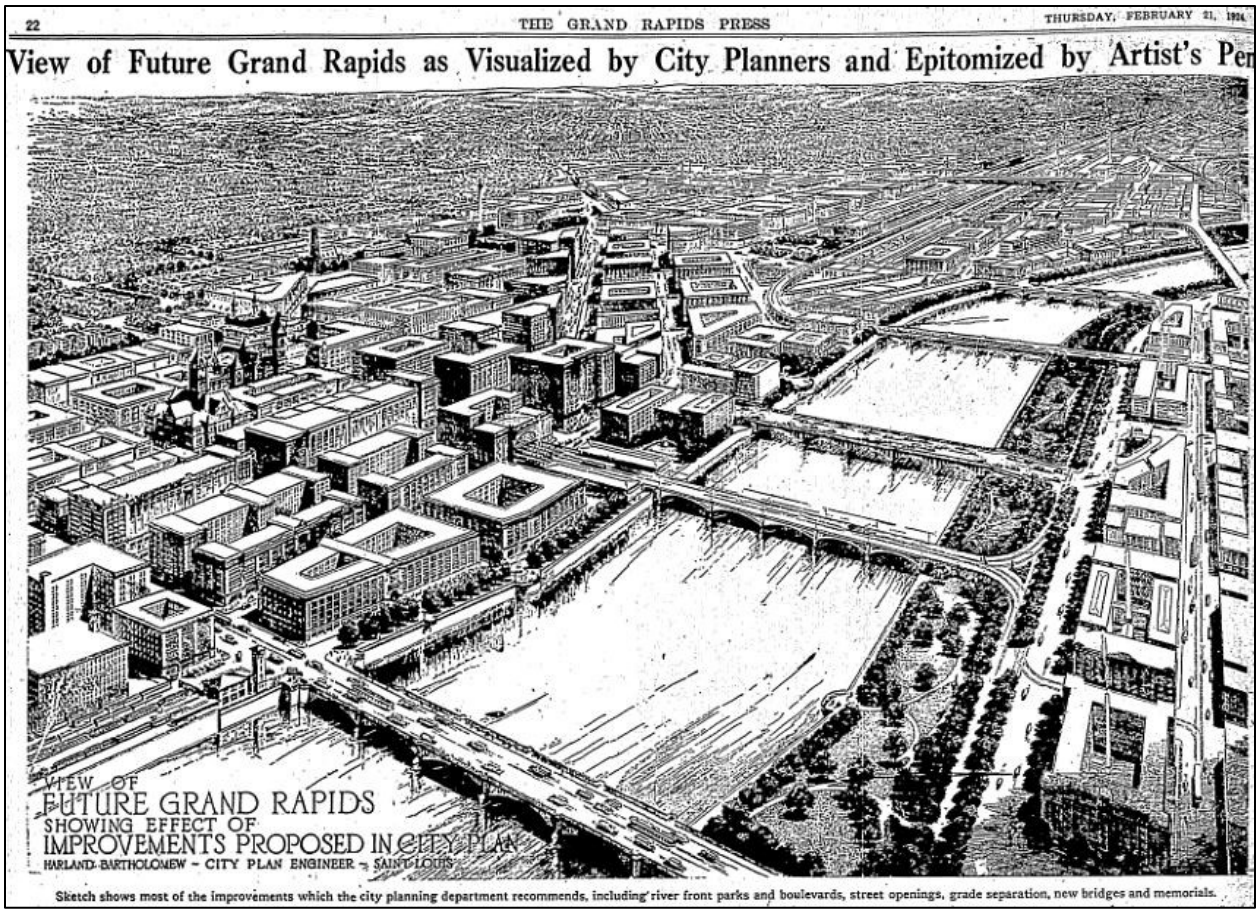

Figure 4.2-5: Artist Rendition of Harland Bartholomew's City Plan (1924)

In October 1925, the city reached an agreement with the Consumers Power Company (the former West Side Water Power Association) and the East Side Power Company to purchase the rights to the East Side Canal, which would be closed to form a sewer and a riverside park. The city had held an option on the rights to the canal for some time, and it appears that the acquisition of the property was part of the effort to carry out the plans for beautification of the river. The agreement stipulated that the city "reserved perpetual right to sufficient water for all city purposes, and that "sufficient water must be kept running over

the large dam to keep a series of smaller dams filled the year around" (*Grand Rapids Press* 1925). The story in the *Grand Rapids Press* stated that the city would keep the river clean, and "To this end it has secured the necessary options for construction of three dams, one just north of Bridge-st., one just south of Bridge-st., and third just north of Pearl-st., calculated to hold enough water to hide the ugly bottom, now strewn with all manner of debris and overgrown with weeds." According to the article, the "pretentious program of beautification, as sketched by Harland Bartholomew of St. Louis, city planning expert responsible for Grand Rapids' zoning ordinance, now approaches a step nearer realization."

The value of improving the river both economically and aesthetically was not lost on observers, even in the planning stages. The *Grand Rapids Press* noted of the plan in 1925 that, "Advantage will be taken of the open sloping west bank, which now is a mass of weeds, and a modest program of landscaping and care is expected to do wonders." The acquisition of the canal land allowed for a reorganized street plan and the availability of valuable land. "When this wilderness of rubbish, old iron and decrepit buildings has been cleared away the increased value of the property, according to the analysis of [assistant to the city's consulting engineer] Mr. Tenlloor, will have justified the trouble, and the city will be rid of perhaps its greatest fire menace" (*Grand Rapids Press* 1925).

The original plan apparently included five dams, but only four were constructed due to water rights of the last user of the West Side Canal for a water wheel (*Grand Rapids Press* 1927a, 1928b). The city appropriated $7,500 in March of 1926 for "…beautification of Grand River through the erection of dams intended to create a greater depth of water inside the city limits" (*Grand Rapids Press* 1926). However, it was not until May of 1927 that a bid was accepted for the project. The $24,000 bid of Peninsular Construction Company of Grand Rapids was over the city's estimate for the work, but was less than the only other bid received. The plans at that time were for the dams to be constructed of concrete and approximately 470 feet long. The dams were to be located 100 feet north of Bridge Street, 36 feet south of Bridge Street, at Brumrich Street, 50 feet north of Pearl Street, and 35 feet south of Pearl Street (*Grand Rapids Press* 1927a). The locations given approximate the final placements, which are detailed in Table 4.2-1.

Profile plans of the dams are shown in Figure 4.2-6 (GRCARC ca. 1927). It is not clear if the dams were built to these exact specifications, as no as-built drawings have been located. The profiles indicate that Dam #1 would have a height of 3 feet, Dam #2 and Dam #4 would be 1.5 feet high, and Dam #3 and Dam #5 would each be 2 feet high. Dam #5 was eventually dropped from the plan. A profile map of the river made in 1928 indicates that the actual dams were lower (GRCARC 1928). Current elevations taken across the dams show irregular heights across the width of the dams and only about a 1–1.5-foot drop between them. This may be due to erosion of the tops of the dam as a result of water scouring. The profiles in Figure 4.2-6 show a typical low-head concrete dam shape that has a slightly sloping upstream face with a beveled cap and a ramp-like downstream face to break the fall of the water. Each dam would have a flap or drain valve at the base. Figure 4.2-7 shows the profile of the dams after construction, which is consistent with the plans. The valve appears to have been constructed as a gated opening rather than an outlet in the base of the dam, as can be seen in Figure 4.2-8.

Work on the coffer dam to divert the river during construction began by July 1927 (*Grand Rapids Herald* 1927). As noted above, the dams were completed on schedule by January 1, 1928, although the $37,000 cost was considerably more than the $24,000 bid. Figure 4.2-9 shows Dam #1 after construction, looking north, with the Sixth Street Dam in the background.

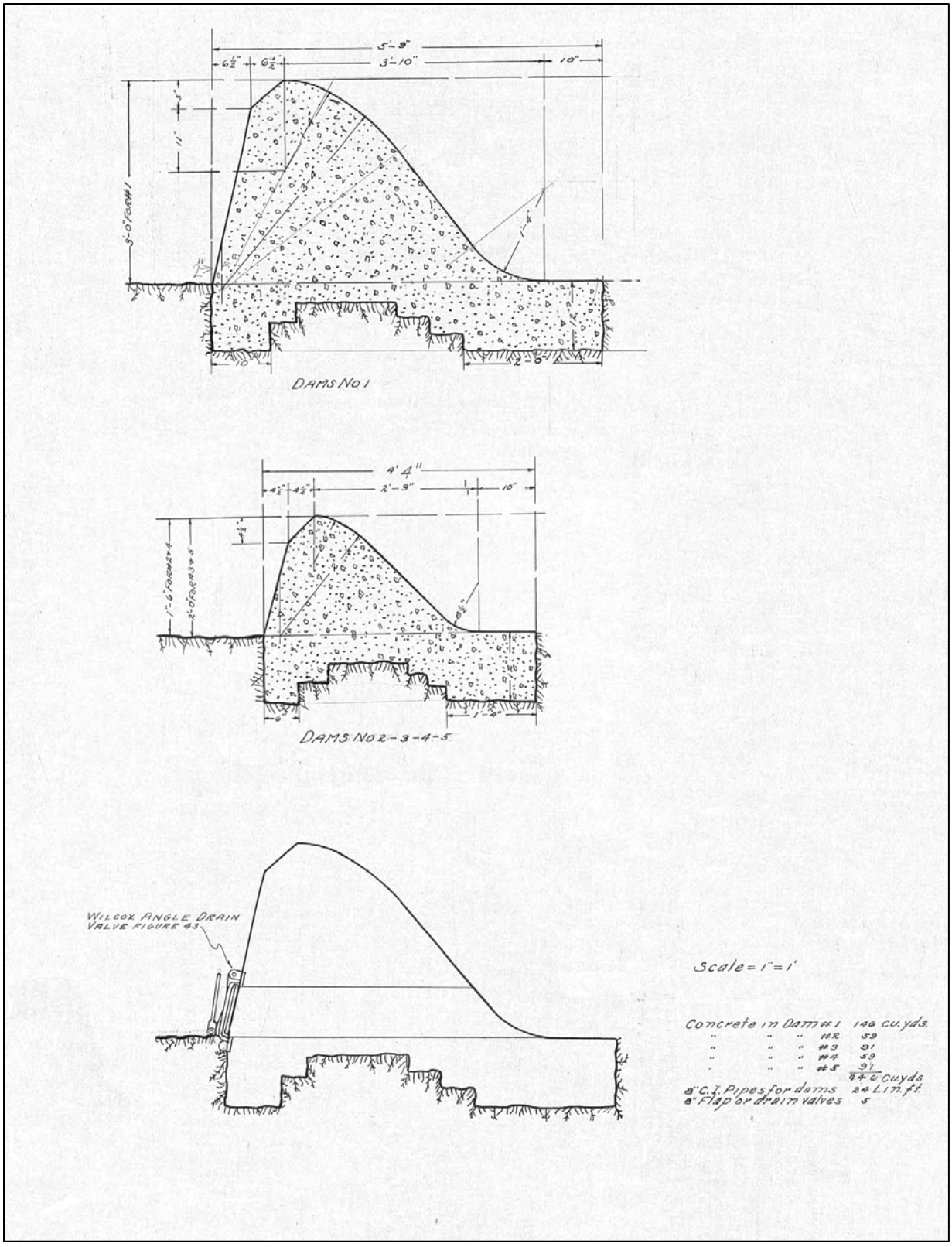

Figure 4.2-6: Engineering Drawings Showing Profile of Dams, ca. 1927 (GRCARC)



Figure 4.2-7: View of Dam #1, North of Bridge Street, 1927, Showing Dam Profile (GRCARC)



Figure 4.2-8: View of Dam #1, North of Bridge Street, 1927, Showing Opening Near Center (GRCARC)



Figure 4.2-9: Dam #1 after Construction, 1927, with Water Flowing in the River Bed (GRCARC)

4.2.2 Beautification Dams: Architectural Description and Evaluation

The Beautification Dams in the Grand River are four low-head, concrete dams that run the width of the river in downtown Grand Rapids. They vary in height from 1.5 to 3 feet, and in length from approximately 425 feet to 440 feet. They are anchored in bedrock to a depth of approximately 1 foot. Historical drawings and photographs indicate that a gated opening was located in each dam, but the nature and location of these openings in the current dams is not clear due to the dams being obscured by water. The dams have the same basic profile as shown in Figures 4.2-6 and 4.2-7. The form and construction technique is typical of low-head dams constructed throughout the United States during the period.

NRHP Evaluation: ERM recommends that the Beautification Dams in Grand River are potentially eligible for the NRHP under Criterion A for their association with events important to the history of Grand Rapids. The dams reflect efforts in the early twentieth century to improve the city through planning, zoning, and public works projects. The result was a shift in the orientation of the downtown area to embrace the river as an attraction for enjoyment and recreation. Parks and trails were established along the banks, and new buildings were constructed with an emphasis on attractive architecture that encouraged public use of the surrounding spaces. ERM recommends that the dams are also significant under Criterion B for their association with Harland Bartholomew, one of the most influential city planners of the twentieth century.

Beginning in St. Louis in 1916, Bartholomew and his firm developed plans for hundreds of cities, influencing zoning decisions and promoting urban renewal and beautification. Bartholomew's plan for Grand Rapids specifically called for the installation of the dams, which consequently influenced the development of the downtown area in the way in which he intended. Although the Beautification Dams retain sufficient architectural integrity to convey the resources' historical significance, their design is utilitarian and common to contemporary structures across the country. As a result, they do not represent exceptional design or engineering and do not constitute an outstanding example of architecture associated with historic water control features. Therefore, ERM recommends the Beautification Dams in Grand River are not potentially eligible for the NRHP under Criterion C. For similar reasons, ERM recommends that the dams are not likely to yield information important to history and are thus not potentially eligible under Criterion D.

Assessment of Effects: The function of the Beautification Dams would not be retained as a result of their removal, although the Project is intended to restore the beauty of the original rapids that once characterized the river. The placid, quiet waters created by the dams would be replaced by faster moving water that would create a different atmosphere than that which characterized the river between 1927 and the present. Although the goal of the Project, in part, is similar to that of the 1925 Bartholomew plan in making the river attractive for expanded recreation and use, the nature of the experience for those using the river space would be different from that intended by Bartholomew. Therefore, it is ERM's opinion that the proposed removal of the dams would compromise the character-defining features of the dams that make them historically significant, and the action would constitute an adverse effect.

5. CONCLUSION AND RECOMMENDATIONS

ERM conducted an evaluation of the NRHP eligibility of four low-head dams in the Grand River in Grand Rapids, which would be affected by the Grand Rapids Whitewater Project. With the support of the City of Grand Rapids and GRWW, ERM prepared this report evaluating whether the beautification dams constructed along the Grand River in the early twentieth century are potentially eligible for the NRHP, and if so, whether removal of the dams as part of the Project would result in adverse effects to these cultural resources. The findings of the current study are intended to support the Section 106 review of the proposed undertaking, which is subject to funding by the NRCS.

Based on the information gathered and presented here, ERM recommends that the four low-head dams, referred to as the Beautification Dams in Grand River, are potentially eligible for the NRHP. The dams meet the requirements for listing under Criterion A for their role in the emergence of city planning and the development of the riverfront as a focal point of downtown development in Grand Rapids, and under Criterion B for their association with city planner Harland Bartholomew, whose ideas on city beautification influenced the development of Grand Rapids during the twentieth century. Although the Beautification Dams retain sufficient architectural integrity to convey their historical significance, their design is utilitarian and common to contemporary structures across the country, and is not likely to yield information important to history. Therefore, ERM recommends that the Beautification Dams are not potentially eligible for the NRHP under Criteria C and D.

The function of the Beautification Dams to maintain water levels across the width of the Grand River would not be retained as a result of their removal. Although the goal of the Project, in part, is similar to that of the 1925 Bartholomew plan in making the river attractive for expanded recreation and use, the nature of the experience for those using the river space would be different from that intended by Bartholomew. Therefore, it is ERM's opinion that the proposed removal of the dams would compromise the character-defining features of the dams that make them historically significant, and the action constitutes an adverse effect. The Project plan as currently proposed requires removal of all of the dams and does not allow for avoidance or minimization of adverse effects. It is ERM's recommendation that, should MI SHPO concur with this assessment, a plan be developed to mitigate the adverse effects of the Project.

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APPENDIX A ARCHITECTURAL PROPERTIES IDENTIFICATION FORM

Michigan SHPO Architectural Properties Identification Form

Property Overview and Location

Street Address	Grand River, between I-196 Bridge and Pearl Street Bridge				
City/Township, State, Zip Code	Grand Rapids, Michigan, 49503				
County	Kent				
Assessor's Parcel #	N/A				
Latitude/Longitude (to the 6th decimal point)	Lat:42.968836	Long: -85.674529			
Ownership	Private ☐	Public-Local ☒	Public-State ☐	Public-Federal ☐	Multiple ☐

Property Type

(Insert primary photograph below.)

Building ☐ select sub-type below Commercial ☐ Residential ☐ Industrial ☐ Other ☐	Structure ☒ Object ☐

Architectural Information

Construction Date	1927	
Architectural Style	Dams (4)	
Building Form	Low-head dams	
Roof Form	N/A	
Roof Materials	N/A	
Exterior Wall Materials	N/A	
Foundation Materials	Bedrock anchor	
Window Materials	N/A	
Window Type	N/A	
Outbuildings	Yes ☐	No ☒

Eligibility

Individually Eligible	Criterion A ☒	Criterion B ☒	Criterion C ☐	Criterion D ☐
Criteria Considerations:		a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐		
Component of a Historic District	Contributing to a district ☐	Non-contributing to a district ☐	Historic District Name	
Not Eligible ☐				

Area(s) of Significance	Events important to history of Grand Rapids, association with Harland Bartholomew						
Period(s) of Significance	1927						
Integrity – Does the property possess integrity in all or some of the 7 aspects?							
Location ☒	Design ☒	Materials ☒	Workmanship ☒	Setting ☒	Feeling ☒	Association ☒	
General Integrity:	Intact ☒	Altered ☐	Moved ☐	Date(s):			
Historic Name	Beautification Dams						
Current/Common Name	Beautification Dams						
Historic/Original Owner	City of Grand Rapids						
Historic Building Use	Dams						
Current Building Use	Dams						
Architect/Engineer/Designer	Harland Bartholomew & Associates						
Builder/Contractor	Peninsular Construction Company						

Survey Date	7 Nov 2018	Recorded By	ERM	Agency Report #	

For SHPO Use Only	SHPO Concurrence?: Y / N	Date:

Narrative Architectural Description

Provide a detailed description of the property, including all character-defining features and any accessory resources. This is required for all properties.

The Beautification Dams in the Grand River are four low-head, concrete dams that run the width of the river in downtown Grand Rapids. They vary in height from 3 feet to 1.5 feet, and in length from approximately 425 feet to 440 feet. They are anchored in bedrock to a depth of approximately 1 foot. The only feature of the dams is an opening, presumably for flow and debris control. The dams have the same basic profile. The form and construction technique is typical of low-head dams constructed throughout the United States during the period.

History of the Resource

Provide information on previous owners, land use(s), and construction and alteration dates in a narrative format. This is required for all intensive level surveys, NRPQs, and nominations, and recommended for other identification efforts.

(see Figures at end of form)

Low-head or low-stage dams typically run the width of a river or stream and allow the water flow to pass over all or most of its length. They can be as high as 15 feet, but are more commonly just a few feet in height. These types of dams are common throughout the United States and are usually constructed to raise the water level for civic, industrial, or agricultural use. They also enhance recreational opportunities. Many low-head dams were constructed across the U.S. in the eighteenth and nineteenth centuries to power gristmills and small industries (Tschantz and Wright 2011:8).

The use of low-head dams for beautification and recreation, rather than commercial and industrial uses in the early twentieth century coincided with the emergence of city planning as a professional pursuit, and a shift in public attitudes toward the environment and the revitalization of urban areas through public improvement projects and regulatory policy (Hill 2000:153). Harland Bartholomew was a prominent city planner from the 1920s to the 1980s, known for advocating for zoning laws and creating the concept of the “City Efficient.” His firm, Harland Bartholomew & Associates (HB&A) developed more than 500 city plans and more than 300 zoning proposals for cities in the U.S. and internationally, making it likely the largest city planning firm in the country (Barone 2018:438).

Bartholomew began working on a plan for Grand Rapids as early as 1921 (GRPL 2017). His plan for Grand Rapids was based on similar principles to those he applied in other cities, both large and small. The plans were based on zoning, a concept that was being recognized by city leaders as the most efficient way to maintain property values and grow their cities in a controlled manner. Bartholomew’s zoning classes were based on variations on three factors: use, building height, and lot size. Industrial uses were zoned to the outskirts of the city, along rail lines and waterways, while the downtown area was designated for commercial use. Planning firms worked with city planning commissions to develop a plan that the commission could sell to city officials, civic groups, and business leaders. The planning commissions also worked to build public support for the plans. The goal was to get buy-in from a variety of interests in the city by highlighting the economic advantages that would accrue from a comprehensive zoning plan. In Grand Rapids, the City Planning Commission presented their early planning work at a municipal fair called “City Show” in 1920 (Moskowitz 1998:308–309).

Bartholomew produced a number of documents for the City of Grand Rapids between 1921 and 1927. His overall vision was presented to the public in 1924 through the *Grand Rapids Press* (1924a), which published a rendering of the “Future Grand Rapids” produced by Bartholomew (Figure 1). The Grand River occupied the prominent spot in the oblique aerial view and was flanked by a tree-lined esplanade on the east bank and a park with trees, open spaces, and walkways on the west bank. The bridge at the bottom of the drawing is the Bridge Street Bridge, with the next two bridges being the interurban rail bridge (Gillette Pedestrian Bridge) and the Pearl Street Bridge. No dams are evident in the view, but the river is full from bank to bank, with no obstructions. Eventually, the esplanade

along the river was constructed in the form of the Riveredge Trail, and parks were established along the west side of the river, as envisioned in the plan. The changes proposed in the plan, including a "beautiful river front," were praised by the paper as "outstanding" (Grand River Press 1924b)

Bartholomew's City Plan for Grand Rapids included a section on riverfront improvement (Bartholomew 1925:100–103). He stated that the river was the city's "raison d'etre," but had fallen into insignificance in the commercial age. However, Bartholomew maintained that opportunities for development were available, and that the city should purchase as much of the riverfront property as possible. The flood walls in place along the river were seen as a positive influence that would permit linear parks adjacent to the river. He recommended reclaiming land adjacent to the east side of the river that was occupied by the East Side Canal and constructing a road alongside the river. This would separate the buildings from the riverside docks and encourage more aesthetic architecture. The improvements would not interfere with the commercial or industrial activities of the city, because the river no longer had value to those interests. The plan for the river was plainly laid out:

> Grand Rapids must complete its flood wall as a protective measure. It would seem that this work would offer the best opportunity to carry out a more thorough riverfront improvement program. Not only should the banks be improved by the use of wall, terraces, small parks and plazas, but the appearance of the river below the dam should be improved. During the dry seasons certain stretches of the rapids have the appearance of an abandoned stone quarry overgrown with weeds and littered with tin cans, crates and rubbish. Several low-stage dams could be constructed at intervals which would maintain water constantly in the river. This would add greatly to the appearance and provide ample water surface for boating. (Bartholomew 1925:102)

In October 1925, the city reached an agreement with the Consumers Power Company (the former West Side Water Power Association) and the East Side Power Company to purchase the rights to the East Side Canal, which would be closed to form a sewer and a riverside park. The city had held an option on the rights to the canal for some time, and it appears that the acquisition of the property was part of the effort to carry out the plans for beautification of the river. The agreement stipulated that the city "reserved perpetual right to sufficient water for all city purposes,"…and that "sufficient water must be kept running over the large dam to keep a series of smaller dams filled the year around" (*Grand Rapids Press* 1925). The story in the *Grand Rapids Press* stated that the city would keep river clean, and "To this end it has secured the necessary options for construction of three dams, one just north of Bridge-st., one just south of Bridge-st., and third just north of Pearl-st., calculated to hold enough water to hide the ugly bottom, now strewn with all manner of debris and overgrown with weeds." According to the article, the "pretentious program of beautification, as sketched by Harland Bartholomew of St. Louis, city planning expert responsible for Grand Rapids' zoning ordinance, now approaches a step nearer realization."

The value of improving the river, both economically and aesthetically was not lost on observers, even in the planning stages. The *Grand Rapids Press* noted of the plan in 1925 that, "Advantage will be taken of the open sloping west bank, which now is a mass of weeds, and a modest program of landscaping and care is expected to do wonders." The acquisition of the canal land allowed for a reorganized street plan and the availability of valuable land. "When this wilderness of rubbish, old iron and decrepit buildings has been cleared away the increased value of the property, according to the analysis of [assistant to the city's consulting engineer] Mr. Tenlloor, will have justified the trouble, and the city will be rid of perhaps its greatest fire menace" (*Grand Rapids Press* 1925).

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exact specifications, as no as-built drawings have been located. The profiles indicate that Dam #1 would have a height of 3 feet, Dam #2 and Dam #4 would be 1.5 feet high, and Dam #3 and Dam #5 would each be 2 feet high. Dam #5 was eventually dropped from the plan. A profile map of the river made in 1928 indicates that the actual dams were lower (GRCARC 1928). Current elevations taken across the dams show irregular heights across the width of the dams and only about a 1–1.5-foot drop between them. This may be due to erosion of the tops of the dam as a result of water scouring. The profiles in Figure 2 show a typical low-head concrete dam shape that has a slightly sloping upstream face with a beveled cap and a ramp-like downstream face to break the fall of the water. Each dam would have a flap or drain valve at the base. Figure 3 shows the profile of the dams after construction, which is consistent with the plans. The valve appears to have been constructed as a gated opening rather than an outlet in the base of the dam, as can be seen in Figure 4.

Work on the coffer dam to divert the river during construction began by July 1927 (*Grand Rapids Herald* 1927). As noted above, the dams were completed on schedule by January 1, 1928, although the $37,000 cost was considerably more than the $24,000 bid. Figure 5 shows Dam #1 after construction, looking north, with the Sixth Street Dam in the background.

Statement of Significance/Recommendation of Eligibility

Provide a detailed explanation of the property's eligibility for the National Register. Include an evaluation under at least one of the four National Register Criteria and one Area of Significance. Include a discussion of the seven aspects of integrity, and make a recommendation about eligibility. This is required for all properties.

The Beautification Dams retain integrity of location, as they have not moved from their original location. In addition, the associated bridges and the river have remained unchanged, and most of the buildings surrounding the dams are original to the construction of the dams, which means the dams still retain integrity of setting. The Beautification Dams do retain their design and material integrity as no alterations to the utilitarian structures are known. Furthermore, the dams retain integrity of workmanship and association as a structure that conveys the craftsmanship of a utilitarian design tied to water control and public works improvement projects. Finally, the Beautification Dams retain integrity of feeling when viewed as a whole, with the river and surrounding bridges. For these reasons, ERM recommends that the Beautification Dams in Grand River are potentially eligible for the NRHP under Criterion A for their association with events important to the history of Grand Rapids. The dams reflect efforts in the early twentieth century to improve the city through planning, zoning, and public works projects. The result was a shift in the orientation of the downtown area to embrace the river as an attraction for enjoyment and recreation. Parks and trails were established along the banks, and new buildings were constructed with an emphasis on attractive architecture that encouraged public use of the surrounding spaces. ERM recommends that the dams are also significant under Criterion B for their association with Harland Bartholomew, one of the most influential city planners of the twentieth century. Beginning in St. Louis in 1916, Bartholomew and his firm developed plans for hundreds of cities, influencing zoning decisions and promoting urban renewal and beautification. Bartholomew's plan for Grand Rapids specifically called for the installation of the dams, which consequently influenced the development of the downtown area in the way in which he intended. Although the Beautification Dams retain sufficient architectural integrity to convey the resources' historical significance, their design is utilitarian and common to contemporary structures across the country. As a result, they do not represent exceptional design or engineering and do not constitute an outstanding example of architecture associated with historic water control features. Therefore, ERM recommends the Beautification Dams in Grand River are not potentially eligible for the NRHP under Criterion C. For similar reasons, ERM recommends that the dams are not likely to yield information important to history and are thus not potentially eligible under Criterion D.

References

List references used to research and evaluate the individual property. For NRPQ's include copies of key documents.

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Figure 1: Artist Rendition of Harland Bartholomew's City Plan (1924).

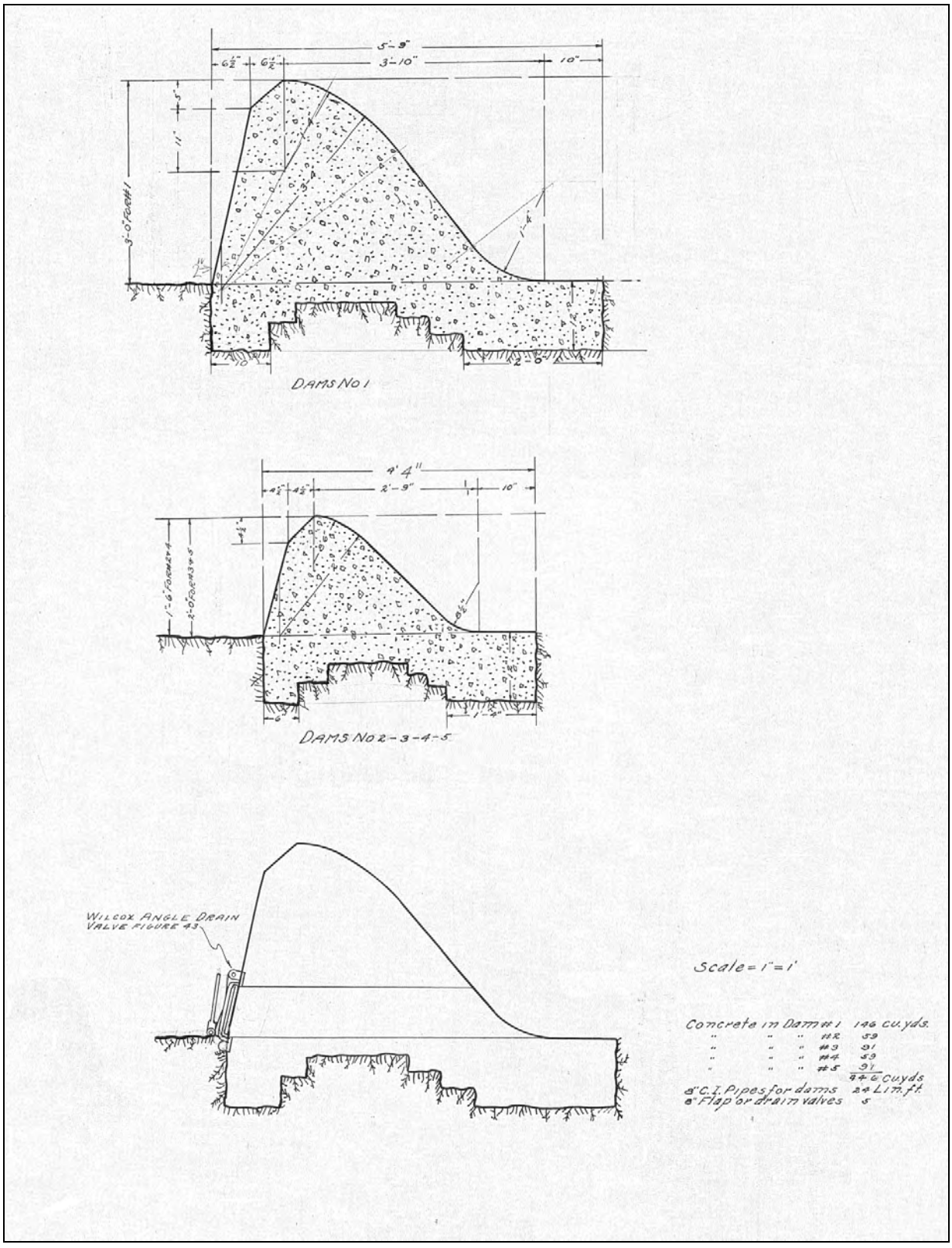


Figure 2: Engineering Drawings Showing Profile of Dams, ca. 1927 (GRCARC)



Figure 3: View of Dam #1, North of Bridge Street, 1927, Showing Dam Profile (GRCARC).



Figure 4: View of Dam #1, North of Bridge Street, 1927, Showing Opening Near Center (GRCARC).



Figure 5: Dam #1 after Construction, 1927, with Water Flowing in the River Bed (GRCARC).



Dam #2, View to the East.



Dam #3, View to the East.



Dam #4, View to the West.

APPENDIX B RESUMES

Jeffrey L. Holland

Historian

Mr. Holland has over 30 years of experience on Cultural Resources Management projects throughout the eastern United States, the Midwest, and Texas. He has conducted historical research and documentation for National Register properties and districts, HABS/HAER recordation, Assessments of Effects reports, and cultural resources survey, testing, and data recovery projects. He has also authored popular histories for major industrial facilities and summaries of archaeological projects for public education. Mr. Holland's specialties include slavery, African American history, nineteenth century agriculture, the Civil War, and the history of military installations, utilities, and infrastructure in the twentieth century.



Experience: 30+ years' experience in Section 106, NEPA, and Historic Preservation Planning for government, energy, and industrial sectors

Email: jeffrey.holland@erm.com

LinkedIn: https://www.linkedin.com/in/jeff-holland-54993548/

Education

- M.A., History (with Historical Archaeology Apprenticeship), College of William & Mary, 1995
- B.A., History, Davidson College, 1984

Fields of Competence

- Historical research, documentation, and assessment of NRHP properties
- NEPA, Section 106
- Historic preservation planning
- Genealogical research
- Cemetery relocation
- Historical archaeology

Languages

- English, native speaker

Key Industry Sectors

- Energy
- Military
- Utilities
- Transportation

Publications

- Holland, Jeffrey. 2007. Landownership and Hardship: Interpreting the Landscape of an African-American Community in Eastern Gwinnett County, Georgia. *Early Georgia* 35(2).
- Holland, Jeffrey. 2006. *Under One Roof: The Story of Air Force Plant 6.* Aeronautical System Center, Acquisition Environmental, Safety, & Health Division, Wright-Patterson Air Force Base, Ohio.
- Garrow, Patrick H., and Jeffrey L. Holland. 2005. Camp Lincoln and the Army of Southeastern Missouri. *Missouri Archaeologist* 66 (Dec):93–118
- Pietak, Lynn Marie, and Jeffrey L. Holland. 2003. Excavations at the Colclough Farmstead: Exploring Rural Life in Nineteenth and Twentieth Century Northeastern Mississippi. *Mississippi Archaeology* 37(2):165–218.

Key Projects at ERM

Energy Client, Pipeline Project, 2015–2019
Conducted cultural resource investigations as part of the permitting of a 600-mile natural gas pipeline in three states. Prepared historical contexts, conducted research on properties, assessed effects of project on resources, prepared mitigation plans for NRHP-eligible properties. Federal Energy Regulatory Commission issued Programmatic Agreement approving implementation of mitigative measures to complete compliance with Section 106 of the National Historic Preservation Act.

Energy Client, Wind Energy Project, 2019–2020
Prepared a Cumulative Visual Effects Assessment for a proposed off-shore wind energy installation of 800-megawatts in the waters of Rhode Island and Massachusetts. The analysis incorporated 17 lease areas and 761 wind generating turbines from the proposed project and reasonable foreseeable future projects. The assessment focused on three historic properties, including a Traditional Cultural Property and a National Historic Landmark.

Energy Client, Wind Energy Project, 2017–2019
Developed context and assessed historic significance for resources in three county area of northeast Pennsylvania that might be affected by a series of proposed wind turbines sites. The context addressed thematic resource types of primary significance in the region including coal industry related sites, railroads, and agricultural properties.

Energy Client, NRHP Evaluation of LNG Terminal, 2019
Developed context and assessed historical significance of an LNG terminal in Alaska completed in 1969 that was the first to export LNG from the United States. The research addressed the process involved in liquefying natural gas and changes to the plant over time. The plant was recommended as eligible for the NRHP.

Energy Client, NRHP Evaluation of Abandoned Pipeline, 2018
Served as author of reports for four western states assessing the historical significance of a 700-mile former oil pipeline converted to natural gas that was slated for abandonment. The assessment was conducted in accordance with a Notice of Exemption issued by the Advisory Council on Historic Preservation regarding abandoned historic natural gas pipelines.

Manufacturing Client, NRHP Evaluation of Historic Orchard Property, 2018
Conducted historical research and produced historical context for historic apple orchard and other historic properties in Jefferson County, West Virginia. Assessed significance of properties and potential direct and visual effects of a fiber manufacturing facility.

Energy Client, Wind Energy Project, 2016–2017
Developed context and assessed historic significance for resources in four county area of northeast West Virginia that might be affected by a series of proposed wind turbines sites. The context addressed a number of resource types including historic coaling and lumber communities, railroads, and industrial sites. Assessed architectural resources for NRHP eligibility under Criteria A and B through local history sources, deed research, and genealogy. Prepared inventory forms for data entry.

Key Projects Prior to Joining ERM

Energy Client, NRHP Documentation, 2014
Researched the ownership history and development of the William Evans farmhouse and associated buildings using county records, historical maps, census returns, and other primary and secondary sources as part of a Memorandum of Agreement to mitigate the effects of a transmission line with a permanent archival record of the property

Government Agency, Nuclear Power Program History, 2013
Conducted historical research using documents from the agency's corporate libraries, records in the National Archives, contemporary newspaper articles, and secondary sources on the nuclear power industry to produce a fully-referenced, illustrated history of what was for many years the nation's largest nuclear power program. The agency commissioned this historical overview of its nuclear power program to provide a concise reference for the agency.

Government Agency, HABS Documentation, 2012
Examined project records and historic photographs, along with other primary and secondary sources to establish the history of the former project offices of the Falcon Dam Project on the Rio Grande, constructed in 1951.

Government Agency, NRHP Assessment, Levees and Water Control Features, 2010–2011
Researched the records of the U.S. Boundary and Waters Commission and the Bureau of Reclamation to assess the significance of two levees constructed on the Rio Grande to control flooding. The levees interfaced with irrigation systems constructed prior to the levees, which also had historic features.

Government Agency, Oral History Documentation of Federal Housing Project, 2009
Conducted historical research on two housing projects slated for demolition using records at the local historical societies and libraries. Current residents of the developments were interviewed about their experiences in public housing. The documentation was part of a recordation of the two facilities intended to produce a comprehensive history of the public housing prior to the sale of the properties by the city.

Energy Client, Pipeline Project, 2008
Produced statewide contexts for five states, as well as more specific histories for dozens of counties and parishes along a 507-mile natural gas transmission pipeline in the southeast U.S. Historical research was also conducted on identified architectural resources to aid the assessment of their NRHP significance. The project was conducted on a short time schedule.

Military Agency, Air Force Facility History, 2006
Served as Historian and Author for the production of a pictorial history of Air Force Plant 6, an aircraft assembly plant operated by Bell Aircraft Company during World War II and later by Lockheed Aeronautics Company and its successors. The book is a fully-illustrated, perfect-bound history of the plant intended for a general audience and was distributed to libraries, government agencies, and other interested organizations.

Government Agency, Cultural Resources Survey of Redevelopment Property, 2006
Researched agency records and photographs on site and at the National Archives Southeast Region Branch in Atlanta, as well as local facilities to document the history and historic significance of a portion of the agency's reservation. The site included numerous industrial properties related to weapons manufacture in World War I, New Deal agricultural programs, and hydroelectric power. The assessment of the facilities was later used to develop an adaptive reuse plan for the property.

Government Agency, Archaeological Data Recovery in Historic District, 2006
Served as a Historian for this investigation of two blocks of a commercial and residential street in a historically black neighborhood of Savannah, Georgia. Using Sanborn Fire Insurance maps, city directories, and a variety of historical sources, documented neighborhood development, racial and social composition, and landscape characteristics over a period of approximately 100 years. The information was applied to the archaeological evidence from the excavation of features related to domestic and business activities on the street during the early twentieth century. A popular pamphlet on the results of the investigation was also produced.

Government Agency, Historical Research for NRHP Historic District Nomination, 2005
Conducted background research on the history of town in West Georgia, the evolution of the built environment within the district, and the construction date of the buildings, as part of a survey of 60+ properties for this historic downtown historic district. The information was used for an NRHP nomination submitted to the Georgia SHPO, and the district was listed in 2007.

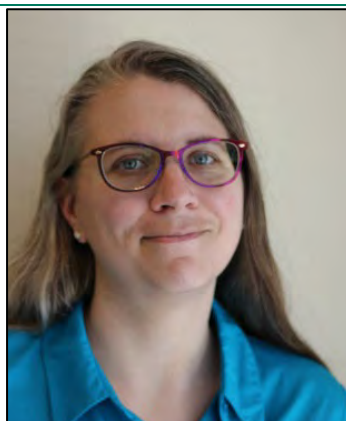
Energy Client, NRHP Assessment of Hydroelectric Power System, 2004
This project involved a review of historical documents related to the design and construction of 11 dams and powerhouses along two major rivers in North and South Carolina. Published histories, company documents, contemporary accounts were consulted, and similar large-scale power and flood-control projects in the Southeast and in the United States were studied to assess the significance of a series pf projects that spanned two states and included multiple facilities along an entire river system.

Military Agency, Context and NRHP Assessment of Korean War and Cold War Structures, 2003
Conducted background research to develop historic contexts to aid in the interpretation and assessment of BASOPS structures from the Korean War and Cold War periods at Fort Bliss and Briggs Army Airfield, Texas. The assessment of the facilities required the application of NRHP guidelines for properties of exceptional significance but less than 50 years old.

Emily Tucker-Laird

Senior Architectural Historian and Archaeologist

Ms. Tucker-Laird is Secretary of the Interior Qualified as an architectural historian and archaeologist. Emily is based in ERM's Duluth Georgia office, and attached to the cultural resources field services group. Emily has extensive experience working as a Principal Investigator. Her projects have included intra and interstate pipelines, electrical transmission lines, wind projects, solar projects, microwave towers, and treatment plans. In addition to fieldwork, Emily has experience supervising and coordinating for complex projects, and developing treatment plans for historic property concerns. Emily's has consulted with a wide range of state and federal agencies, as well as local stakeholders and interested parties.



Experience: 15 years of experience in the field of Cultural Resource Management

LinkedIn: https://www.linkedin.com/in/emily-tucker-laird-9224b4132/

Email: emily.laird@erm.com

Professional Affiliations & Registrations

- Society of Architectural Historians
- Register of Professional Archaeologists
- The Vernacular Architecture Forum

Fields of Competence

- Architectural surveys and evaluations
- Development of research and fieldwork designs for cultural resources
- National Register of Historic Places eligibility evaluation and assessments for historic resources
- Compliance with state, and federal cultural resource regulations, including guidelines set forth by various State Historic Preservation Offices, the National Historic Preservation Act and the National Environmental Policy Act
- Phase I, II, and III Archaeological Field Investigations and report preparation
- Project management and coordination

Education

- M.A., Anthropology, Ball State University, 2013
- M.S., Historic Preservation, Ball State University, 2003
- B.S., Social Sciences, University of Pittsburgh, 1999

Languages

- English, native speaker

Key Industry Sectors

- Power generation and transmission
- Oil and gas
- Public and private land development
- Telecommunications

Key Projects

Energy Client, Wind Project, 2016
Architectural historian 2016 for a 72-turbine wind project in Grant and Tucker County West Virginia. Key tasks included field survey and reporting, and analysis of visual simulations. Project met the requirements of the West Virginia Public Service Commission, and Section 106.

Energy Client, Pipeline Project, 2015-present
600-mile-long natural gas pipeline extending from West Virginia to North Carolina. Architectural Historian and Principal Investigator for historic architecture survey and assessment of effects and Historic Architecture Task Manager responsible for overseeing treatment plans to mitigate project effects. Task Manager for FCC tasks. Responsibilities also include consultations with the FERC, SHPO, and consulting parties.

Energy Client, Transmission Line Project, 2017
Six transmission line alternatives in Fairfax County, Virginia. Cultural resource specialist who prepared sections of the routing study, SCC application, and pre-application analysis, and conducted the technical review for the cultural resource investigations conducted for a proposed line to be sited in northern Virginia.

Energy Client, Pipeline Project, 2016
Architectural Historian for a 96-mile natural gas pipeline in Calcasieu, Jefferson Davis, Acadia, and Evangeline parishes. Completed architectural survey to meet the requirements of the FERC and LASHPO.

Telecommunications Client – Nationwide 2014-2015
Architectural Historian and Archaeologist for a nationwide NEPA Program Management Team serving a major national telecommunications carrier. Provide QA/QC oversight on cultural resources submittals and client deliverables. Tasks include assuring that all compliance submittals conform to regulatory requirements as well as meeting client standards, and assuring that required documentation of compliance is included in all client deliverables.

Key Projects before Joining ERM

Energy Projects, 2012
Muscle Shoals Reservation, Alabama: Architectural Historian for the HABS Level II documentation of selected resources of the Tennessee Valley Authority Muscle Shoals Reservation. The architectural survey included a detailed survey of both the interior and exterior of 20 resources. Final products included a photographic record, historical context of each resource, and architectural descriptions.

City Planning Project, 2010
Georgetown, SC Historic District Survey: One of a team of Architectural Historians recording 900 resources within the National Register-listed historic district. Final products included a comprehensive historic district inventory, maps which identified building by period of construction and contributing status, South Carolina Department of Archives and History Intensive-level historic structure forms and photographs, and a report.

Macon Cemetery Preservation Corporation, 2007
Cemetery Preservation Plan in Georgia: Architectural Historian for a conditions assessment of the 13-acre Linwood Cemetery. Containing over 4,000 burials. Identified the extent of interments, overall conditions across the cemetery, and specific graves and markers requiring repair and stabilization. The product of the work was an assessment of the cemetery's condition and a preservation plan.

Energy Client, Lateral Pipeline Project, 2013-2015
75-mile crude oil pipeline in Illinois and Indiana: Principal Investigator for historic structures, Field Director and Crew Coordinator for the project. Managed several crews, and subcontractors, met with the land office to determine what was available for survey, and acted as the health and safety officer.

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APPENDIX E

Other Supporting Information

2020 FEMA Docs:

- GRFPS Closure Evaluation; Fishbeck, 1/31/2020
- GRFPS Embankment Protection; Fishbeck, 1/31/2020
- GRFPS Freeboard Evaluation; Fishbeck, 1/31/2020
- GRFPS Embankment & Foundation Stability; Fishbeck, 1/31/2020
- GRFPS Interior Drainage Analysis; Fishbeck, 1/31/2020
- GRFPS Emergency Action Plan for Grand Rapids; Fishbeck, 1/31/2020
- GRFPS Emergency Action Plan for Walker; Fishbeck, 1/31/2020
- GRFPS Operational Maintenance & Inspection Grand Rapids; Fishbeck, 7/16/2020 Revised
- GRFPS Operational Maintenance & Inspection Walker; Fishbeck, 1/31/2020

Grand River Flood Protection System
44 CFR 65.10 (b)(2)
Closure Evaluation

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

fishbeck
Engineers | Architects | Scientists | Constructors

44 CFR 65.10 (b) (2) Tab

(2) *Closures.* All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice.

P.E. Signature: Peter W. Soltys

Non Applicable: _____

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

fishbeck
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Grand Rapids, Michigan 49546

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Grand River Flood Protection System
44 CFR 65.10 (b)(2)
Closure Evaluation

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

January 31, 2020
Project No. 120330LMP

Final

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List of Abbreviations/Acronyms

BFE	Base Flood Elevation
CIP	Cast Iron Pipe
City	City of Grand Rapids
CMP	Corrugated Metal Pipe
CONC	Concrete
DIP	Ductile Iron Pipe
GRFPS	Grand River Flood Protection System
MAPS	Market Avenue Sanitary Pump Station
MARB	Market Avenue Retention Basin
MDOT	Michigan Department of Transportation
PE	Polyethylene
PVC	Polyvinyl Chloride
PW	Public Works
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
RR	Railroad
STL	Steel
VCP	Vitrified Clay Pipe
WRRF	Water Resources Recovery Facility

Description

A comprehensive survey of the pipe penetrations and backflow prevention measures for the Grand River Flood Protection System (GRFPS) was completed. The reaches, shown in Figures 1 through 10, are along the Grand River in Grand Rapids and Walker, Michigan and consist of the following:

East Side of Grand River

- Reach E1 – Knapp Street downstream to Leonard Street.
- Reach E2 – Leonard Street downstream to Interstate Route 196 (I-196).
- Reach E3 – Gillett Pedestrian Bridge downstream to U.S. Route 131 (US 131).
- Reach E4 – US 131 downstream to 50% distance to the Water Resource Recovery Facility (WRRF).
- Reach E5 – WRRF perimeter levee

West Side of Grand River

- Reach W1 – U.S. Route 131 ramp crossing of railroad track in the City of Walker downstream to Indian Mill Creek and then up Indian Mill Creek along the north bank for approximately 2,400 feet to the second railroad bridge.
- Reach W2 – Down Indian Mill Creek along the south bank from second railroad bridge crossing for approximately 2,400 feet to the confluence with the Grand River and then downstream to I-196.
- Reach W3 – I-196 downstream to Fulton Street.
- Reach W4 – Fulton Street downstream to the Butterworth Landfill.

This survey included the following:

- Review of floodwall and levee construction plans.
- Review of highway drainage construction plans provided by the Michigan Department of Transportation (MDOT).
- Visual inspection of the riverside face of the flood protection system to document the location of outfalls and backflow prevention devices installed on the floodwalls and ends of individual pipes and to determine if the outfalls were active or abandoned.
- Inspection of backflow prevention devices installed in upstream manholes (including flap gates, bolt-down manhole castings, slide gates, and bulkheads).
- Discussions with private property owners and inspections of storm water drainage pipes from these properties.

According to 44 CFR 65.10(b)(2), “All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice”. Under the provisions of FEMA’s *Analysis and Mapping Procedures for Non-Accredited Levee Systems*, dated July 2013, the City is seeking Freeboard Deficient Reach status for the GRFPS. For Freeboard Deficient Reach status, the following conditions must be met:

- The flood protection floodwalls and embankments (levees) must be above the Base Flood Elevation (BFE) defined as the 100-year return interval flood elevation.
- There must be closure structures/devices on any penetrations through and any openings in the floodwall and earth embankments (levees) to prevent backflow of water into the protected areas. The closures structures/devices must provide protection to a level above the BFE.

- An Operations and Maintenance Plan covering the effective reaches must meet the standards of 44CFR65.10(c).
- The structural design of floodwalls and levees within the effective reaches must meet the design standards for closures in 44 CFR 65.10(b)(2).

Inspection

The pipe penetrations, flap gates, bolt-down manhole lids, and sluice gates within each reach were located and visually inspected in the period 2014 - 2015. Figure 11 shows the outfall locations that received improvements to backflow prevention measures as a result of the inspections. All of the active pipe penetrations with outfalls below the BFE have flap gates, bolt-down manhole lids, or sluice gates as the primary means of backflow protection. The Wealthy Street, Market Avenue, Front-Scribner, Caledonia Street and Palmer Street Storm Water Pump Stations have flap gates on their outlet conduits to prevent backflow into the wet wells. Inactive pipe penetrations have all been plugged. The inactive pipe penetrations have not been included in the tables at the end of this report.

During the inspection, several flap gates were observed to be damaged and not in working order. In addition, several floodwall penetrations with outfalls below the BFE did not have flap gates. The City installed flap gates on the active pipe penetrations, repaired the damaged flap gates, and plugged the inactive pipe penetrations under "Grand River Floodwall Contract No. 1 (Backflow Prevention)" in 2016.

Pipe Penetrations

Reach E1

Within Reach E1, 20 active outfalls were identified along the Grand River of which 2 are for upland sewers with no inlets below the BFE and have bolt-down manhole castings below the BFE, 15 had flap gates, 1 had both a flap gate and inlets above the BFE with bolt-down manhole castings along the upland sewer, 1 was for a roof drain with inlets above the BFE, and 1 was controlled by a pressure relief valve. For the pipes designated as having inlets above the BFE in Reach E1, all meet the freeboard requirements of 44 CFR 65.10(b)(1)(i).

All of the active pipe penetrations below the BFE, except for the roof drain that discharges to outfall 62, have primary backflow devices (bolt-down manhole lids, sluice gates, or flap gates). The flap gates are mounted on the surface of the floodwalls, embankment headwalls, inside manholes, or on the ends of the pipes. Table 1 provides a summary of the GRFPS outfalls below the BFE in Reach E1, and the outfall locations are shown on Figure 2. Note the stationing used in Table 1 (and subsequent tables) is consistent with the river stationing used in the HEC-RAS water surface profile model of the Grand River approved by FEMA for Grand Rapids. The stationing represents feet from the mouth of the Grand River at Lake Michigan.

Reach E2

Within Reach E2, 10 active outfalls were identified along the Grand River. For the 10 active pipe penetrations, 2 had inlets above the BFE, 6 had flap gates, 1 was for an upland sewer with no inlets below the BFE and with bolt-down manhole lids below the BFE, and 1 had inlets above the BFE and a flap gate. For the pipes designated as having inlets above the BFE in Reach E2, all meet the freeboard requirements of 44 CFR 65.10(b)(1)(i).

All of the active pipe penetrations below the BFE have primary backflow devices (flap gates) or inlets above the BFE with bolt-down manhole castings along the upland sewers. Five of the flap gates are installed in manholes upstream from the river and 1 is mounted on the floodwall. Table 2 provides a summary of the GRFPS outfalls below the BFE in Reach E2, and the outfall locations are shown on Figure 3.

Reach E3

Within Reach E3, 16 active outfalls were identified along the Grand River. For the 16 active pipe penetrations, 6 had inlets above the BFE, 1 had both a flap gate and inlets above the BFE, and 9 had flap gates. Table 3 provides a summary of the GRFPS outfalls below the BFE in Reach E3, and the outfall locations are shown on Figure 4.

In Reach E3 outfalls 21B, 21C, 22, 22A, and 31A meets the requirements of 44 CFR 65.10(b)(1)(i) and outfalls 21A and 29A meet the requirements for Freeboard Deficient Reach status. For the pipes in Reach E3 that do not meet the freeboard requirements, additional closure measures may be needed to meet full accreditation requirements per 44 CFR 65.10(b)(1)(i) and 44 CFR 65.10(b)(2).

Reach E4

Within Reach E4, 12 active outfalls were identified along the Grand River. For the 12 active pipe penetrations, 5 had inlets above the BFE, 7 had flap gates. Table 4 provides a summary of the GRFPS outfalls below the BFE in Reach E4, and the outfall locations are shown on Figure 5.

In Reach E4 there are 5 pipes with inlets above the BFE with 4 (outfalls 13, 14, 18A, and 19) that meet the requirements of 44 CFR 65.10(b)(1)(i) and 1 (outfall 21-A) that meet the requirements for Freeboard Deficient Reach status. For the pipes in Reach E4 that do not meet the freeboard requirements, additional closure measures may be needed to meet full accreditation requirements per 44 CFR 65.10(b)(1)(i) and 44 CFR 65.10(b)(2).

Reach E5

Reach E5 consists of the ring levee that encircles the WRRF. Within Reach E5, 6 active outfalls were identified through the levee sections along the Grand River. Two of the active pipe penetrations had inlets above the BFE with sluice gate closures within the WRRF. The remaining 4 levee penetrations are for storm and sanitary sewers that extend from the CSX property on the south side of the WRRF. These 4 pipes are controlled using manually operated gate valves operated from the crest of the levee. Table 5 provides a summary of the GRFPS outfalls below the BFE in Reach E5, and the outfall locations are shown on Figure 6. Both of the outfalls from the WRRF meet the requirements of 44 CFR 65.10(b)(1)(i).

Reach W1

Within Reach W1, 16 active pipe penetrations were identified through the levee along the Grand River, including 12 in the City of Walker north of the Grand Rapids boundary, and 6 along the left (north) bank of Indian Mill Creek. Along the Grand River, 5 of the active outfalls had inlets above the BFE, 4 of the outfalls were in the floodplain and were protected by outfalls further along the drainage path, and 7 had flap gates. The Indian Mill Creek outfalls included 3 with flap gates, 2 with inlets above the BFE, and 1 had no backflow protection. During the base flood in the Grand River, water would backflow up this outfall without backflow protection (outfall 141) resulting in flooding of a truck well with no flooding of adjacent areas.Table 6 provides a summary of the GRFPS outfalls below the BFE in Reach W1, and the outfall locations are shown on Figure 7.

For the outfalls with inlet invert elevations above the BFE, 3 of the outfalls along the Grand River (outfalls 133B, 134, and134A) and 1 along Indian Mill Creek (outfall 136-C) meet the requirements of 44 CFR 65.10(b)(1)(i). Outfalls 135 and135B2 along the Grand River and outfall 139 along Indian Mill Creek have inlet invert elevations above the BFE and meet the requirements for Freeboard Deficient Reach status. For the pipes in Reach W1 that do not meet the freeboard requirements, additional closure measures may be needed to meet full accreditation requirements per 44 CFR 65.10(b)(1)(i) and 44 CFR 65.10(b)(2).

Reach W2

Within Reach W2, 27 active pipe penetrations were identified through the levee/floodwall along the Grand River and 1 along the south bank of Indian Mill Creek.

For the 27 active pipe penetrations along the Grand River, 6 had inlets above the BFE, 18 had flap gates, 2 were manually closed using inflatable plugs (see Appendix 2) per the GRFPS Emergency Action Plan, and 1 had its inlet in the floodplain where backwater would be contained to the immediate area. The 1 active outfall along the right (south) bank of Indian Mill Creek was protected by a flap gate. Table 7 provides a summary of the GRFPS outfalls below the BFE in Reach W2, and the outfall locations are shown on Figure 8.

In Reach W2, the 5 outfalls with inlets above the BFE include 4 outfalls (outalls 109A, 109B, 110A, and 111) that meet the requirements of 44 CFR 65.10(b)(1)(i) and 1 outfall (outfall 123) that meets the requirements for Freeboard Deficient Reach status. For the pipe in Reach W2 that does not meet the freeboard requirements, additional closure measures may be needed to meet full accreditation requirements per 44 CFR 65.10(b)(1)(i) and 44 CFR 65.10(b)(2).

Reach W3

Within Reach W3, 14 active outfalls along the Grand River were identified including 8 outfalls with inlets above the BFE, 2 outfalls protected by flap gates, and 4 outfalls without backflow protection because their inlets were in the floodplain. Table 8 provides a summary of the GRFPS outfalls below the BFE in Reach W3, and the outfall locations are shown on Figure 9.

For the outfalls with inlets above the BFE in Reach W3, 5 outfalls are in natural ground with the top of bank elevation above the BFE (outfalls 105A, 105B, 105C, 107, and 107C) and 2 outfalls (outfalls 99A and 100) are for roof drains. These outfalls meet the requirements of 44 CFR 65.10(b)(1)(i). The remaining outfall with an inlet above the BFE (outfall 97) meets the requirements for Freeboard Deficient Reach status. For the pipe in Reach W3 that does not meet the freeboard requirements, additional closure measures may be needed to meet full accreditation requirements per 44 CFR 65.10(b)(1)(i) and 44 CFR 65.10(b)(2).

Reach W4

Within Reach W4, 20 active outfalls along the Grand River were identified including 4 with inlets above the BFE, 1 with a duckbill valve, 11 with flap gates, 2 protected by flap gates downstream of their outfalls, 1 with a manual sluice gate, and 1 that was manually plugged. The manually plugged outfall (outfall 83D) is included as one of the "action items" in Table 4 of the GRFPS Emergency Action Plan. Table 9 provides a summary of the GRFPS outfalls below the BFE in Reach W4, and the outfall locations are shown on Figure 10.

For the outfalls with inlets above the BFE in Reach W4, 3 outfalls (outfalls 83C, 86-A and 87) are for roof drains and meet the requirements of 44 CFR 65.10(b)(1)(i). The remaining outfall with an inlet above the BFE (outfall 81-A) meets the requirements for Freeboard Deficient Reach status. For the pipe in Reach W3 that does not meet the freeboard requirements, additional closure measures may be needed to meet full accreditation requirements per 44 CFR 65.10(b)(1)(i) and 44 CFR 65.10(b)(2).

Bridge Approach Closures

There are 14 bridges over the Grand River within Reaches E1 to E4 and no bridges in Reach E5. The same 14 bridges occur in Reaches W1 to W4 plus 1 additional bridge in Reach W3 and 3 additional bridges over Indian Mill Creek in Reaches W1 and W2. The minimum elevation for each bridge roadway approach on the east and west banks of the Grand River and the north and south banks of Indian Mill Creek were evaluated to determine if a closure structure is needed to meet the closure requirements of 44 CFR 65.10(b)(2) and the freeboard requirements of 44 CFR 65.10(b)(1)(i). Tables 10 and 11 summarize the minimum bridge roadway approach elevations with respect to the BFE.

Seven of the 14 east bridge roadway approaches and 7 of the 15 west bridge roadway approaches were less than 3 feet above the BFE. Six of these bridges (6th Street, Fulton Street, Blue Pedestrian, Pearl Street, Gillett Pedestrian, and Wealthy Street) had east and west bridge approaches that were above the BFE. The west approach of the CSX Railroad Bridge upstream of Wealthy Street was less than the BFE. Table 4 in the GRFPS Emergency Action Plan stipulates that a fabricated temporary closure be installed at the west approach to the CSX Railroad Bridge upstream of Wealthy Street to close the opening in the flood protection system. Drawings of the closure are included in Appendix 3 of this report.

The bridges with roadway approaches above the BFE but less than 3 feet above the BFE meet the requirements for a freeboard deficient reach, but not full FEMA accreditation. For full accreditation, closure structures will be required for the east and west side of these bridges to meet the closure requirements of 44 CFR 65.10(b)(2) and the freeboard requirements of 44 CFR 65.10(b)(1)(i). All of the remaining bridges over the Grand River and the 2 bridges over Indian Mill Creek have roadway approach elevations greater that 3 feet, which meet the requirements of 44 CFR 65.10(b)(2) and the freeboard requirements of 44 CFR 65.10(b)(1)(i) for full accreditation.

Sidewalk Closures

One temporary closure is required for a sidewalk penetrating through the flood control berm at Fishladder Park on the west side of the river at station 2159+21. The aluminum closure was special fabricated and is 9’ 8” wide by 5’ 3” tall with a mid-span support and ten 4’ 10” aluminum flood logs. Construction plans for the closure structure are included in Appendix 1. The closure is stored in the Front and Scribner Stormwater Pump Station maintenance building located 180 feet to the south. The closure meets the requirements for freeboard deficient certification.

Outfalls with Inlets Above BFE

Several outfalls along the GRFPP do not have flap gates, sluice gates or duckbill valves to prevent backflow during floods. These outfalls are located on storm water drainage pipes that have inlets above the BFE and bolt-down manhole lids on any manholes between the river and the inlets. Materials Testing Consultants, Inc. (MTC) prepared a revised geotechnical analysis to evaluate floodwall stability and possible soil heave behind the floodwall that could result from seepage at joints or points of damage in their report “*Revised Geotechnical Report, Grand River Floodwall and Embankment Stability, Grand Rapids, Michigan*” dated March 2018, which is included in the stability and settlement analysis section of the GRFPP levee certification documents. The results of this analysis indicate that this type outfall will not cause any floodwall instability or result in soil heave that would cause interior flooding.

Table 1 - Grand River Flood Protection System Reach E1 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
55	2203+50	48" RCP	At Howland Street extended	Flap gate on headwall, bolt-down manhole lids on upland sewer and inlets above Base Flood Elevation
55A	2207+50	24" STL	Parking lot drains	Flap gate in upstream manhole
55B	2211+50	30"	Backwash Line	Flap gates in upstream manholes
56	2211+50	48” RCP	At Caledonia Street extended	Bolt-down manhole lids on upland sewer and inlets above Base Flood Elevation; Flap gate in upstream manhole in Monroe Avenue
56A	2214+00	18" DIP	Outlet for Pressure relief Valve that protects Water Tank	Valve
56B	2214+50	36" DIP	Caledonia Storm Water Pump Station	Flap gates in storm water pump station
57	2227+00	18" RCP	Catch Basins in rear of Baker Furniture; at Dale Street extended	Flap gate on headwall at river
59	2231+00	18" RCP	Catch Basins in rear of Baker Furniture; at Travis extended	Flap gate on headwall
60	2233+00	18" RCP	Catch Basins in rear of Baker Furniture; at Palmer Street extended	Flap gate on headwall
61	2235+00	36" RCP	South of Ann Street at Palmer Street Storm Water Pump Station	Flap gates in storm water pump station
61A	2235+00	36" RCP	South of Ann Street at Palmer Street Storm Water Pump Station	Flap gate on headwall
62	2235+50	12” VCP	Roof drain for 150 Ann Street; south of Ann Street	Roof drain pipe with inlet above BFE
63	2238+00	8" STL	Catch basin for Shell Station north of Ann Street	Flap gate mounted to pipe
64	2242+00	24" RCP	Between Dean Street and Burr Oak Street	Flap gate in upstream manhole
64A	2243+50	12" RCP	At Burr Oak Street Extended	Flap gate on headwall
64B	2245+50	12" RCP	Between Burr Oak Street and Elmwood Street	Flap gate on headwall
64C	2246+50	12" RCP	At Elmwood Street extended	Flap gate on headwall
65	2247+00	54" RCP	At Elmwood Street extended	Flap gate on headwall
66	2250+50	54" RCP	At Knapp Street extended	Bolt-down manhole lids on upland sewer and inlets above Base Flood Elevation
66A	2251+00	12" RCP	At Knapp Street extended	Flap gate in upstream manhole

Table 2 - Grand River Flood Protection System Reach E2 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
48	2153+50	48” RCP	MDOT; Storm sewer for I-196	Bolt-down manhole lids on upland sewer and inlets above Base Flood Elevation
49	2156+50	30" STL	At Trowbridge Street extended	Flap gate on wall
49A	2159+00	54"	4th Street Dam	Relief sewer outfall; Flap gates in upstream manhole (see outfalls 49B, 49C, 53, 53A)
49B	2160+50	36"	4th Street Dam; Ties into Outfall 49-A	Flap gate in manhole
49C	2167+00	36” DIP	At 6th Street west of Monroe Avenue	Flap gate in manhole
53	2174+00	42" RCP	At Mason Street extended	Flap gate in upstream manhole
53A	2181+00	36" RCP	At Walbridge Street extended	Flap gate in upstream manhole
53C	2189+00	42” RCP	Old river intake converted to outfall at Coldbrook Street extended	Inlet above Base Flood Elevation
54	2190+00	10'x9' Brick	Coldbrook Creek Drain	Inlet above Base Flood Elevation
54A	2197+50	15" RCP	Leonard Street Drainage	Flap gate on floodwall; Inlets above Base Flood Elevation

Table 3 - Grand River Flood Protection System Reach E3 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
21B	2112+00	12” RCP	MDOT; Under US-131 S-Curve (middle)	Inlets above Base Flood Elevation
21C	2113+50	12” RCP	MDOT; Under US-131 S-Curve (north)	Inlets above Base Flood Elevation
22	2114+00	24” RCP	MDOT; north of US-131 S-Curve	Inlets above Base Flood Elevation
22A	2115+00	10” STL	Roof drains for Charlie’s Crab	Inlets above Base Flood Elevation
23	2118+00	8" RCP	Amway parking Lot catch basins	Flap gate mounted on headwall
29	2120+00	60" RCP	Fulton Street outfall; just north of Fulton Street	4 - 12" Flap gates in manholes at Monroe/Fulton and 1 - 24" flap gate at Ottawa/Fulton
29A	2122+00	12” RCP	Just south of water sculpture	Inlet above Base Flood Elevation
31	2128+00	6'x6' Cast-in-Place	At Louis Street	16" and 24" flap gates in upstream manholes; boltdown castings
31A	2128+00	36” RCP (24” DIP & 8” PVC)	Grand Plaza parking structure	Inlets above Base Flood Elevation
32A	2129+50	12" DIP	Between Louis Street and Pearl Street	Flap gate located in manhole in the lower parking area.
33	2131+00	12" RCP	at Pearl Street	Flap gate and inlets above Base Flood Elevation
34	2132+50	6” STL	Amway Grand Plaza drain	Flap gate on floodwall
35	2133+00	10” STL	Amway Grand Plaza drain	Flap gate on floodwall
36	2133+50	10” STL	Amway Grand Plaza drain	Flap gate on floodwall
37	2134+00	18” RCP	Lyon Street outfall; at Lyon Street	Flap gate on floodwall
38	2134+50	12” STL	Welsh Auditorium; just north of Lyon Street	Flap gate on floodwall

Table 4 - Grand River Flood Protection System Reach E4 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
7C	2074+00	60" RCP	Market Storm Water Pump Station north of RR Bridge	Sluce Gates and flap gates in storm water pump station
11	2093+00	15" RCP	Traffic Safety parking lot	Flap Gate on headwall
12B	2096+00	CSO Outfall	North of RR track	Multiple flap gates located in upstream manholes; bolt-down manhole castings
12A	2099+00	15" DIP	Drainage for parking lot	Flap gate on wall
13	2097+50	10” PVC (in 12” RCP)	Dept. of Public Works yard between RR and Barlett Street	Roof drains with inlets above Base Flood Elevation
14	2100+00	6” STL	Roof drains for maintenance building; at Barlett Street extended	Roof drains with inlets above Base Flood Elevation
15	2101+00	42" RCP	Outfall of Market Avenue; at Bartlett extended	Flap gate in upstream manhole
16	2101+00	18" RCP	Catch basins in PW yard; at Bartlett Street extended	Flap gate on floodwall
18A	2102+50	4” STL	Roof drains for maintenance building; at Barlett Street extended	Roof drains with inlets above Base Flood Elevation
19	2103+50	8” STL	Roof drains for maintenance building; at Barlett Street extended	Roof drains with inlets above Base Flood Elevation
20A	2107+50	15" VCP	Catch basins in Public Services yard	Flap gate in upstream manhole
21A	2110+50	12” RCP	MDOT; Under US-131 S-Curve (south)	Inlets above Base Flood Elevation

Table 5 - Grand River Flood Protection System Reach E5 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
3A WRRF Discharge	2021+00	42” Conc	WRRF Outfall	Sluice gate on outlet pipe at WRRF
3B WRRF Overflow	2021+00	113"x72” CIP	WRRF Overflow	Sluice gate on outlet pipe at WRRF
3C	2018+75	12”	Sanitary sewer from CSX Property	Gate valve (manual) in grass embankment between asphalt drive and perimeter fence
3D	2018+80	24”	Storm sewer from CSX Property	Gate valve (manual) in grass embankment between asphalt drive and perimeter fence
3E	2024+00	24”	Storm sewer from CSX Property	Gate valve (manual) in grass embankment between asphalt drive and perimeter fence
3F	2024+05	12”	Sanitary sewer from CSX Property	Gate valve (manual) in grass embankment between asphalt drive and perimeter fence

Table 6 - Grand River Flood Protection System Reach W1 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
Grand River Outfalls				
133B	2233+00	12" VCP	South Parking Lot of Holly's Landing	Inlet above Base Flood Elevation
134	2236+50	8" STL	North Parking lot of Holly's Landing	Inlet above Base Flood Elevation
134A	2238+00	18" RCP	Just North of Ann Street	Inlet above Base Flood Elevation
135	2244+00	12" RCP	MDOT; north of Ann	Inlet above Base Flood Elevation
135A*	2250+50	24" RCP	MDOT; under US-131	Flap Gate on Headwall
135B*	2257+00	60" RCP	MDOT; under US-131	None, pipe is in flood plain; flood protection provided on pipe 135B1
135B1*	2257+00	36" RCP	City of Walker - Turner Avenue Drainage	Flap Gate on Headwall
135B2*	2257+00	12" PE	United Rentals	Inlet above Base Flood Elevation
135C*	2267+00	36" RCP (SB); 48" RCP (NB)	MDOT; under US-131	None, pipes are in flood plain; flood protection provided on upstream pipes
135C1*	2268+00	12" RCP	Visser Properties	Flap Gate on Headwall
135C2*	2273+00	12" RCP	Visser Properties	Flap Gate on Headwall
135C3*	2277+00	12" RCP	Visser Properties	Flap Gate on Headwall
135C4*	2277+00	24" RCP	City of Walker - Turner Avenue Drainage	Flap Gate on Headwall
135D*	2273+50	36" RCP	MDOT; under US-131	None, pipe is in flood plain; Protection provided by Outfalls 135C2 and 135C3 flap gates
135E*	2284+00	72" RCP	MDOT; under US-131	None, pipe is in flood plain; flood protection provided on pipe 135F
135F*	2285+00	60" RCP	Under Visser Site	Flap Gate on Headwall
Indian Mill Creek Outfalls**				
136C	2+45	8" CIP	Parking lot drainage for building south of Holly's Landing	Inlet above Base Flood Elevation
136A	9+55	24" RCP	Drains 330 Ann Street and portion of Turner Avenue	Flap gate in Upstream Manhole
137A	16+70	36" RCP	Discharge Pipe at Indian Mill Creek Stormwater Pump Station	Flap Gate in Stormwater Pump Station
137-B	17+00	36" RCP	Flow through gravity outlet at Indian Mill Creek Stormwater Pump Station	Flap Gate in Stormwater Pump Station
139	21+00	20" PVC	Ann Street drainage	Inlet above Base Flood Elevation

Table 6 - Grand River Flood Protection System Reach W1 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
141	21+75	12" RCP	Catch basins from CSN Manufacturing	None, truck well will flood.

* Outfalls are in the City of Walker but provide flood protection for the City of Grand Rapids.

** Indian Mill Creek outfall stations measured along the centerline of the stream in the upstream direction from the mouth at the confluence with the Grand River.

Table 7 - Grand River Flood Protection System Reach W2 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
Grand River Outfalls				
107B	2155+00	(3) 72”x72” Flap Gates	Front/Scribner Storm Water Pump Station	Flap gates mounted to outfall structure
108	2159+00	36" RCP	At fish ladder	Has small drain connected into an upstream manhole (in floodplain)
109	2162+50	12" RCP	Catch basin from parking lot at 678 Front Street	Flap gate in upstream manhole behind floodwall
109A	2164+50	10” RCP	Roof drains for 678 Front Street	Inlets above Base Flood Elevation
109D	2165+00	5" Core Hole	Sidewalk/Riverwalk Drain	Manually plugged with inflatable plug as part of Emergency Action Plan
109B	2167+50	6” STL	Roof drains for 678 Front Street	Inlets above Base Flood Elevation
109C	2168+00	4" STL	Transformer vault drainage on north side of 678 Front Street	Manually plugged with inflatable plug by building owner as part of Emergency Action Plan
110A	2170+00	4" STL	Roof drains for 750 Front Street	Inlets above Base Flood Elevation
111	2172+00	10” RCP	Roof drains for 750 Front Street	Inlets above Base Flood Elevation
112	2180+00	42" STL	10th Street Storm Sewer; 10th Street extended	Flap gate in upstream manhole behind floodwall; If gate closed, water routed to relief sewer that goes to Outfall 107B at pump station
113	2180+00	30” RCP	MDOT highway drainage; 10th Street Extended	Inlets above Base Flood Elevation: Has boltdown castings
117	2198+50	36" RCP	Leonard Street storm sewer; north of Leonard Street	Flap gate in upstream manhole
118	2201+00	8" RCP	Catch basin in rear of MDOT garage; Between Leonard Street and Crosby Street	Flap gate in upstream manhole
119	2203+00	10" RCP	Catch basin from rear parking area; between Leonard Street and Crosby Street	Flap gate on floodwall
120	2205+50	15" RCP	Catch basin from rear parking area; north of Crosby Street	Flap gate in upstream manhole
121A	2207+00	4" STL	Loading docks in rear of 1300 Front Street	Flap gate in upstream manhole

Table 7 - Grand River Flood Protection System Reach W2 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
122	2208+50	10" CIP	Catch basin in rear of 1336 Front Street; between Crosby Street and Myrtle Street	Flap gate in upstream manhole
123	2211+00	30" RCP	MDOT highway drainage; at Myrtle Street extended	Inlets above Base Flood Elevation
124	2211+00	24" RCP	Front Street storm sewer; at Myrtle Street extended	Flap gate in upstream manhole
125	2213+50	8" DIP	Parking lot drainage; between Myrtle Street and Webster Street	Flap gate on floodwall
127A	2215+50	8" STL	Catch basin for 1440 Front Street	Flap gate on floodwall
128	2217+00	12" DIP	Catch basin for 1444 Front Street; at Webster Street extended	Flap gate on floodwall
131	2222+50	15" RCP	Storm sewer for KCRC parking lot; south of Richmond Street extended	Flap gate on headwall
132	2223+00	24" CMP	Storm sewer for KCRC parking lot; south of Richmond Street extended	Flap gate on headwall
133	2224+50	15" RCP	MDOT; north of Richmond Street extended	Flap gate on headwall
133A	2226+00	12" DIP	Surface Drainage at NE corner of KCRC yard	Flap gate on headwall
Indian Mill Creek Outfalls*				
138	18+20	30" RCP (South)	Broadway Avenue and Hamilton Avenue drainage	Flap gate in upstream manhole in Broadway Avenue If gate is closed, water is routed to a relief sewer that drains to outfall 107B.

* Indian Mill Creek outfall stations measured along the centerline of the stream in the upstream direction from the mouth at the confluence with the Grand River.

Table 8 - Grand River Flood Protection System Reach W3 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
96	2119+00	30" RCP	North of Fulton Street	Flap gate on headwall
97	2121+50	8" PVC	GVSU sidewalk drain; north of Fulton Street	No protection required; inlets are in floodplain.
99	2126+00	12” RCP	Public Museum	No protection required; inlets are in floodplain.
99A	2127+00	12” PVC	Public Museum; south of Carousel	Inlets above Base Flood Elevation
100	2128+00	12” RCP (6” PVC)	Public Museum	Inlets above Base Flood Elevation
102	2134+00	12" CMP	Ford Museum	No protection required; inlets are in floodplain.
103	2136+00	30" RCP	Ford Museum	Flap Gate on floodwall
104	2138+00	18" RCP	Ford Museum	No protection required; Inlets are in floodplain
105	2142+50	18" RCP	Ford Museum	No protection required; Inlets are in floodplain
105A	2144+50	24” RCP	Bridge Street storm sewer; south of Bridge Street	Inlets above Base Flood Elevation
105B	2147+00	24” RCP	Bridgewater Place	Inlets above Base Flood Elevation
105C	2148+00	12” RCP	Bridgewater Place	Inlets above Base Flood Elevation
107	2151+00	60” RCP	MDOT; south of I-196	Inlets above Base Flood Elevation
107C	2151+00	12” RCP	Just south of outfall 107	Inlets above Base Flood Elevation

Table 9 - Grand River Flood Protection System Reach W4 Pipe Penetrations Below the BFE

Outfall No.	Station	Size & Material	Description/Location	Backflow Protection
72	2041+00	(2) 48" CMP	Westside Ditch	(2) Flap gates mounted to corrugated metal pipes (CMP) at river
72A	2041+00	96"x84" CONC	Garfield/Wealthy sluice gate	Manual sluice gate and flap gates at upstream end of Westside Ditch
72B	2041+00	30" CMP	Westside Ditch just southwest of Garfield/Wealthy intersection	Flap gate mounted on CMP at Westside Ditch; Not needed if Outfall No. 72 flap gates work.
72C	2041+00	48" CMP	Butterworth Landfill, east of West Side Ditch	Flap gate mounted on CMP at Westside Ditch; Not needed if Outfall No. 72 flap gates work.
72E	2022+00	48" CMP	Butterworth Landfill, near I-196	Flap gate mounted on CMP pipe at Westside Ditch
72F	2022+00	21" CMP	Butterworth Landfill, near I-196	Flap gate mounted to end of CMP pipe
72G	2068+00	(10) 54" STL	Wealthy Street Storm Water Pump Station	Flap gates on outfall structure wall.
72H	2068+00	12" DIP	Wealthy Street Storm Water Pump Station	Duckbill valve at outfall structure wall
72I	2078+50	15" PE	Between railroad bridge and Wealthy Street	Flap gate on headwall
72J	2082+00	24" PE	Between railroad bridge and Wealthy Street	Flap gate on headwall
81A	2087+00	8" STL	Just north of Wealthy Street	Inlets above Base Flood Elevation
83	2090+00	8" STL	Sidewalks for Correctional Facility	Flap gate mounted in private manhole
83A	2090+00	6" CMP	Sidewalks and roof drains for Correctional Facility	Protection provided by Outfall 83 flap gate
83B	2090+00	6" CMP	Sidewalks and roof drains for Correctional Facility	Protection provided by Outfall 83 flap gate
83C	2095+50	6” CIP	Building south of railroad bridge	Inlets above Base Flood Elevation
83D	2096+50	4" Core Hole	Building south of railroad bridge	Manually plugged as part of Emergency Action Plan
84	2099+00	10" PVC	Parking lot basin for 201 Front Street; Between Emperor Street and Butterworth Street	Flap gate on floodwall
86	2100+50	10" PVC	Parking lot basin for 210 Front St; Between Emperor Street and Butterworth Street	Flap gate on floodwall
86A	2101+00	8” STL	Roof drain	Inlets above Base Flood Elevation
87	2101+50	4” CIP	Roof drain for 140 Front Street; at Butterworth Street extended	Inlets above Base Flood Elevation

Table 10– Reaches E1 to E4 –Bridge Approach Freeboard

Bridge	Station	Min. Roadway Approach Elevation (feet, NAVD88)	Base Flood Elevation (feet, NAVD88)	Freeboard (feet)
Reach E1				
Leonard Street Bridge	219+802.8	620.07	614.88	5.19
Railroad Bridge	222+724.2	628.57	616.01	12.56
Ann Street Bridge	223+766.0	623.87	616.34	7.53
Reach E2				
I-196 Bridge – Eastbound	215+284.2	626.27	612.72	13.55
I-196 Bridge – Westbound	215+358.1	635.97	612.76	23.21
6th Street Bridge	216+850.9	615.75	614.05	1.70
Reach E3				
U.S. Route 131 Bridge	211+242.4	622.87	609.63	13.24
Fulton Street Bridge	211+918.1	612.69	610.18	2.51
Blue Pedestrian Bridge	212+431.8	613.00	610.66	2.34
Pearl Street Bridge	213+128.6	612.47	611.32	1.15
Pedestrian (Gillett) Bridge	213+506.2	612.87	611.91	0.96
Reach E4				
Oxford Street Trail Bridge	207+332.5	627.87	608.53	19.34
Wealthy Street Bridge	208+814.8	609.19	608.61	0.58
CSX Railroad Bridge	209+683.8	609.80	609.33	0.47

Table 11– Reaches W1 to W4 –Bridge Approach Freeboard

Bridge	Station	Min. Roadway Approach Elevation (feet, NAVD88)	Base Flood Elevation (feet, NAVD88)	Freeboard (feet)
Reach W1				
Turner Avenue Bridge over Indian Mill Creek – North Approach*	222+730.9	623.87	616.04	7.83
US 131 Bridge over Indian Mill Creek – North Approach*	222+730.9	649.87	616.04	33.83
Elizabeth Avenue Pedestrian Bridge over Indian Mill Creek*	222+730.9	620.27	616.04	4.23
Ann Street Bridge	223+766.0	623.87	616.34	7.53
Reach W2				
I-196 Bridge – Eastbound	215+284.2	616.97	612.72	4.25
I-196 Bridge – Westbound	215+358.1	643.07	612.76	30.31
6th Street Bridge	216+850.9	615.97	614.05	1.92
Leonard Street Bridge	219+802.8	620.82	614.88	5.94
Railroad Bridge	222+724.2	627.67	616.01	11.66
Turner Avenue Bridge over Indian Mill Creek – South Approach*	222+730.9	623.87	616.04	7.83
US 131 Bridge over Indian Mill Creek – South Approach*	222+730.9	649.87	616.04	33.83
Elizabeth Avenue Pedestrian Bridge over Indian Mill Creek*	222+730.9	620.27	616.04	4.23
Reach W3				
Fulton Street Bridge	211+918.1	612.30	610.18	2.12
Blue Pedestrian Bridge	212+431.8	613.00	610.66	2.34
Pearl Street Bridge	213+128.6	611.61	611.32	0.29
Pedestrian (Gillett) Bridge	213+506.2	612.87	611.91	0.96
Bridge Street Bridge	214+566.8	616.69	612.25	4.44
Reach W4				
Oxford Street Trail Bridge	207+332.5	619.87	608.53	11.34
Wealthy Street Bridge	208+814.8	609.27	608.61	0.66
CSX Railroad Bridge	209+683.8	609.60	609.33	0.27
U.S. Route 131 Bridge	211+242.4	622.87	609.63	13.24

* Stations and BFE's are referenced to the confluence of Indian Mill Creek with the Grand River.

Conclusions

Primary closures for the GRFPS consist of backflow prevention devices on the pipe penetrations through the levee and floodwall sections. The primary backflow prevention devices consist of flap gates on the pipe outfalls or in upstream manholes, duckbill valves, pressure release valves, sluice gates, and bolt-down manhole lids that result in water backing up in some pipes such that the inlet invert elevations are above the BFE. The outlet conduits and pump discharge pipes for the five storm water pump stations in the GRFPS have flap gates installed.

The closures on the pipe penetrations through the levee, floodwall, and natural ground sections of the GRFPS provide protection from the 100-year flood, which is consistent with the requirements for Freeboard Deficient Reach status.

However, some of the pipe penetrations with inlet invert elevations above the BFE do not provide sufficient freeboard to meet the requirements of 44 CFR 65.10(b)(1)(i). The inlets for these pipes may need to be raised, additional bolt-down manhole lids installed, or new flap gates installed to meet the freeboard requirements for full accreditation of the reaches.

There are 14 bridges across the Grand River in Reaches E1 to E5 and 17 bridges in Reaches W1 to W4 including two bridges over Indian Mill Creek in the backwater from the Grand River.

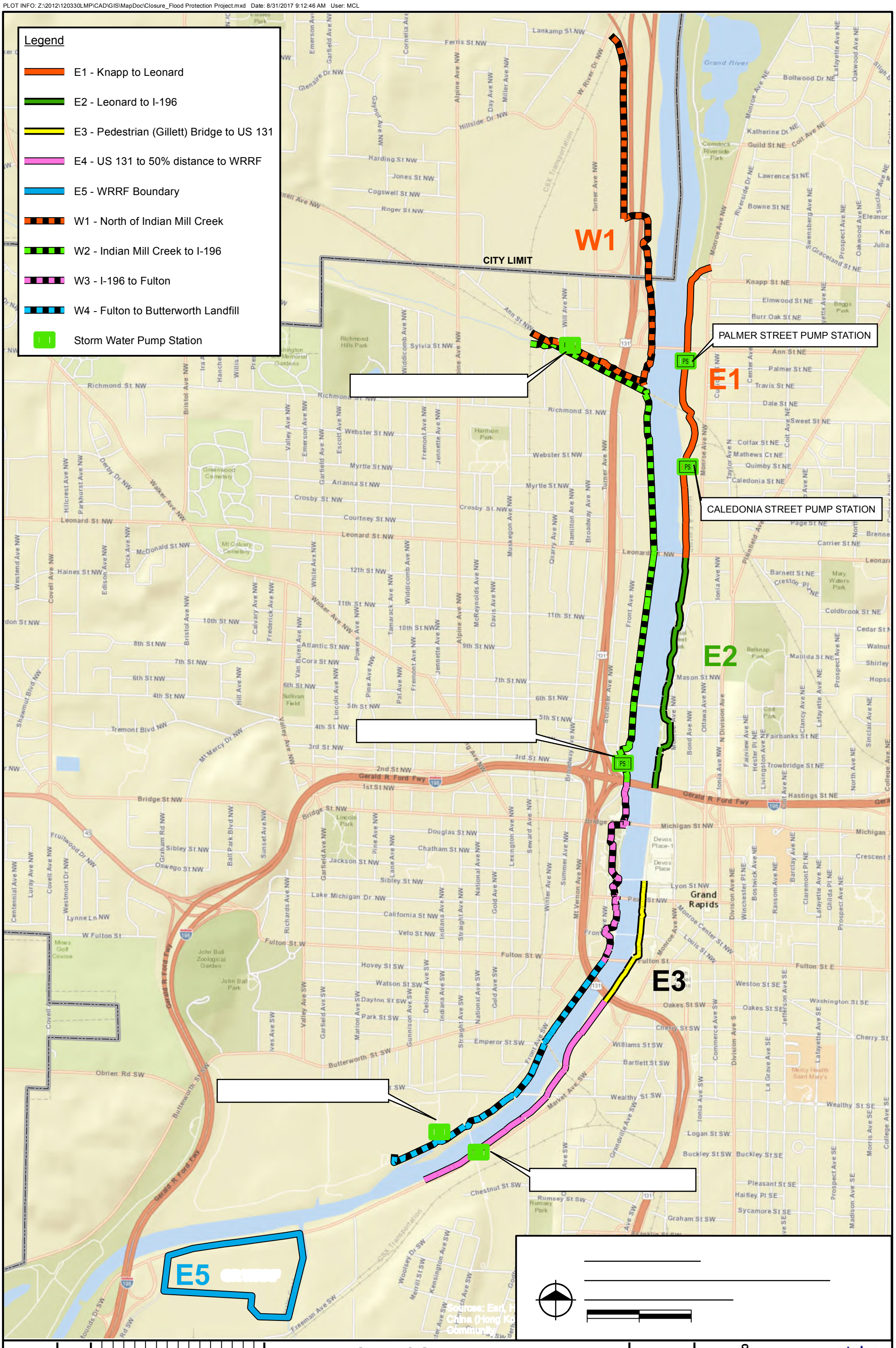
The lowest roadway elevations at the east and west ends of each bridge over the Grand River, except for the west end of the CSX Railroad Bridge upstream of Wealthy Street, are above the BFE consistent with the requirements for Freeboard Deficient Reach status. The GRFPS Emergency Action Plan has provisions to install a fabricated temporary closure on the westside of the CSX Railroad Bridge upstream of Wealthy Street to provide protection to above the BFE. See Appendix 3 for closure drawings.

If at a future date the City decides to pursue full levee accreditation with respect to the closure and freeboard requirements of 44 CFR 65.10(b)(2) and (1)(i) for bridges, the following should be noted:

- The Wealthy Street Bridge, Fulton Street Bridge, Blue Pedestrian Bridge, Pearl Street Bridge, and Gillett Pedestrian Bridge all have minimum approach roadway elevations less than 4 feet above the BFE. Therefore, these bridges may need to have closure structures installed on the east and west ends of each bridge to meet the freeboard requirements for full accreditation.
- The CSX Railroad Bridge upstream of Wealthy Street has a west approach elevation less than the BFE and will need permanent closure structures on both ends to meet the freeboard requirements for full accreditation.

Figures

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Closure_Flood Protection Project.mxd Date: 8/31/2017 9:12:46 AM User: MCL



City of Grand Rapids

Kent County, Michigan

Closure Evaluation

PROJECT NO. G120330LMP

FIGURE NO. 1

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EXISTI□G O□TFA□□S
REACH E1

SCALE: 1" = 600'

0 300 600

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Cit□ o□Grand Ra□ids
Kent Count□, Michigan

Closure E□aluation

PROJECT NO.
G12□33□

FIGURE NO.
2

P:□OT □FO□□2□12\2□33□MP\CAD\REF\EXISTI□G O□TFA□□S.D□ G □A□O□T□REACH E1 DATE:8/29/2□17 TIME:9:46:4□ AM □SER□□K

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EXISTI G O TFA S
REACH E2

ORTH

SCALE: 1" = 600'

0 300 600

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Cit o Grand Ra ids
Kent Count , Michigan
Closure E aluation

PROJECT NO.
G12 33

FIGURE NO.
3

P:OT FO 2-12 12:33 MP CAD REF: EXIST G O TFA S.D G A:O T: REACH E2 DATE: 8 28 2 17 TIME: 1 4945 AM SER: K

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EXISTING OUTFALLS
REACH E3

NORTH

SCALE: 1" = 600'

0 300 600

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Closure E aluation

PROJECT NO.
G120330

FIGURE NO.
4

PLOT INFO: Z:\2012\120330LMP\CADREF\EXISTING OUTFALLS.DWG LAYOUT: REACH E3 DATE: 8/28/2017 TIME: 10:49:56 AM USER: JNK

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EXISTING OUTFALLS
REACH E4

NORTH

SCALE: 1" = 600'

0 300 600

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P:\OT\FO\2012\12123\MP\CAD\REF\EXISTING OUTFALLS.DG [A:\OUT\REACH E4 DATE:8/28/2017 TIME:1:58:08 AM USER:KK

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City of Grand Rapids
Kent County, Michigan
Closure Evaluation

PROJECT NO.
G12033

FIGURE NO.
5



EXISTING OUTFALLS
REACH E5

NORTH

SCALE: 1" = 600'

0 300 600

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Closure E□aluation

PROJECT NO.
G120330

FIGURE NO.
6

PLOT INFO: Z:\2012\120330LMP\CAD\REF\EXISTING OUTFALLS.DWG LAYOUT: REACH E5 DATE: 1/24/2018 TIME: 2:16:49 PM USER: JNK

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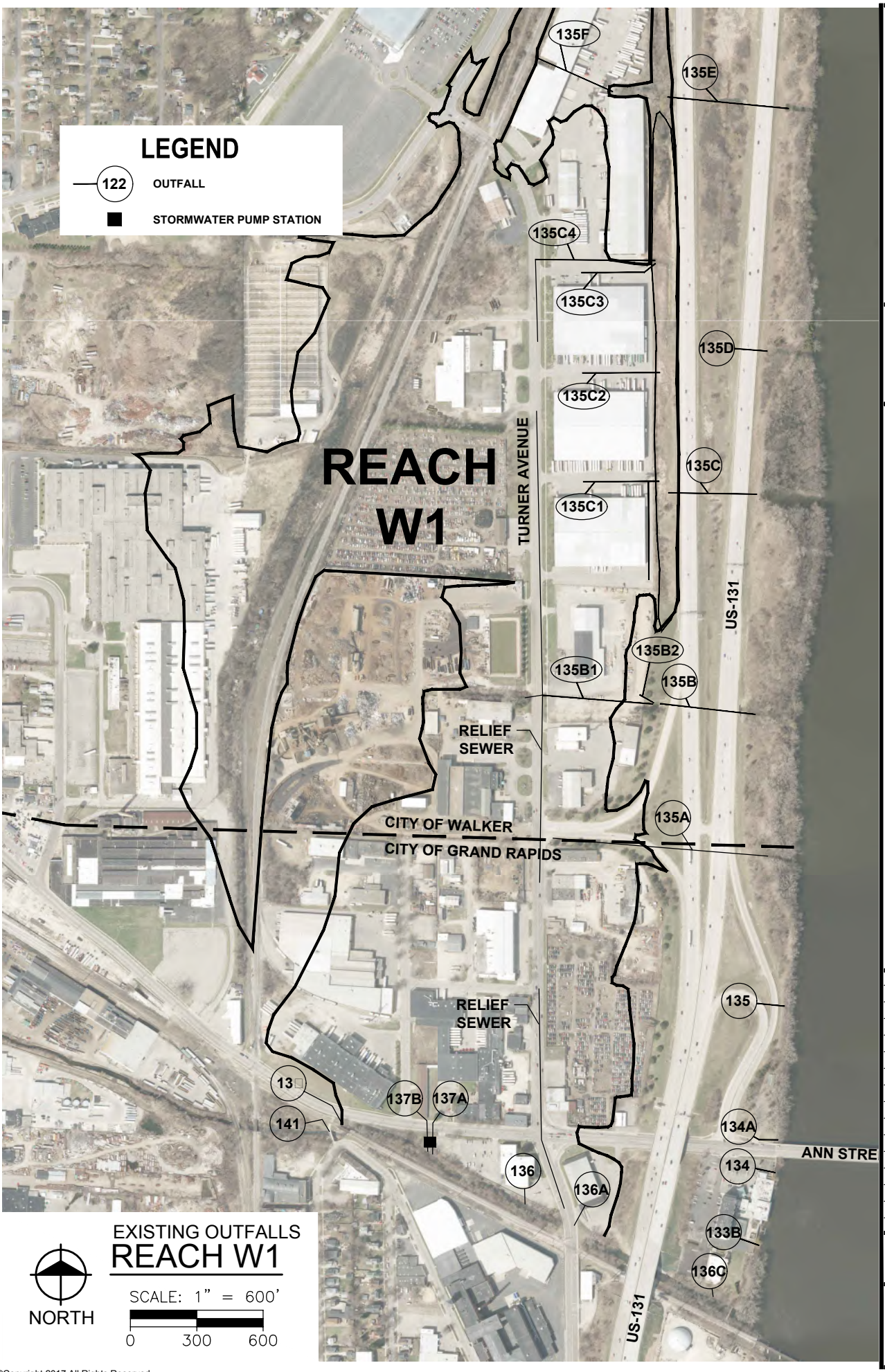

EXISTING OUTFALLS
REACH W1

SCALE: 1" = 600'

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Closure E□aluation

PROJECT NO.
G120330

FIGURE NO.
7

PLOT INFO: Z:\2012\120330LMP\CAD\REF\EXISTING OUTFALLS.DWG LAYOUT: REACH W1 DATE: 8/28/2017 TIME: 10:50:34 AM USER: JNK

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EXISTING OUTFALLS
REACH W2

NORTH

SCALE: 1" = 900'

0 450 900

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PLOT INFO: Z:\2012\120330LMP\CADREF\EXISTING OUTFALLS.DWG LAYOUT: REACH W2 DATE: 8/29/2017 TIME: 9:44:47 AM USER: JNK

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Kent County, Michigan

Closure E aluation

PROJECT NO.
G120330

FIGURE NO.
8



EXISTI□G O□TFA□□S
REACH □ 3

□ORTH

SCALE: 1" = 600'

0 300 600

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Cit□ o□Grand Ra□ids
Kent Count□, Michigan

Closure E□aluation

PROJECT NO.
G12□33□

FIGURE NO.
□

P□OT □FO □□2□12□12:33□MP□CAD□REF□EXISTI□G O□TFA□□S.D□ G □A□O□T□REACH □3 DATE□8/28/2□17 TIME□1□5□56 AM □SER□□K

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EXISTING OUTFALLS
REACH W4

NORTH

SCALE: 1" = 800'

0 400 800

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Kent County, Michigan

Closure E□aluation

PROJECT NO.
G120330

FIGURE NO.
10

PLOT INFO: Z:\2012\120330LMP\CADREF\EXISTING OUTFALLS.DWG LAYOUT: REACH W4 DATE: 8/29/2017 TIME: 9:41:58 AM USER: JNK

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PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Closure_Backflow Prevention Improvements 2015.mxd Date: 3/29/2018 9:15:34 AM User: MCL

Outfall 135F STA 2285+00
Outfall 135C4 STA 2277+00
Outfall 135C3 STA 2277+00
Outfall 135C2 STA 2273+00
Outfall 135C1 STA 2268+00
Outfall 135B1 STA 2257+00
Outfall 135A STA 2250+50
Outfall 133 STA 2224+50
Outfall 124 STA 2211+00
Outfall 113 STA 2180+00
Temporary Fabricated Closure STA 2159+30
Temporary Fabricated Closure STA 2098+00
Outfall 72-J STA 2082+00
Outfall 72-I STA 2078+50
Outfall 70 STA 2277+00
Outfall 65 STA 2247+00
Outfall 64-C STA 2246+50
Outfall 64-B STA 2245+50
Outfall 49-A STA 2159+00
Outfall 48 STA 2153+50
Outfall 31 STA 2128+00
Outfall 29 STA 2120+00
Outfall 23 STA 2118+00
Outfall 20-A STA 2107+50
Outfall 12-A STA 2099+00
Outfall 12-B STA 2096+00

I-96
COMSTOCK RIVERSIDE PARK
3 MILE RD.
US-131
MONROE AVE.
KNAPP ST.
TURNER AVE.
ANN ST.
RICHMOND ST.
RR
LEONARD ST.
GRAND RIVER
6TH ST.
6TH ST. DAM
I-196
MICHIGAN ST.
PEARL ST.
FULTON ST.
US 131
BUTTERWORTH ST.
WEALTHY ST.
I-196
GRAND RIVER
MARKET AVE.
RR
GR WWTP
PLASTER CREEK

Legend

- Backflow Prevention Improvement Location
- Temporary Closure

NORTH

BACKFLOW PREVENTION IMPROVEMENTS 2015

0 1,000 2,000 FEET

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid,

FIGURE NO. 11

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PROJECT NO. G120330LMP

City of Grand Rapids
Kent County, Michigan

Closure Evaluation

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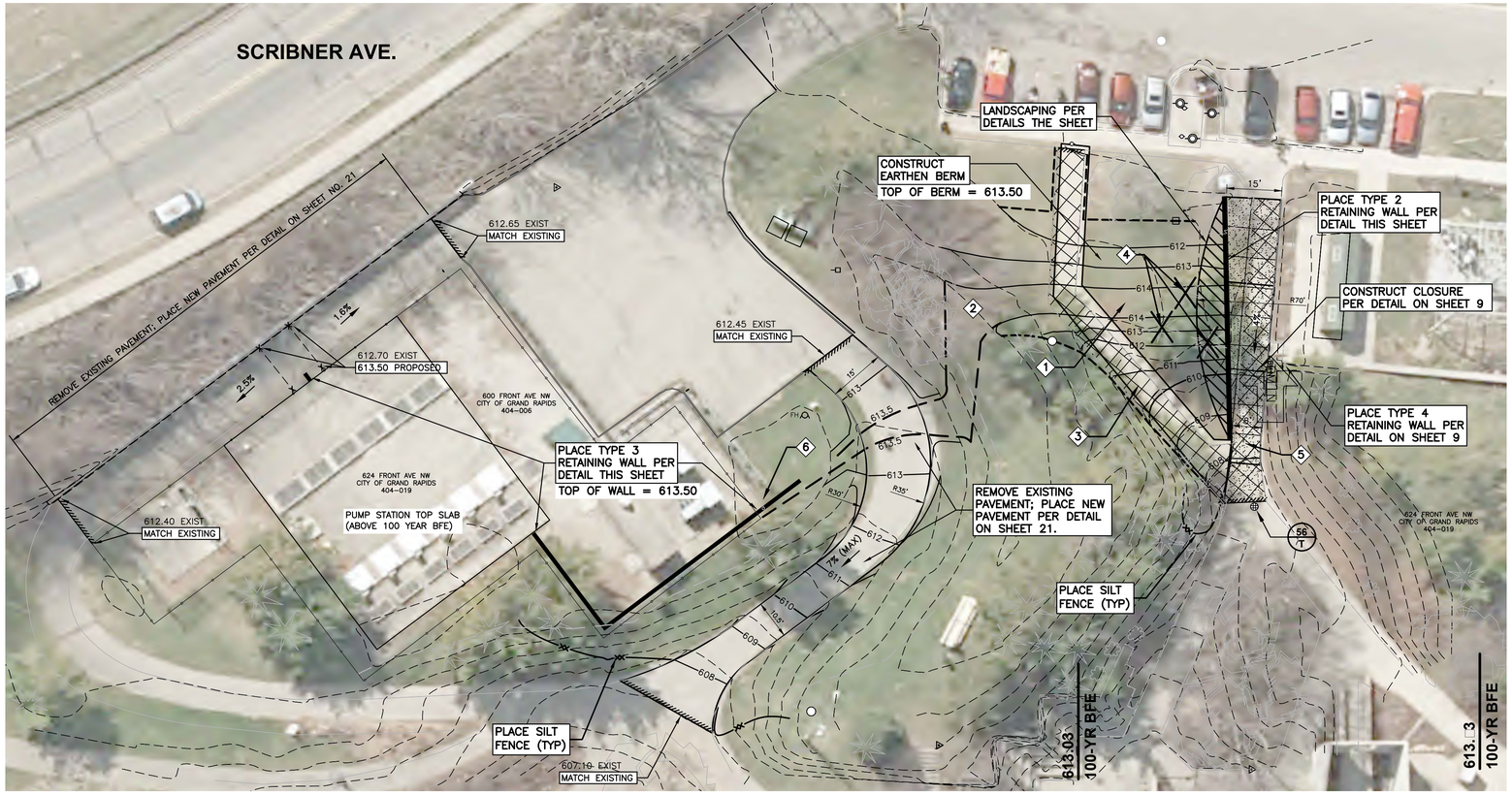
Appendix 1

Fish Ladder Park Closure Structure



BENCHMARK

BENCHMARK N ELEVATION: 609.67

CHISELED SQUARE ON SE CORNER OF FIRST CONCRETE STEP, 10 FEET SOUTH AND 6 FEET EAST OF SE CORNER OF RESTROOM BUILDING AT FISH LADDER PARK

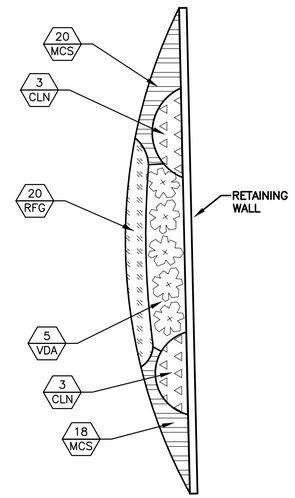
NORTH

SCALE

PLAN: 1"=20'

PLANT LIST

	KEY	BOTANICAL NAME	COMMON NAME	SIZE	ROOT	SPACING
ORNAMENTAL GRASSES	CLN	CHASMANTHIUM LATIFOLIUM	NORTHERN SEA OATS	1 GAL.	CONT.	24" O.C.
PERENNIALS	MCS	MONARDA 'CAMBRIDGE SCARLET'	CAMBRIDGE SCARLET BEE BALM	1 GAL.	CONT.	18" O.C.
	RFG	RUDBECKIA FULGIDA 'GOLDSTURM'	BLACK EYED SUSAN	1 GAL	CONT.	18" O.C.
SHRUBS	VDA	VIBURNUM DENTATUM	ARROWWOOD VIBURNUM	3 GAL.	CONT.	60" O.C.



KEY NOTES

1. REMOVE SOD AND TOPSOIL FROM NEW GRADING AREA. PLACE FILL TO ACHIEVE NEW ELEVATIONS AS SHOWN. TOP OF BERM = 614. PLACE 4" TOPSOIL AND SOD DISTURBED AREAS.
2. PLACE 4" TOPSOIL AND SEED DISTURBED AREAS.
3. REMOVE EXISTING CONCRETE WALK AND GRAVEL BASE.
4. REMOVE EXISTING PINE TREES.
5. PLACE 6" THICK CONCRETE WALK. SAWCUT 8'x8' SQUARES (MAX)
6. REMOVE AND REINSTALL FENCE AND GUARD RAILING.

SOIL EROSION AND SEDIMENTATION CONTROL

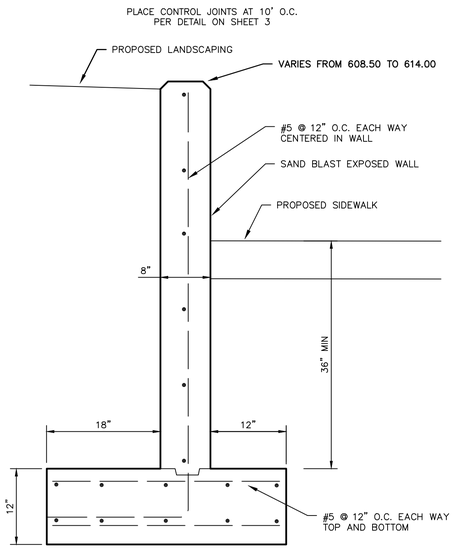
1. SEE SHEET 20 FOR SOIL EROSION AND SEDIMENTATION CONTROL NOTES AND DETAILS.
2. PREDOMINANT SOILS TYPE: URBAN LAND (NRCS WEB SOIL SURVEY)
3. PROXIMITY TO GRAND RIVER: 50 FEET

LANDSCAPING DETAIL

NO SCALE

GRAND RIVER

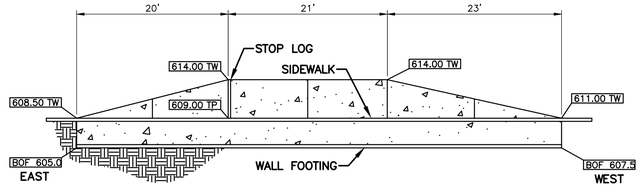
APPROXIMATE FILL VOLUME = 210 CYD



CONCRETE RETAINING WALL - TYPE 2

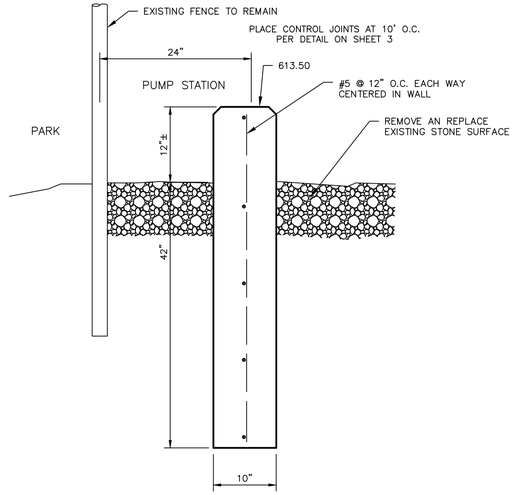
(624 FRONT AVE.)

SCALE: 1"=1'



RETAINING WALL - ELEVATION VIEW

SCALE: 1"=10'



CONCRETE RETAINING WALL - TYPE 3

(624 FRONT AVE.)

NO SCALE

624 FRONT AVENUE FISH LADDER PARK

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

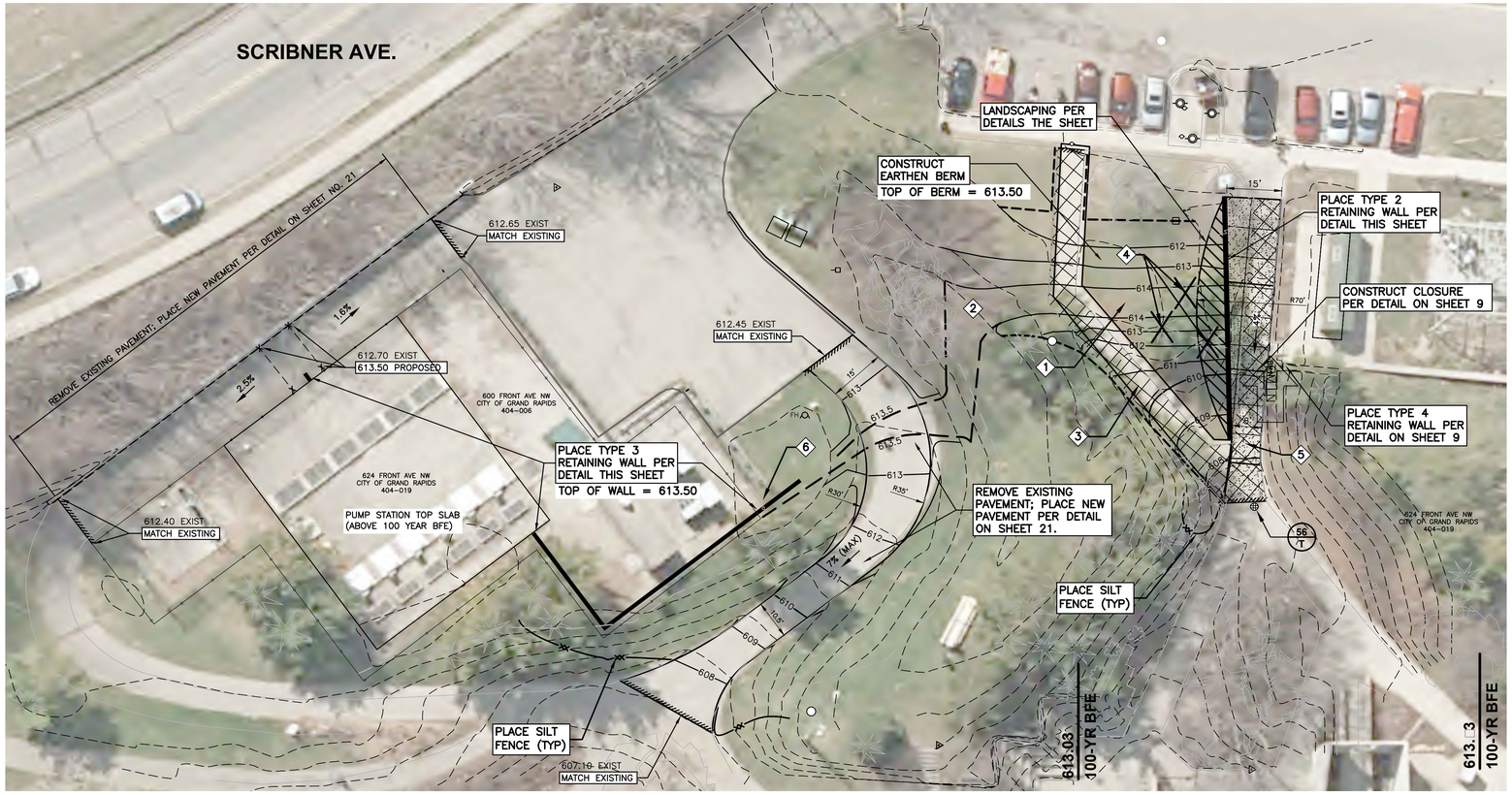
City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

Drawn by NRT	GPF No.	Sheet No.
Check: Field	5426	8 of 23
Check: Office		

PLOT INFO: Z:\2012\120330FB\CAD\CD2\08_120330FB.DWG LAYOUT: 08 DATE: 7/1/2016 TIME: 6:03:31 PM USER: JNK



BENCHMARK

BENCHMARK N ELEVATION: 609.67

CHISELED SQUARE ON SE CORNER OF FIRST CONCRETE STEP, 10 FEET SOUTH AND 6 FEET EAST OF SE CORNER OF RESTROOM BUILDING AT FISH LADDER PARK

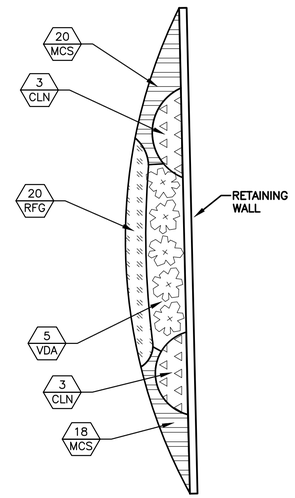
NORTH

SCALE

PLAN: 1"=20'

PLANT LIST

	KEY	BOTANICAL NAME	COMMON NAME	SIZE	ROOT	SPACING
ORNAMENTAL GRASSES	CLN	CHASMANTHIUM LATIFOLIUM	NORTHERN SEA OATS	1 GAL.	CONT.	24" O.C.
PERENNIALS	MCS	MONARDA 'CAMBRIDGE SCARLET'	CAMBRIDGE SCARLET BEE BALM	1 GAL.	CONT.	18" O.C.
	RFG	RUDBECKIA FULGIDA 'GOLDSTURM'	BLACK EYED SUSAN	1 GAL	CONT.	18" O.C.
SHRUBS	VDA	VIBURNUM DENTATUM	ARROWWOOD VIBURNUM	3 GAL.	CONT.	60" O.C.



KEY NOTES

1. REMOVE SOD AND TOPSOIL FROM NEW GRADING AREA. PLACE FILL TO ACHIEVE NEW ELEVATIONS AS SHOWN. TOP OF BERM = 614. PLACE 4" TOPSOIL AND SOD DISTURBED AREAS.
2. PLACE 4" TOPSOIL AND SEED DISTURBED AREAS.
3. REMOVE EXISTING CONCRETE WALK AND GRAVEL BASE.
4. REMOVE EXISTING PINE TREES.
5. PLACE 6" THICK CONCRETE WALK. SAWCUT 8'x8' SQUARES (MAX)
6. REMOVE AND REINSTALL FENCE AND GUARD RAILING.

SOIL EROSION AND SEDIMENTATION CONTROL

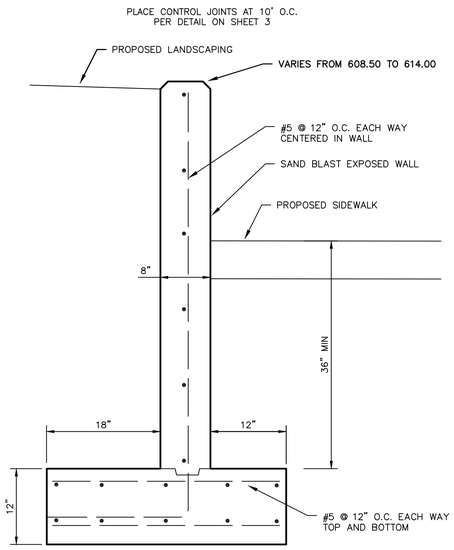
1. SEE SHEET 20 FOR SOIL EROSION AND SEDIMENTATION CONTROL NOTES AND DETAILS.
2. PREDOMINANT SOILS TYPE: URBAN LAND (NRCS WEB SOIL SURVEY)
3. PROXIMITY TO GRAND RIVER: 50 FEET

LANDSCAPING DETAIL

NO SCALE

GRAND RIVER

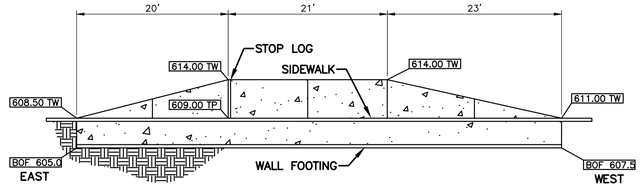
APPROXIMATE FILL VOLUME = 210 CYD



CONCRETE RETAINING WALL - TYPE 2

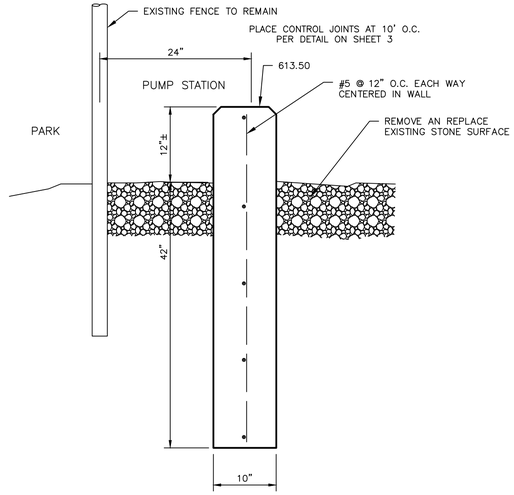
(624 FRONT AVE.)

SCALE: 1"=1'



RETAINING WALL - ELEVATION VIEW

SCALE: 1"=10'



CONCRETE RETAINING WALL - TYPE 3

(624 FRONT AVE.)

NO SCALE

624 FRONT AVENUE FISH LADDER PARK

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
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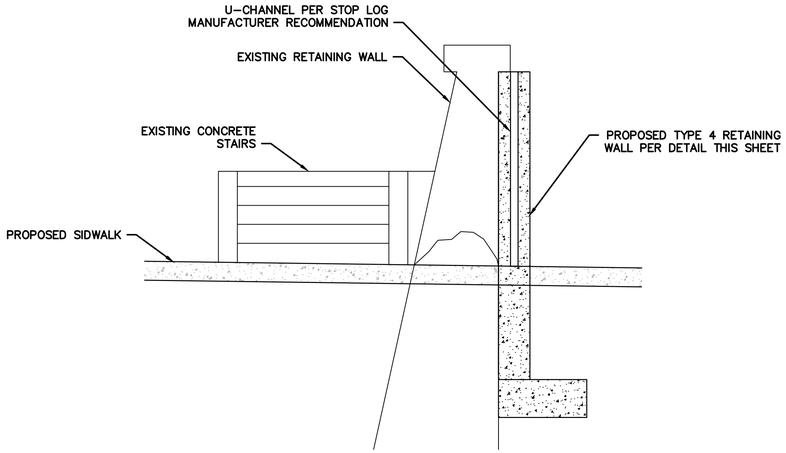
City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

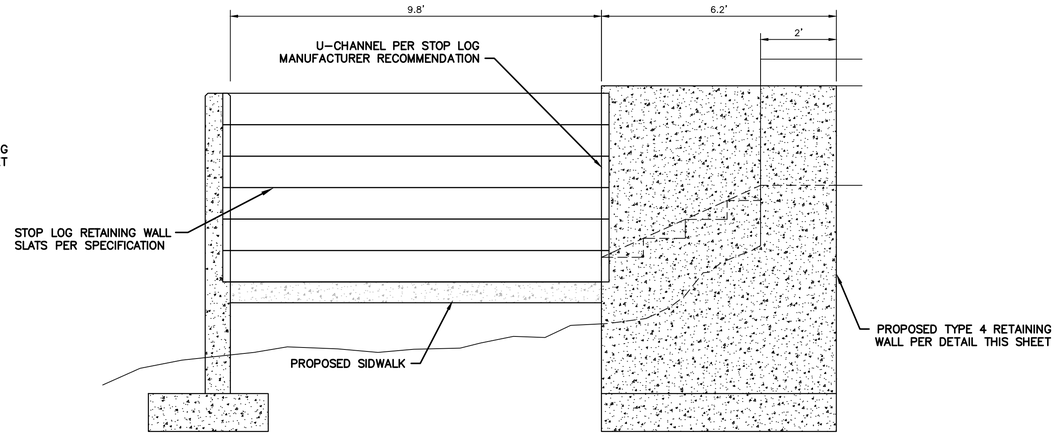
Drawn by NRT	GPF No.	Sheet No.
Check: Field	5426	8 of 23
Check: Office		

PLOT INFO: Z:\2012\120330FB\CAD\CD2\08_120330FB.DWG LAYOUT: 08 DATE: 7/1/2016 TIME: 6:03:31 PM USER: JNK



CLOSURE DETAIL SECTION (B-B)

SCALE: 1"=2'

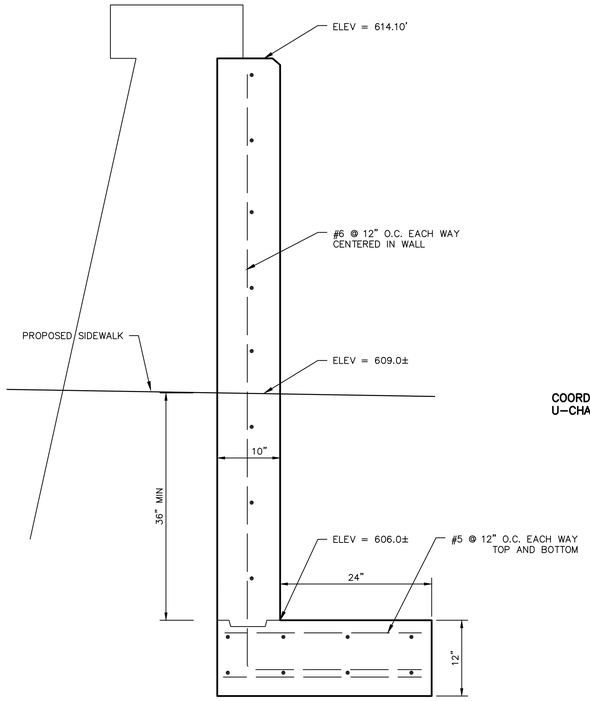


CLOSURE DETAIL SECTION (A-A)

SCALE: 1"=2'

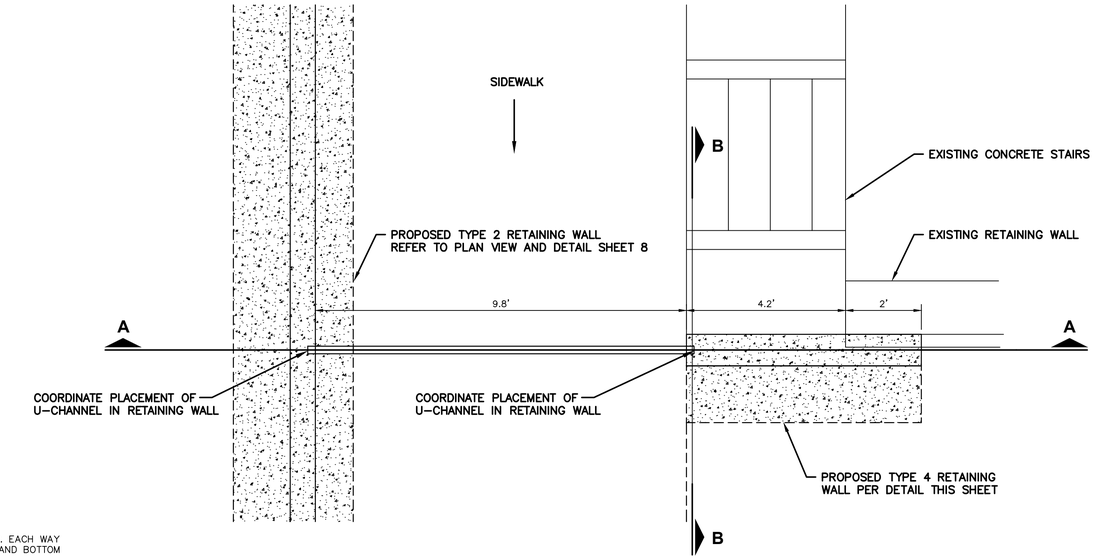
NOTES

1. ASSUMED SOIL CAPACITY = 3000 PSF. SOIL CAPACITY TO BE VERIFIED IN FIELD.
2. PROVIDE KEYWAY AT WALL–FOUNDATION CONNECTION.
3. UNLESS NOTED OTHERWISE, PROVIDE 2" CLEAR COVER TO REINFORCING BARS.
4. USE BLACK REINFORCING BARS.
5. MINIMUM LAP SPLICE LENGTH, IN INCHES, SHALL BE AS FOLLOWS:
   #5 – 17"
   #6 – 20"
   #7 – 32"
6. UNLESS NOTED OTHERWISE, PROVIDE 3/4" CHAMFERS ON ALL EXPOSED EDGES.
7. UNLESS NOTED OTHERWISE, DOWELS AND BENT BARS TO HAVE STANDARD ACI/CRSI 90 OR 180 DEGREE BEND AS INDICATED.



CONCRETE RETAINING WALL - TYPE 4 (624 FRONT AVE.)

SCALE: 1"=1'



CLOSURE DETAIL (PLAN VIEW)

SCALE: 1"=2'

624 FRONT AVENUE FISH LADDER PARK

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO

GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

Drawn by NRT	GPF No.	Sheet No.
Check: Field		☐ of 23
Check: Office		

PLOT INFO: Z:\2012\120330FB\CAD\CD2\09_120330FB.DWG LAYOUT: 09 DATE: 6/29/2016 TIME: 5:50:44 PM USER: JNK

DIVERSCO
CONSTRUCTION

570 Market Ave. SW
Grand Rapids, MI 49503
Ph : 616-458-6379

Letter of Transmittal

To: Jeremy P. McDonald P.E.
FTCH
1515 Arboretum Dr.

Transmittal #: 4
Date: 10/14/16
Job: Grand River Flood Wall Contract #2

Subject: Removable Aluminum Flood Barriers

WE ARE SENDING YOU ✔ Attached — Under separate cover via the following items:

✔	Shop drawings		Prints	–	Plans		Samples
–	Copy of letter		Change order	✔	Specifications	☐	

Document Type	Copies	Date	No.	Description
submittal	1	10/14/16		Removable Aluminum Flood Barriers

THESE ARE TRANSMITTED as checked below:

✔	For approval		Approved as submitted		Resubmit copies for approval
	For your use		Approved as noted		Submit copies for distribution
	As requested	–	Returned for corrections	–	Return corrected prints
	For review and comment	–			
–	FOR BIDS DUE		PRINTS RETURNED AFTER LOAN TO US		

Remarks:

Copy To:

From: Mark A. Robinson Manager **Signature:**

If enclosures are not as noted, kindly notify us at once.

DIVERSCO
CONSTRUCTION

570 Market Ave. SW
Grand Rapids, MI 49503
Ph : 616-458-6379

Submittal

Job: Grand River Flood Wall Contract #2

Spec Section No:
Submittal No: 4
Revision No:
Sent Date: 10/14/16

Spec Section Title: Removable Aluminum Flood Barriers

Submittal Title: Removable Aluminum Flood Barriers

Contractor:
DIVERSCO CONSTRUCTION CO.

FISHBECK, THOMPSON, CARR & HUBER, INC.

Submittal Review	
REVIEWED, NO EXCEPTIONS NOTED	☒
REVIEWED WITH CORRECTIONS NOTED	☐
REVISE AND RESUBMIT	☐
REJECTED, RESUBMIT	☐
RECEIVED FOR RECORD	☐

FTC&H's review and approval of this submittal are expressly limited as provided in the Contract Documents and are only to determine compliance with information given in Contract Documents and conformance with design concept of completed Project as a functioning whole. CONTRACTOR is, and FTC&H is NOT, responsible for all matters relating to fabrication, shipping, handling, storage, assembly, installation and construction, for all safety aspects of performing the Work and for coordinating the Work.

Joe Platte, PE 10/20/16
Signature Date

☐ REVIEW MEMO ATTACHED

4

Contractor's Stamp

Diversco Construction Co., Inc.

☒ Approved ☐ Resubmit
☐ Approved As Noted ☐ Reviewed

Date 10-19-16

This action does not release supplier or subcontractor from complete compliance with plans.

Architect's Stamp

Engineer's Stamp

FLOOD PANEL

INDEX:

General Notes	Notes
Elevations and plan	A1
Details	J, MS, MS.1

Approval Stamp

STATE OF MICHIGAN
JOSEPH R. PLATTE
ENGINEER
No. 43898
LICENSED PROFESSIONAL ENGINEER

Approval Review

☒ Approved for release to production

☐ Approved as corrected for release to production

☐ Revise and re-submit

☐ Submit specific item

This review is only for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Corrections or comments made on the shop drawings during this review do not relieve the contractor from compliance with the plans and specifications. Approval of a specific item shall not include approval of an assembly of which the item is a component. Contractor is responsible for: dimensions to be confirmed and correlated at the job site. This review does not pertain to the fabrication process or to the means, methods, sequences and procedures of construction or installation of this product or coordination of the work of all trades and for performing all work in a safe and satisfactory manner.

Approved By (signature): Joseph R Platte

Approved By (Print Name): Joseph R. Platte

Company Name: FTCH

Approval Date: 10/20/2016

JOB LOCATION	ARCHITECT OF RECORD	ENGINEER OF RECORD	FLOOD CERTIFICATE ENDORSEMENT:
ADDRESS:	ARCHITECT NAME:	ENGINEER NAME: Joseph R Platte	NAME OF AOR OR EOR
	COMPANY NAME:	COMPANY NAME: FTCH	
	ADDRESS:	ADDRESS: 1515 Arboretum Dr.	
	CITY/STATE:	CITY/STATE: Grand Rapids, MI 49546	
	PHONE:	PHONE: 616-464-3937	

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ARCHITECTURE METALS LTD/FLOOD PANEL LLC
5500 MILITARY TRAIL
SUITE 22-220
JUPITER, FL 33458
561-744-2727 FAX 561-744-2755
WWW.FLOODPANEL.COM

TITLE: Improvements to Grand River

DATE: 10.13.16

AS-BUILT
6/2017

GENERAL NOTES IBC:

1. The structural design of these removable flood panels has been designed for hydrostatic flood loads with water pressures corresponding to maximum water height as depicted in the enclosed drawings plus hydrodynamic pressure. Free board of 1 foot in ht. is added to the system height of each opening in accordance with the documents listed below in notes 2,3 and 5.
2. It shall be determined, on a job by job basis, the required Panel height and flow speed for the design of Removable Flood Panels, based on FEMA's criteria (See Note #3) as well as per ASCE 24–05 Standard. Installation and construction of these Flood Panels for use within flood hazard areas shall be in accordance with the American Society of Civil Engineers Flood Resistant Design and Construction Standard SEI/ASCE 24–05.
3. Design criteria has been based on the 2012 Edition of the International Building Code, the corresponding provisions of ASCE 24–05, FEMA flood proofing non–residential structures manual FEMA 102, FEMA P–936 dated July, 2013 and FEMA Technical Bulletin 3–93. Design flood loads have been determined in accordance with ASCE 7–10. Design wind loads have been determined in accordance with ASCE 7–10 for 130 mph Basic Wind Speed for category 2 building.
4. Flood Panels shall not be installed within areas where ice flows or ice jams occur.
5. In order to certify flood elevation, Flood Panel design have tested by an independent testing lab for water infiltration in accordance with FEMA 102 manual for flood proofing of non–residential structures, specifications Section 8, Page 70.
6. Flood Panel installer to use gaskets and approved sealants following all the recommendations and specifications of the manufacturers respectively.
7. Owner, General contractor or installer to verify all dimensions, wall and floor conditions at site before proceeding with the work, and shall notify this engineer if any discrepancy is found that would alter the structural design of these Flood Panels.
8. Existing slabs and walls adjacent to opening where Flood Panel is to be installed shall be given a surface treatment by means of water proof sealer before flood Panel is installed. Surface must be smooth, square, plumb and level.
9. Existing slabs and walls adjacent to openings where Flood Panels are to be installed shall be structurally designed by engineer of record, to sustain the same hydrostatic, hydrodynamic and impact pressures that correspond to maximum water elevation above finished floor at top of Panel , based on criteria mentioned on Note #3.
10. Drop–in anchors embedded into concrete for removable support installation shall be covered with a cap or similar device to protect their inside hold from dust, so that machine screws can easily be installed at time of flood warning. Concrete anchors by others.
11. Separation of Panel to window/door shall be measured from back of Panel to window/door including any knob, handle, or protruding device, and shall be 2" minimum.
12. All aluminum extrusions to be 6063–T6 alloy, and 6005–T5 alloy.
13. All sheet metal screws shall be as manufactured by ITW/Buildex "TEK Screws", and to be made of non–corrosive material.
14. All bolts to be galvanized steel ASTM A–307 designation or 304 Series Stainless Steel.
15. All gaskets installed shall be neoprene per drawings.
16. All welding to conform to the American Welding Society AWS D1.2. 1998 Regulations. Use certified welders. Use ER–5356 Electrodes.
17. The engineer, Architecture Metals Ltd. or Flood Panel LLC. is not responsible for construction safety at site which is the owner, general contractor or installer's responsibility. Flood Panel Manufacturer to be responsible for providing the tenant with shop drawings and proper instructions for the installation of these Flood Panels.
18. Surfaces against which the sealing gasket presses must be built "paper–smooth" to prevent excessive water extrusion, beyond that allowed by requirements. All surfaces must be plumb, square and level.
19. To receive a warranty for the flood barriers provided by Flood Panel LLC as depicted in this set of drawings, the following information must be provided by the building owner to Flood Panel LLC:

To receive credit for flood proofing, a completed Flood proofing Certificate for Non–Residential Structures is required for non–residential and business buildings in the Regular Program communities, located in zones A1–A30, AE, AR, AR Dual, AO, AH, and A with BFE.

In order to ensure compliance and provide reasonable assurance that due diligence had been applied in designing and constructing flood proofing measures, the following information must be provided with the completed Flood proofing Certificate:

1. Photographs of shields, gates, barriers, or components designed to provide flood proofing protection to the structure installed and deployed on the building.
2. Written certification that the barrier system was inspected during and after initial installation and is installed per the drawings, engineering and instructions provided by the manufacturer.
3. Written certification that the envelope of the structure is watertight with walls substantially impermeable to the passage of water required under 44 Code of Federal Regulations (44 CFR 60.3 (c)(3))
4. A comprehensive Maintenance Plan for the entire structure to include but not limited to:
   - Exterior envelope of the structure
   - All penetrations to the exterior of the structure
   - All shields, gates, barriers, or components designed to provide flood proofing protection to the structure
   - All seals or gaskets for shields, gates, barriers, or components
   - Location of all shields, gates, barriers, and components as well as all associated hardware, and any
   - Materials or specialized tools necessary to seal the structure.

U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
National Flood Insurance Program
NFIP Flood proofing

19. Responsibility for filing the building "Flood Proofing Certificate" is the responsibility of the owner's architect and/or engineer and not of Architecture Metals Ltd. or Flood Panel LLC.

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General Notes

ARCHITECTURE METALS
FLOOD LOG SHOP
DRAWINGS

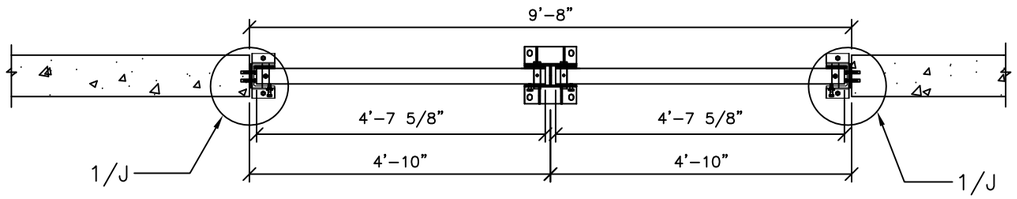
No.	Revision/Issue	Date

Firm Name and Address
ARCHITECTURE METALS
5500 MILITARY TRAIL
STE 22–220
JUPITER, FL 33458
561–630–0020

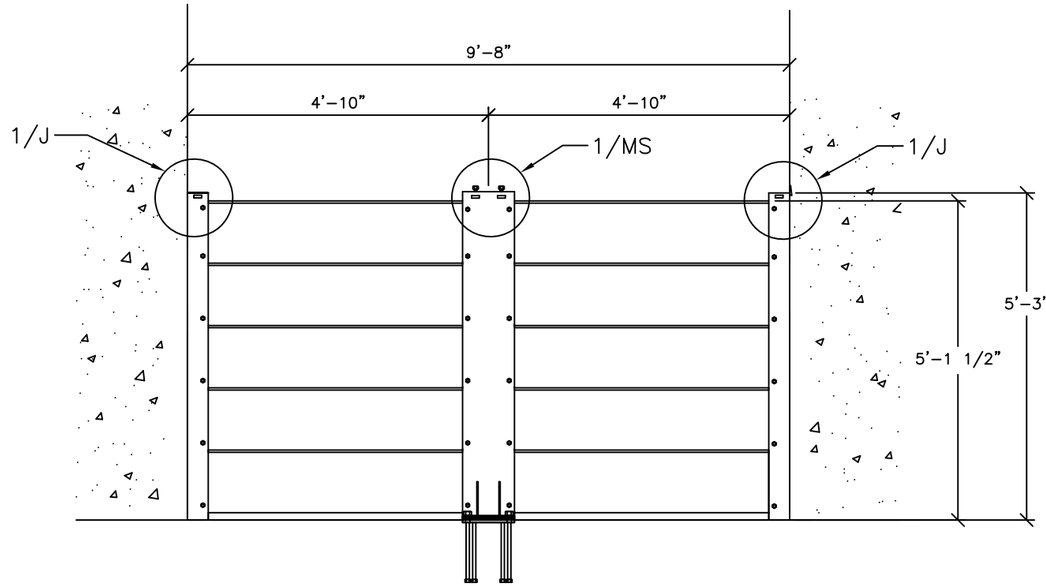
Project Name and Address
IMPROVEMENTS
TO GRAND RIVER

Project
Date 10.13.16
Scale NTS
Sheet NOTES

PLAN



ELEVATION



OPENING 01
FLOOD LOG ARRAY
J/MS/J
60" HT.
NTS

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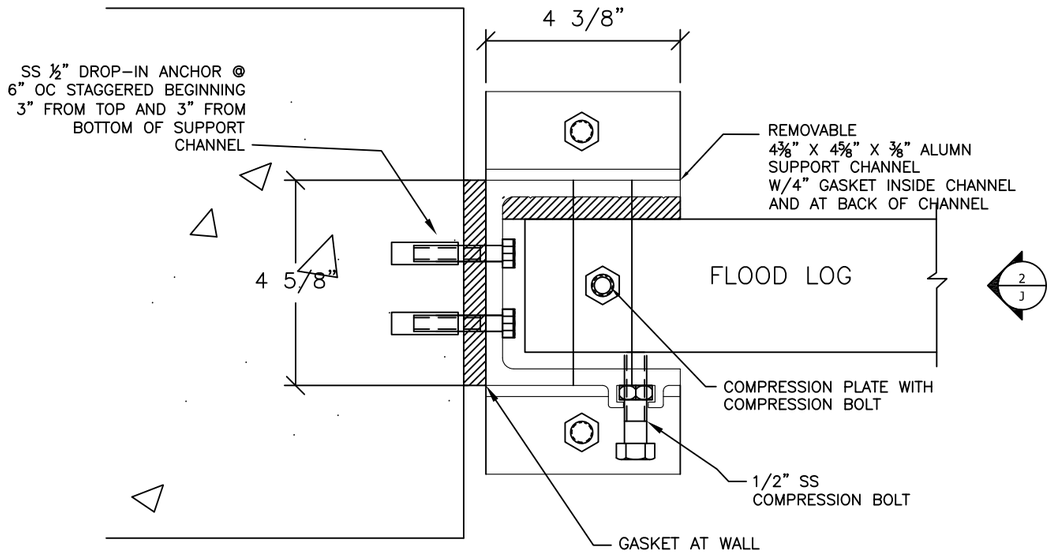
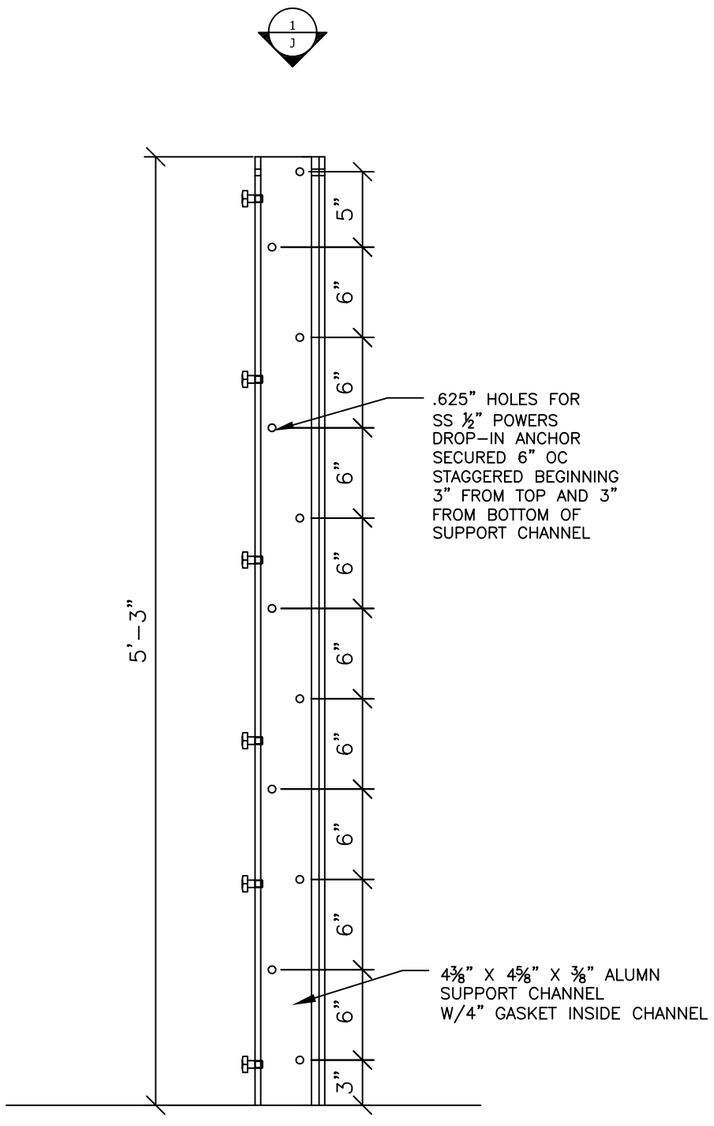
JUPITER, FL 33458
561–630–0020

Project Name and Address
IMPROVEMENTS
TO GRAND RIVER

Project	Sheet
Date 10.13.16	A1
Scale NTS	



1/J
PLAN VIEW JAMB MOUNT
REMOVABLE SUPPORT BRACKET
NTS



2/J
5 FT FLOOD LOG HT
REMOVABLE ALUMN. JAMB
MOUNT WALL SUPPORT BRACKET
JAMB VIEW

General Notes

ARCHITECTURE METALS
FLOOD LOG SHOP DRAWINGS

No.	Revision/Issue	Date

Firm Name and Address
ARCHITECTURE METALS
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STE 22–220
JUPITER, FL 33458
561–630–0020

Project Name and Address
IMPROVEMENTS TO GRAND RIVER

Project	Sheet
Date 10.13.16	J
Scale NTS	

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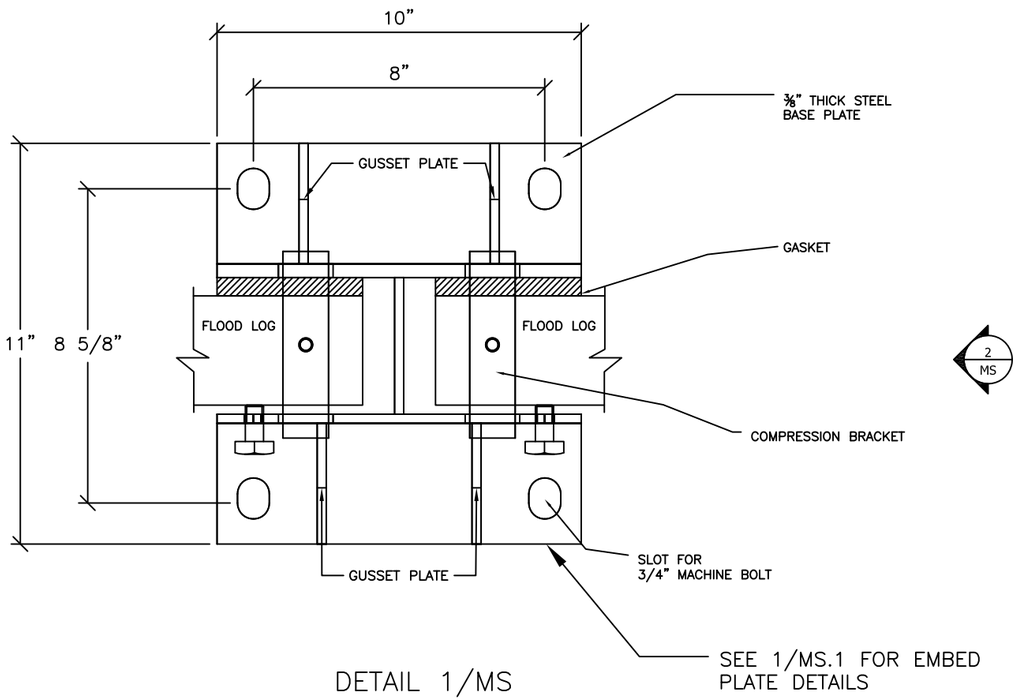
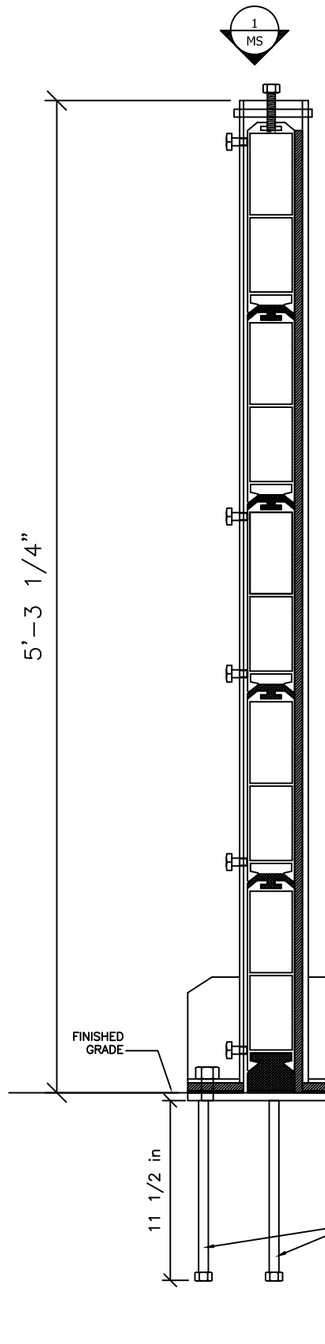


DETAIL 1/MS
PRIMED/PAINTED STEEL
MID–SPAN SUPPORT
BRACKET PLAN VIEW
NTS



DETAIL 2/MS
PRIMED STEEL
MID–SPAN
SUPPORT
BRACKET
SECTION VIEW
NTS

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General Notes

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FLOOD LOG SHOP
DRAWINGS

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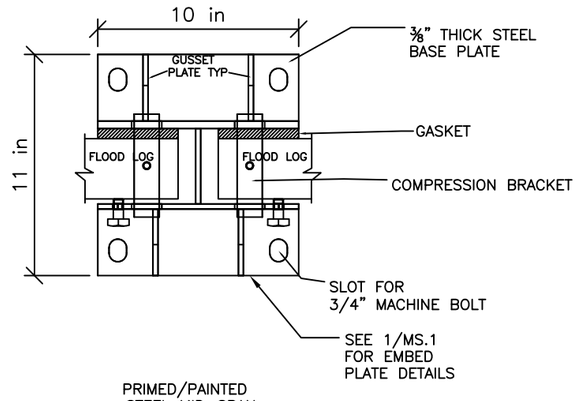
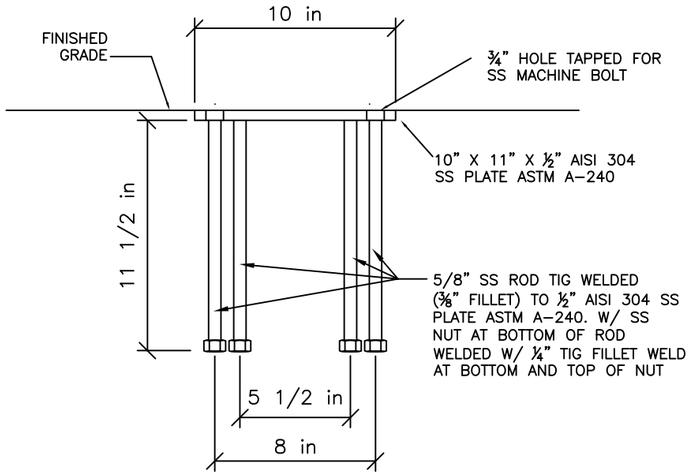
ARCHITECTURE METALS
5500 MILITARY TRAIL
STE 22–220
JUPITER, FL 33458
561–630–0020

Project Name and Address
IMPROVEMENTS
TO GRAND RIVER

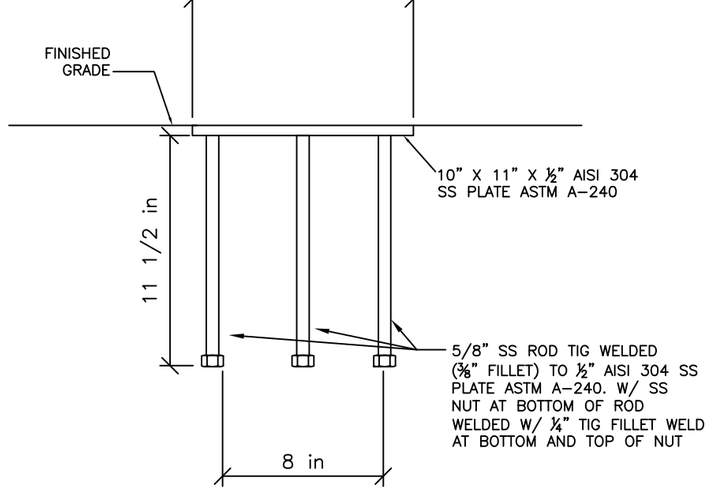
Project	Sheet
Date 10.13.16	MS
Scale NTS	



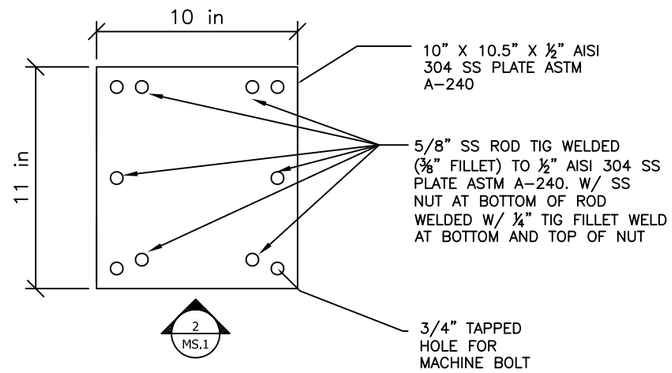
PRIMED/PAINTED STEEL MID-SPAN SUPPORT BRACKET PLAN VIEW NTS



DETAIL 2/MS.1
MID-SPAN SUPPORT EMBED PLATE SECTION



DETAIL 3/MS.1
MID-SPAN SUPPORT EMBED PLATE SECTION



DETAIL 1/MS.1
MID-SPAN SUPPORT EMBED PLATE PLAN

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General Notes

ARCHITECTURE METALS
FLOOD LOG SHOP
DRAWINGS

No.	Revision/Issue	Date

Firm Name and Address
ARCHITECTURE METALS
5500 MILITARY TRAIL
STE 22-220
JUPITER, FL 33458
561-630-0020

Project Name and Address
IMPROVEMENTS TO GRAND RIVER

Project	Sheet
Date 10.13.16	MS.1
Scale NTS	

Appendix 2

Inflatable Plug Manufacturer's Literature

Test Ball® Plugs – Underground

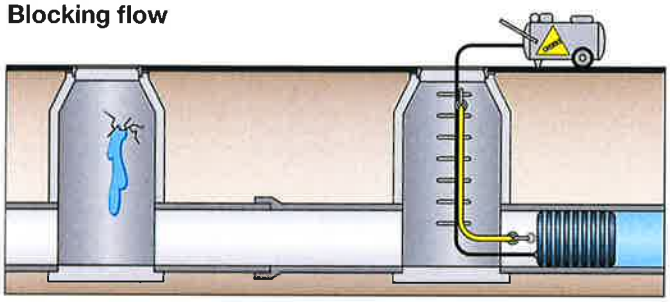
Cherne's Original Single Size and Multi-Size Test Ball Plugs are our most economical pneumatic plugs for blocking flow to do maintenance in sanitary and storm sewer systems. These plugs may also be used as a back plug for sewer air tests.

All of the single-size and multi-size Test Ball plugs have eyebolts for attaching a rope or clevis for lifting and lowering the plug. And each plug also has a removable Schrader valve for easy replacement or substitution with a quick disconnect fitting.

Made from natural rubber, these plugs are tough, tear-resistant and will work on any type of pipe, including out-of-round pipe.



Blocking flow



Single Size Original Test Balls

Part Number	Nominal Size	Usage Range	Maximum Back Pressure		Inflation Pressure	Product Weight	Deflated Length	Deflated Diameter	Inflation Thread	Chain / Eye bolts
041386	8" (200 mm)	7"-8.25" (178-210 mm)	17 psi (1,2 bar)	40 ft. (12 M)	25 psi (1,7 bar)	3.4 lbs (1.6 kg)	10.25" (257 mm)	6.75" (172 mm)	1/4" (1)	3/8" (1)
041394	10" (250 mm)	9"-10.25" (229-260 mm)	17 psi (1,2 bar)	40 ft. (12 M)	25 psi (1,7 bar)	5.6 lbs (2.5 kg)	11.75" (298 mm)	8.75" (221 mm)	1/4" (1)	3/8" (1)
041408	12" (300 mm)	10.5"-12.25" (267-311 mm)	17 psi (1,2 bar)	40 ft. (12 M)	25 psi (1,7 bar)	10.9 lbs (5 kg)	13.75" (351 mm)	10.25" (262 mm)	1/4" (1)	3/8" (1)
041416	15-16" (375-400 mm)	14" - 16.25" (356-413 mm)	13 psi (0,9 bar)	30 ft. (9,1 M)	25 psi (1,7 bar)	29.5 lbs (13.4 kg)	19.75" (502 mm)	13.75" (346 mm)	1/4" (1)	3/8" (2)

Multi-Size Original Test Balls

Part Number	Nominal Size	Usage Range	Maximum Back Pressure		Inflation Pressure	Product Weight	Deflated Length	Deflated Diameter	Inflation Thread	Chain / Eye bolts
275048	4" - 6" (100-150 mm)	3.75"-6.25" (92-159 mm)	17 psi (1,2 bar)	40 ft. (12 M)	30 psi (2,1 bar)	2 lbs (0.91 kg)	9.8" (250 mm)	3.5" (85 mm)	1/8" (1)	1/4" (1)
275058	6" - 8" (150-200 mm)	5.25"-8.25" (135-210 mm)	17 psi (1,2 bar)	40 ft. (12 M)	30 psi (2,1 bar)	3.5 lbs (1.6 kg)	14" (356 mm)	5" (127 mm)	1/4" (1)	3/8" (1)
275088	8" - 12" (200-300 mm)	7"-12.25" (178-311 mm)	11 psi (0,75 bar)	25 ft. (8 M)	20 psi (1,4 bar)	6.63 lbs (3 kg)	16" (406 mm)	6.75" (171 mm)	1/4" (1)	3/8" (1)
275128	12" - 18" (300-450 mm)	10.75"-18.25" (273-464 mm)	11 psi (0,75 bar)	25 ft. (8 M)	25 psi (1,7 bar)	22.4 lbs (10.2 kg)	24" (610 mm)	10.5" (267 mm)	1/4" (1)	3/8" (1)

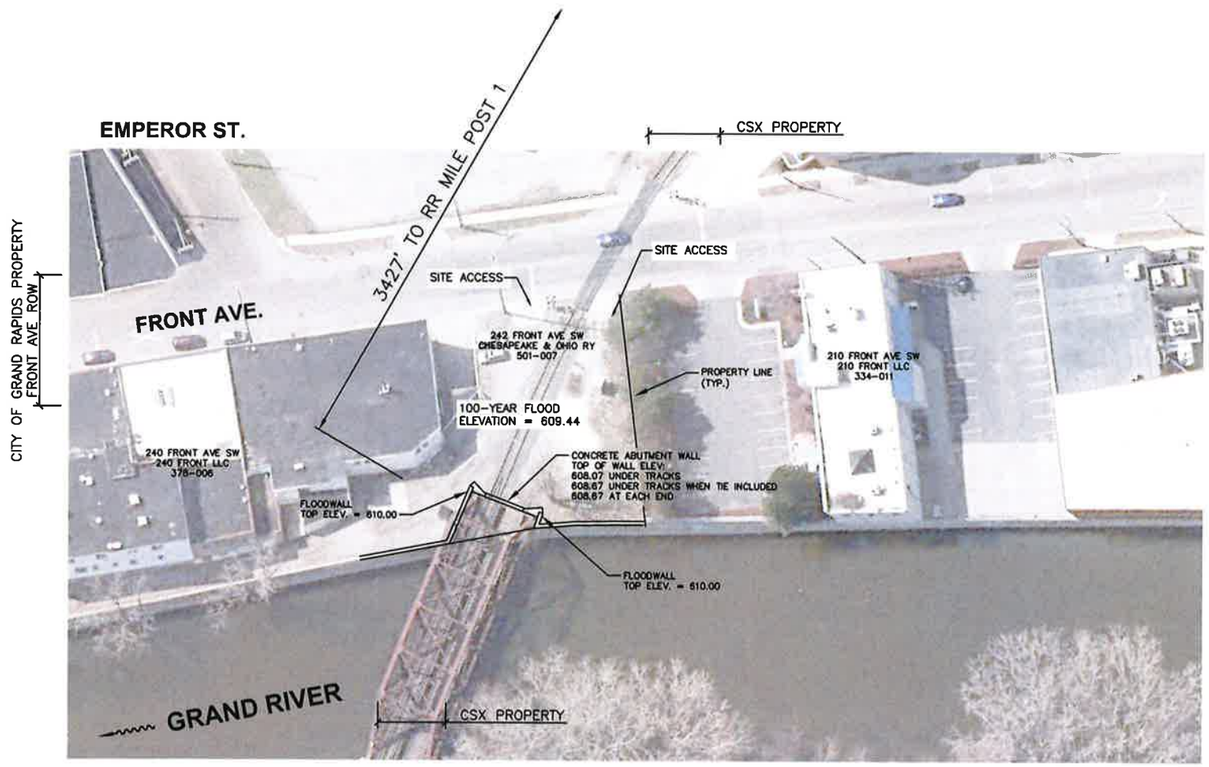
Always block plugs when conducting air tests.

Appendix 3

CSX RR Bridge Closure Structure

SHEET 1 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 1
Sheet: 1 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: 1" = 40'



EXISTING CONDITIONS
SCALE: 1" = 40'-0"

NORTH



PROPOSED IMPROVEMENTS
SCALE: 1" = 40'-0"

NORTH

STATE OF MICHIGAN
LICENSED PROFESSIONAL ENGINEER
JOSEPH R. PLATTE
ENGINEER
No.
43898

Joseph R Platte

fteh

engineers
scientists
architects
constructors

fishbeck thompson carr & huber, inc
www.ftch.com

CITY OF GRAND RAPIDS
CSX RAILROAD BRIDGE - WEST ABUTMENT
TEMPORARY FLOOD CONTROL CLOSURE

REVISIONS

As built
10/19
Joseph R Platte

Drawn By
Designer
Reviewer
Manager

Hard copy is intended to be 22"x34" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

PROJECT NO.
120330FB

SHEET NO.
1 of 7

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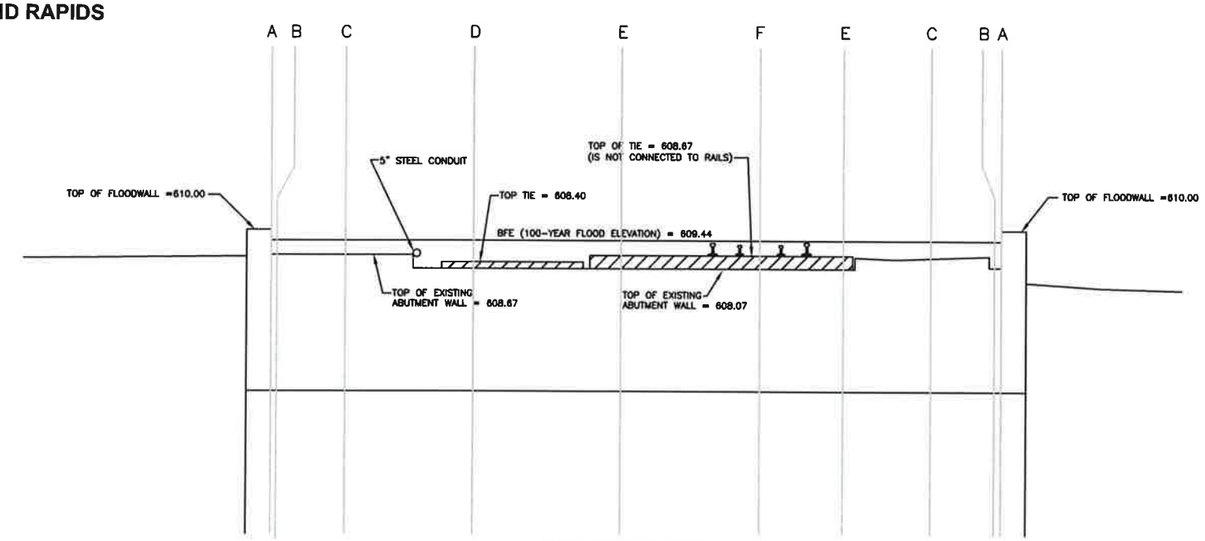
All Rights Reserved

PLOT INFO: Z:\2019\120330FB\WORK\PERMITS\REGULATORY\CSX CLOSURE PERMIT\SHEETS 1 THROUGH 8 TEMPORARY OPTION 3.DWG LAYOUT: 01_PLAN VIEW OF SITE DATE: 8/13/2019 TIME: 3:31:24 PM USER: JRP

SHEET 2 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 2
Sheet: 2 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: 1" = 4'



EXISTING SECTION
(LOOK EAST TOWARDS THE GRAND RIVER)
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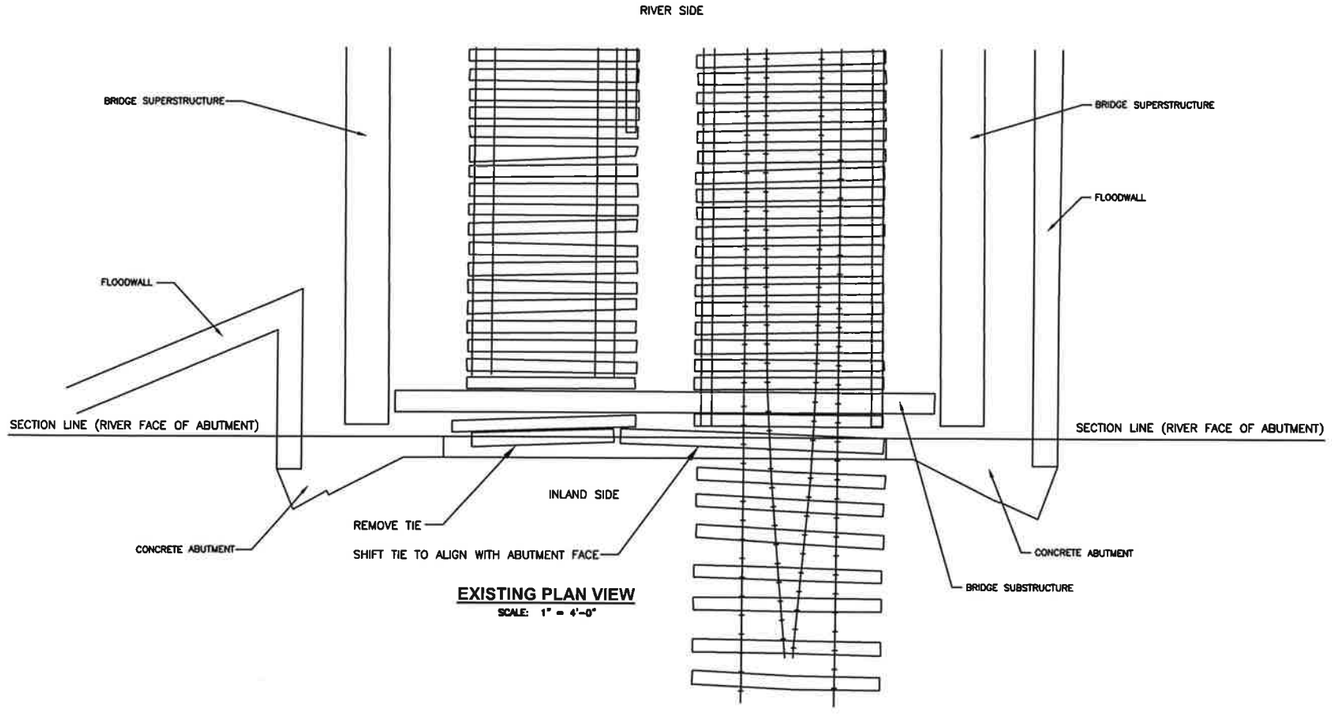

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ENGINEER
No.
43898
LICENSED PROFESSIONAL ENGINEER

Joseph R Platte

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CITY OF GRAND RAPIDS
CSX RAILROAD BRIDGE - WEST ABUTMENT
TEMPORARY FLOOD CONTROL CLOSURE

REVISIONS
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10/2019
Joseph R Platte

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Designer
Reviewer
Manager

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SHEET NO.
2 of 7

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SHEET 3 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

NORTH PORTION OF TEMPORARY CLOSURE
(SEE SHEET 4 FOR SOUTH PORTION)
(SEE SHEET 5 FOR CROSS-SECTIONS)

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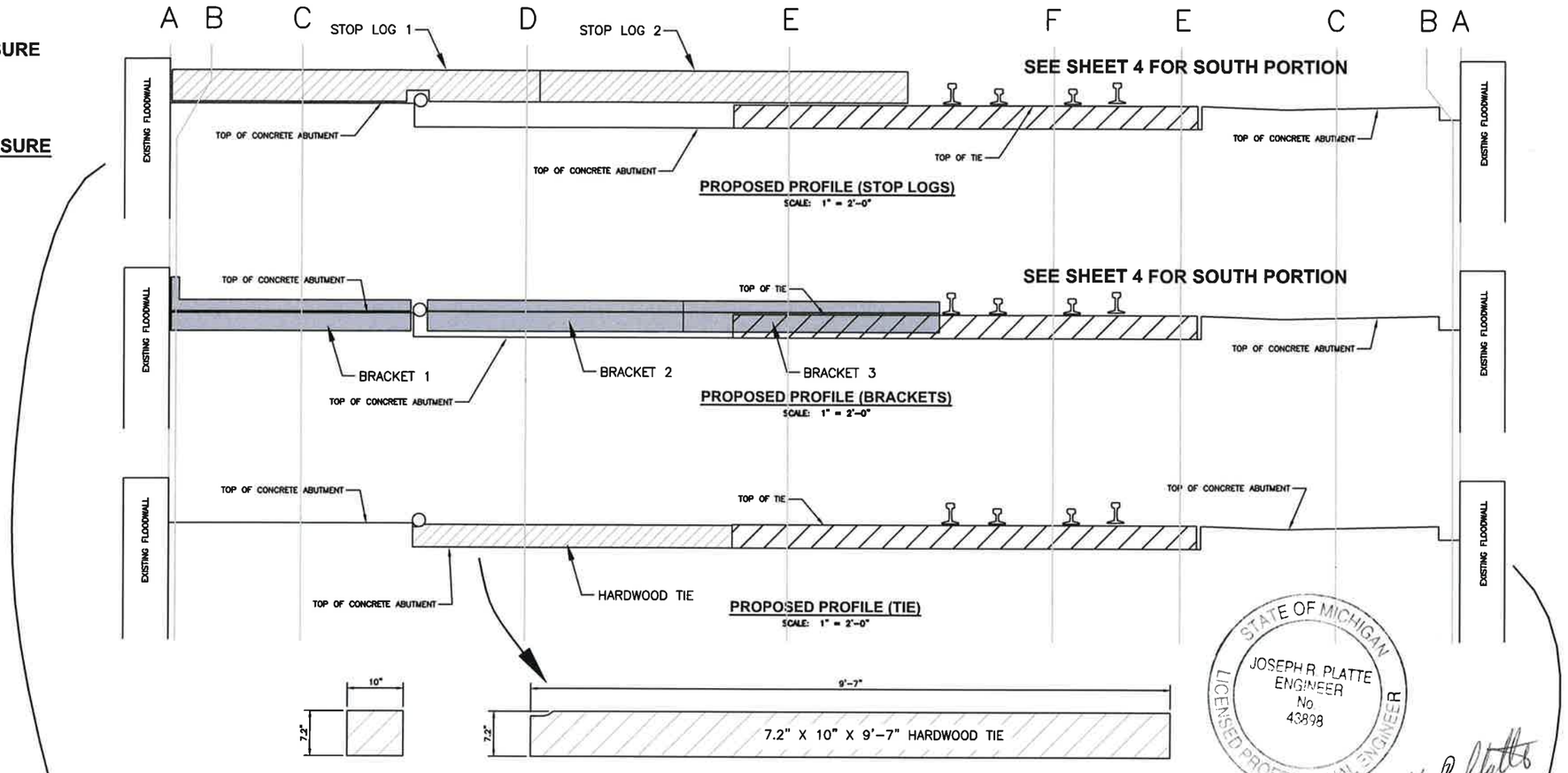
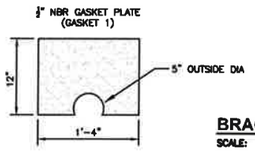
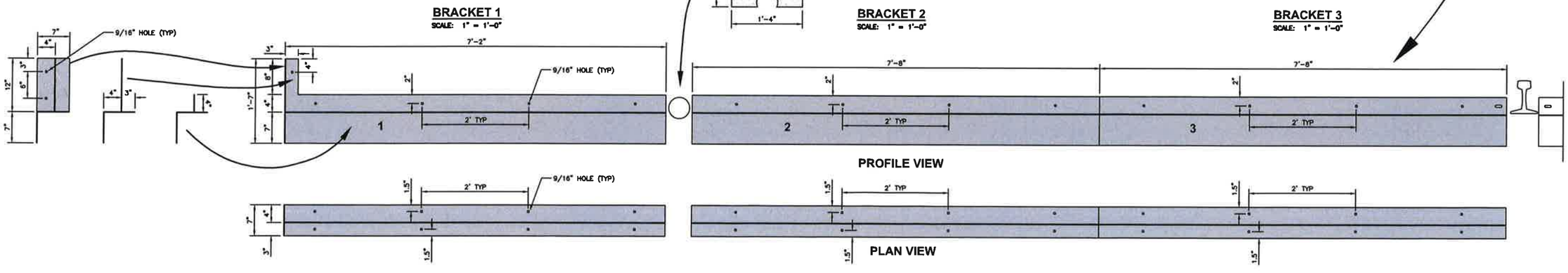
Longitude: -85.681464
Drawing No.: 3
Sheet: 3 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: See Details









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SHEET 4 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

SOUTH PORTION OF TEMPORARY CLOSURE
(SEE SHEET 3 FOR NORTH PORTION)
(SEE SHEET 5 FOR CROSS-SECTIONS)

Location: CITY OF GRAND RAPIDS
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Longitude: -85.681464
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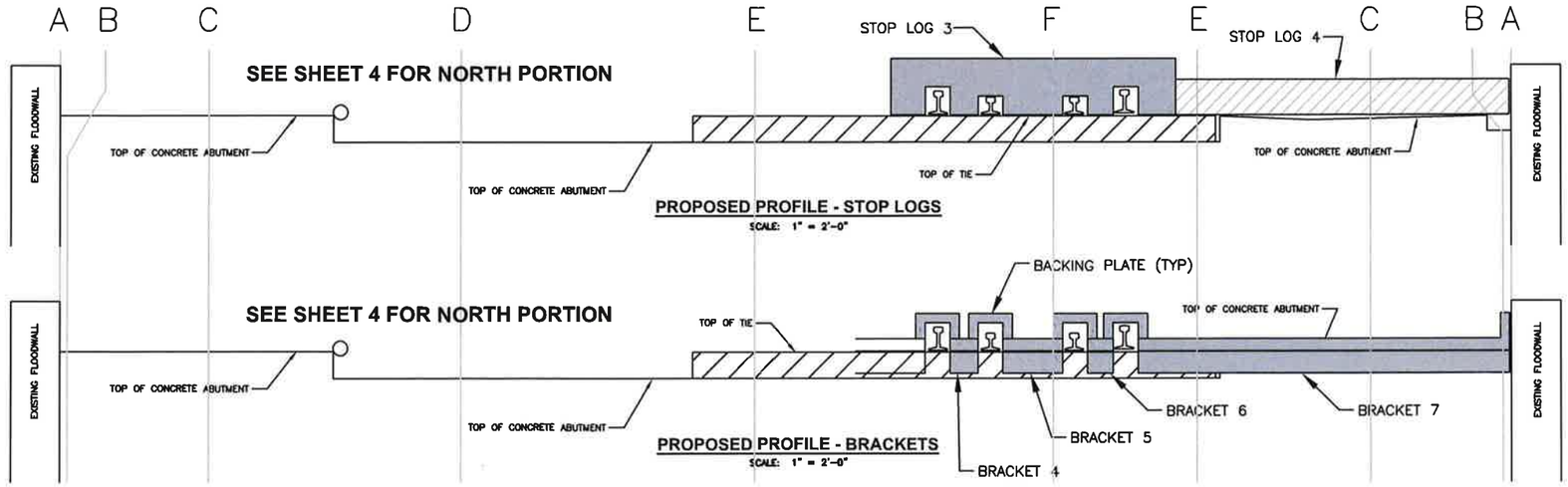
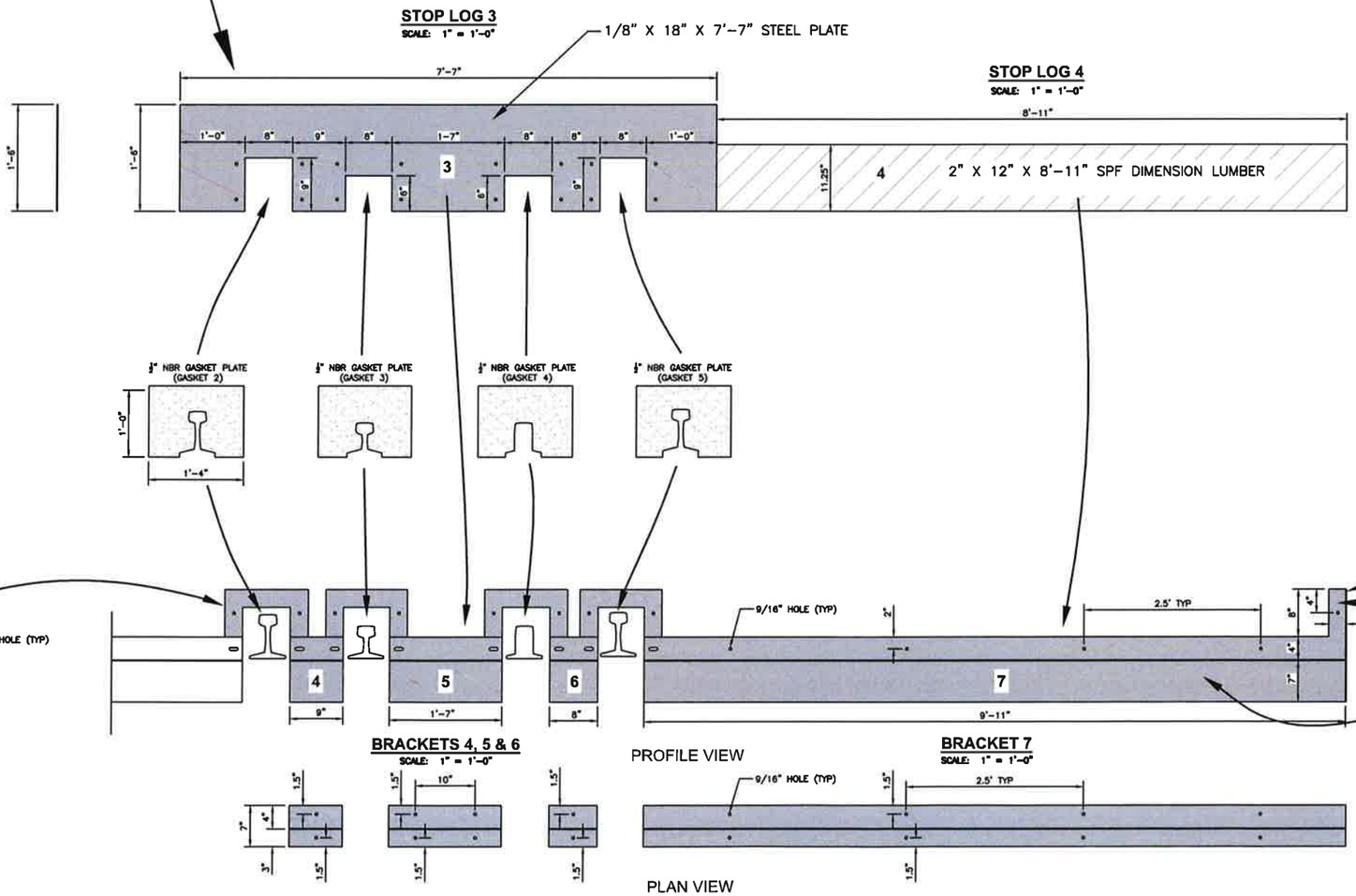
Sheet: 4 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: See Details





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SHEET 5 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
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Location: CITY OF GRAND RAPIDS
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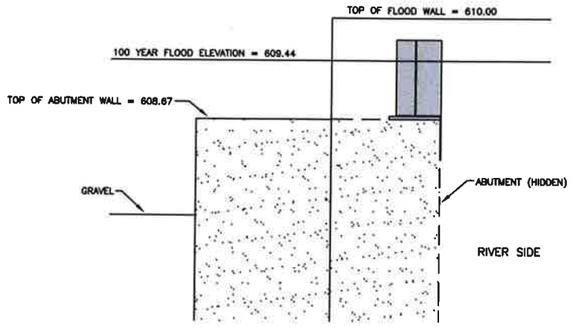
Drawing No.: 5
Sheet: 5 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: See Details



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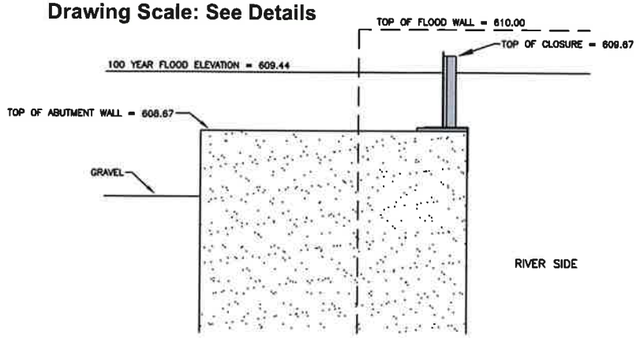

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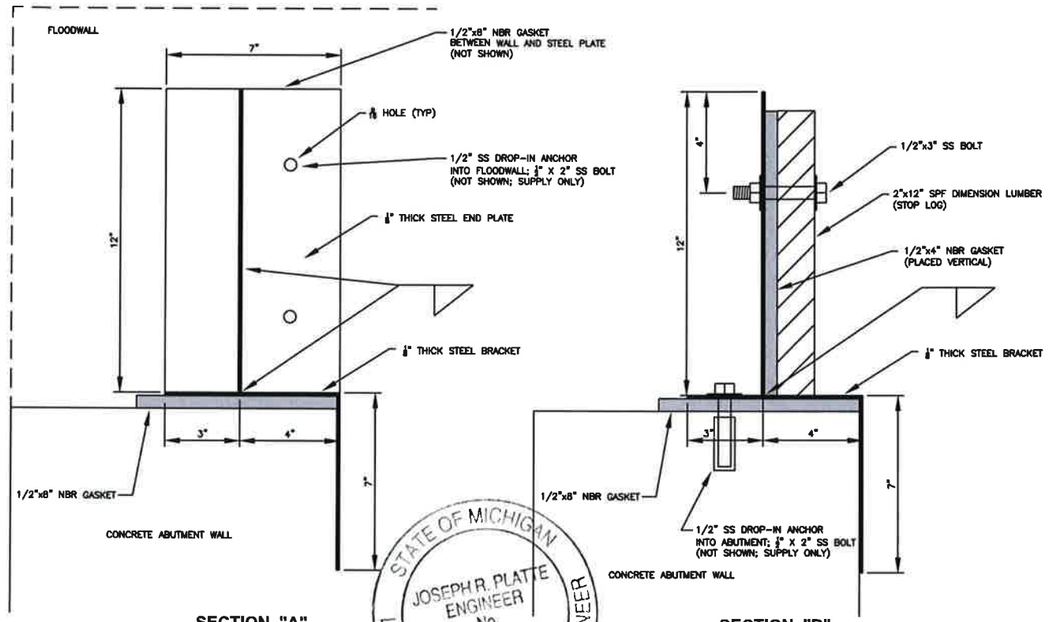

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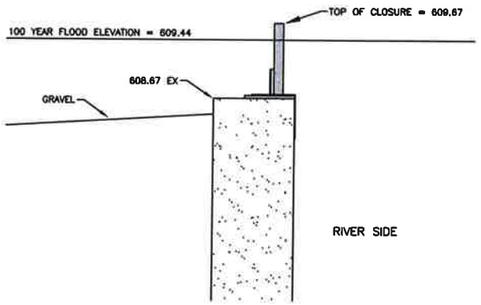

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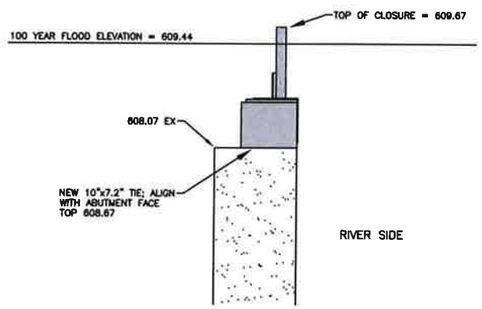

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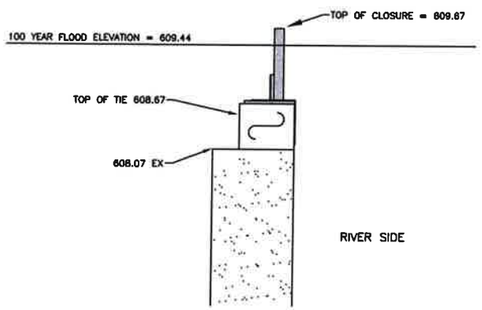

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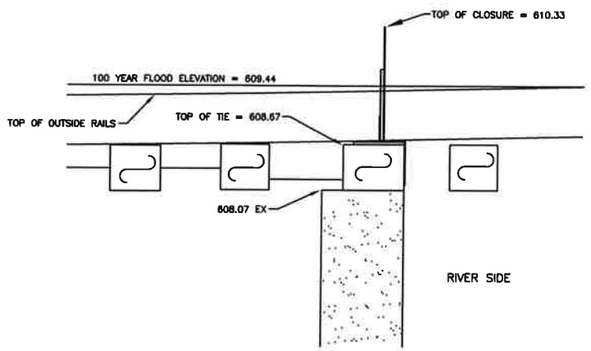

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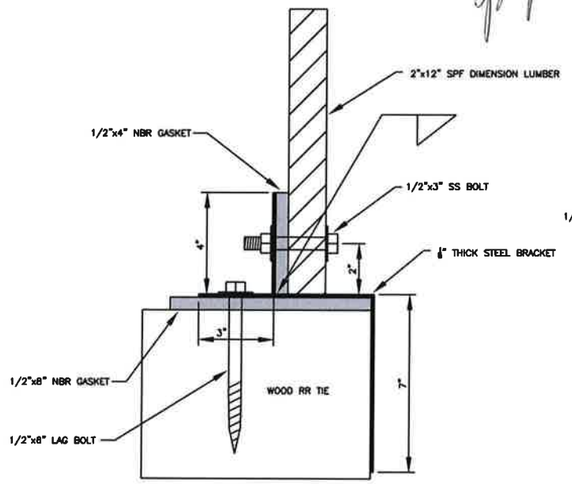

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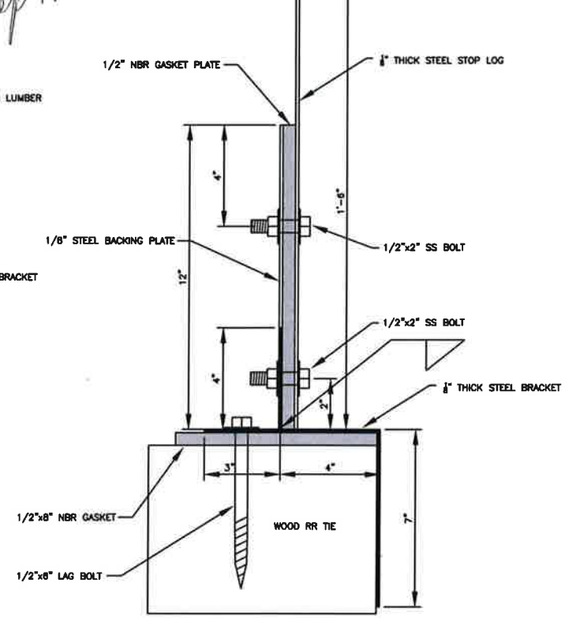

SECTION "F"
SCALE: 1" = 3"

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DRAWING NO. 1
SHEET 6 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

100–YEAR FLOOD ELEVATION = 609.44

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 6
Sheet: 6 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: NA



NORTH SIDE LOOKING TOWARD RIVER



SOUTH SIDE LOOKING TOWARD RIVER

SOUTH SIDE LOOKING TOWARD RIVER

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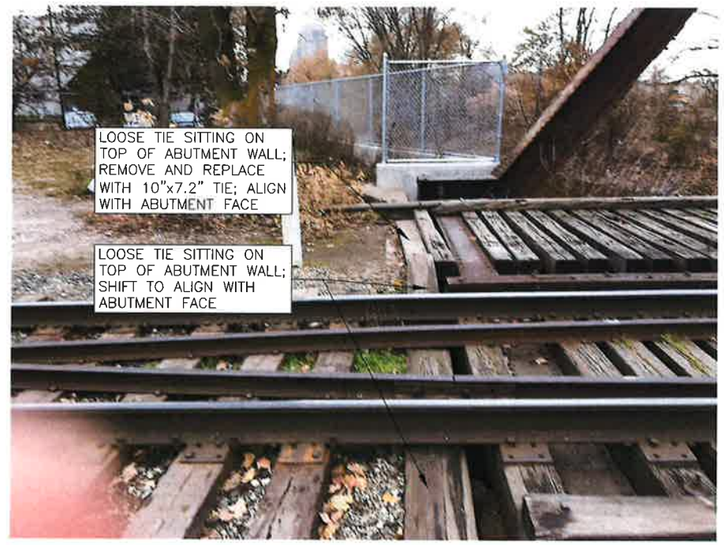
SHEET 7 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

100-YEAR FLOOD ELEVATION = 609.44

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 7
Sheet: 7 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: NA



SOUTH SIDE LOOKING NORTH



SOUTH SIDE LOOKING NORTH



SOUTH SIDE LOOKING NORTH

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Grand River Flood Protection System
44 CFR 65.10 (b)(3)
Embankment Protection Analysis

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

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44 CFR 65.10 (b) (3) Tab

(3) *Embankment protection.* Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

P.E. Signature: Peter W. Soltys

Non Applicable: _____

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

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Grand River Flood Protection System
44 CFR 65.10 (b)(3)
Embankment Protection Analysis

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

January 31, 2020
Project No. 120330LMP

Final

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Plate 1 Grand River Flood Protection System

List of Abbreviations/Acronyms

City	City of Grand Rapids
DFIRM	Digital Flood Insurance Rate Map
EM	Engineer Manual
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FMMP	Flood Map Modernization Program
GRFPS	Grand River Flood Protection System
LAMP	Levee Analysis Mapping Procedures
MDEQ	Michigan Department of Environmental Quality
MDOT	Michigan Department of Transportation
NAVD88	North American Vertical Datum of 1988
USACE	U.S. Army Corps of Engineers

1.0 Introduction

The Grand River Flood Protection System (GRFPS), shown in Figure 1, is along the Grand River in Grand Rapids, Michigan and consists of the following:

- Approximately 22,760 feet of earthen embankment levee including 12,670 feet along the left (east) bank and 10,090 feet along the right (west) bank;
- Approximately 7,560 feet of ring dike around the Grand Rapids Wastewater Treatment Plant;
- Approximately 16,210 feet of counterfort, gravity, and cantilevered reinforced concrete floodwall including 6,620 feet along the left (east) bank and 9,950 feet along the right (west) bank;
- 136 pipe penetrations through the levee, floodwall, and natural bank sections with flap gate closures, rubber duck-billed valves, sluice gates, or bolt-down manhole covers for backflow prevention; and
- 6 storm water pumping stations.

The GRFPS was designed and constructed by the City of Grand Rapids (City) to meet the level of the 100-year return interval flood. The most recent construction of the flood prevention works was completed in 2017. The City flood maps are being converted to digital flood insurance rate maps (DFIRM) as a result of Federal Emergency Management Agency's (FEMA) Flood Map Modernization Program (FMMP). The GRFPS is subject to the levee certification requirements of 44 CFR 65.10; however, the City is currently seeking freeboard deficient reach status for all reaches, except Reach E5, as provided by the Federal Emergency Management Agency's (FEMA) Analysis and Mapping Procedures for Non-Accredited Levee Systems, dated July 2013. The City is seeking full accreditation for Reach E5.

The provisions of 44 CFR 65.10 include 7 requirements necessary to certify a flood protection project including an engineering analysis to evaluate the flood protection works for erosion during the 100-year flood. In terms of the GRFPS, the structures that would be subject to erosion during the 100-year flood would be the natural stream banks and earth embankment levees, all of which face the Grand River. Approximately 7,220 feet of stream bank and levee embankments are protected by riprap embankment protection from the levee embankment or stream bank toe to various elevations depending on location. This report summarizes the analysis performed by Fishbeck, to evaluate the adequacy of the GRFPS levee embankment and stream bank protection to prevent erosion caused by the Grand River in Grand Rapids, Michigan during the 100-year flood.

2.0 Background

The GRFPS was designed and constructed by the City in the period 1907 to 2017. The earth embankment levees were largely constructed atop existing ground along the river's edge and have varying slopes and crest widths. The concrete retaining walls are of the counterfort, gravity, and cantilever types.

As part of the Levee Analysis and Mapping Procedures (LAMP) agreed to by the City and FEMA, FEMA divided the GRFPS into reaches for evaluation. The reaches shown in Figure 1 are along the Grand River in Grand Rapids, Michigan and consist of the following:

East Side of Grand River

- Reach E1 – Knapp Street downstream to Leonard Street.
- Reach E2 – Leonard Street downstream to Interstate Route 196 (I-196)
- Reach E3 – Gillett Pedestrian Bridge downstream to U.S. Route 131 (US 131)
- Reach E4 – US 131 downstream to 50% distance to the Water Resource Recovery Facility (WRRF)
- Reach E5 – WRRF Boundary

West Side of Grand River

- Reach W1 – North city boundary downstream to Indian Mill Creek and along the north bank of Indian Mill Creek for approximately 2,400 feet
- Reach W2 – Lower 2,400 feet of the south bank of Indian Mill Creek and then downstream along the Grand River to I-196
- Reach W3 – I-196 downstream to Fulton Street
- Reach W4 – Fulton Street downstream to the Butterworth Landfill

Viewed in the downstream direction, the left (east) bank flood protection measures begin in Reach E1 with a former earthen railroad embankment, including a hiking/biking trail on its crest, that starts at Knapp Street and extends 5,150 feet along the river in the downstream stream direction to natural topography above the 100-year flood upstream of Leonard Street. The natural topography section extends past Leonard Street for a distance of 1,660 feet in the downstream direction into Reach E2. At this point, a levee embankment section begins and extends downstream 3,360 feet to a 380-foot long section of concrete floodwall that ends just south of the eastbound Interstate 196 (I-196) Bridge (downstream limit of Reach E2). A 1,880-foot long section of natural topography above the 100-year flood elevation begins just south of the eastbound I-196 bridge and continues in the downstream direction to the Gillett Pedestrian Bridge. This section of the east bank of the Grand River is not included in the FEMA designated reaches. Reach E3 begins at the Gillett Pedestrian Bridge with an approximately 100-foot long section of concrete plaza structure and then a 1,430-foot long section of concrete floodwall that extends in the downstream direction past the Fulton Street Bridge. The concrete floodwall ends at a 600-foot long section of natural topography above the 100-year flood elevation that extends to U.S. Route 131 (downstream end of Reach E3).

Reach E4 begins on the downstream side of U.S. Route 131 with an earthen levee embankment section that extends about 750 feet downstream along the river to a concrete floodwall section. The flood wall section extends about 1,070 feet to a 380-foot long section of earth embankment levee that ends at the Wealthy Street Bridge. From the Wealthy Street Bridge, a 3,540-foot long section of concrete floodwall extends in the downstream direction to the downstream end of Reach E4 at a section of natural ground above the 100-year flood elevation. Reach E5 consists of an earthen ring dike around the City Water Resources Recovery Facility (WRRF).

Flood protection works on the right (west) bank begin in Reach W1 with natural stream bank that extends from the City of Walker 3,500 feet in the downstream direction to the mouth of Indian Mill Creek. The natural stream

bank is lined with the earth embankment for U.S. Route 131. The natural stream bank in Reach W1 also wraps from the west bank along the Grand River to the north bank of Indian Mill Creek for a distance of about 2,400 feet to account for backwater from the Grand River. The natural stream bank along Indian Mill Creek is above the 100-year flood elevation for the Grand River. Reach W2 begins approximately 2,400 feet upstream of the Grand River along Indian Mill Creek with natural stream bank above the 100-year flood elevation for the Grand River. The natural stream bank extends to the railroad bridge at the confluence with the Grand River. From the railroad bridge there is an 890-foot long section of earthen levee embankment along the Grand River that ends at a concrete floodwall section south of the end of Richmond Street. The concrete floodwall section extends in the downstream direction for about 6,150 feet to the concrete fish ladder structure adjacent to the 4th Street Dam. Downstream of the fish ladder, there is a 2,070-foot long section of natural stream bank. This section extends past the I-196 Bridges (downstream end of Reach W2) into Reach W3 ending at the downstream side of the Michigan Street Bridge. From the downstream side of the Michigan Street Bridge, approximately 2,830 feet of earthen embankment levee with various configurations was constructed downstream to the Fulton Street Bridge (downstream end of Reach W3. Reach W4 begins at the downstream side of the Fulton Street Bridge with a concrete floodwall that follows the river bank in the downstream direction for 3,320 feet to the downstream side of the Wealthy Street Bridge. At this point, an approximately 2,870-foot long earth embankment levee section begins and extends to a point downstream of the Wealthy Street Storm Water Pump Station. The final section of the GRFPS in Reach W4 consists of an approximately 120-foot long embankment across the West End Ditch that spans between natural topography above the 100-year flood on both sides of the ditch.

The levee and floodwall sections have various configurations because they were constructed at different times for the City. Figure 2 illustrates typical levee embankment, stream bank, and floodwall cross-sections for the GRFPS. Plate 1 provides the location of each of the types of levee embankment, stream bank, and floodwall sections shown in Figure 2.

Riprap stone was placed on critical areas of the levee and natural stream banks to protect against erosion due to stream water velocity and impact by debris and floating ice (see photographs, Attachment 1). The provision of 44 CFR 65.10 do not identify the method to be used to analyze the adequacy of the riprap embankment protection; therefore, the riprap design guidance provided by the USACE Engineer Manuals EM 1110-2-1913, *Design and Construction of Levees,* and EM 1110-2-1601, *Hydraulic Design of Flood Control Channels*, and the specifications provided in the Michigan Department of Transportation (MDOT) *Standard Specifications for Construction* and the Michigan Department of Environmental Quality (MDEQ) *Guidebook of Best Management Practices for Michigan Watersheds* were used.

3.0 Levee Embankment

The earth embankment levee sections of the GRFPS have several different configurations including the following:

- Low earth berms consisting of compacted clay soils constructed atop natural stream banks. Some of these earth berms are located at the top of the stream bank slope while others are set back from the top of the stream bank slopes. In some cases, the earth berms are located behind a concrete retaining wall at the edge of the water.
- Railroad embankments constructed along the river's edge. The tracks atop these embankments have been removed and portions of the crest have been converted into hiking/biking trails.
- Roadway embankments for I-196 and U.S. Route 131. These embankments are set back from the river's edge.

The portion of the GRFPS that is exposed to the direct currents of the Grand River during flood events depends on the magnitude of the flood. For the 100-year flood, the entire length of the GRFPS is exposed to the direct currents of the stream. For the portion of the project that consists of levee embankment, riprap protection was placed on the stream-facing levee embankment slope at the following locations. Note that the stationing refers to the centerline of the mouth of Plaster Creek at the Grand River, which was assumed to be Station 72+00. The HEC-RAS model cross-section numbers refer to the hydraulic model of the Grand River discussed in the next section of this report.

- Left (East) Bank Station 129+47 to Station 133+77 (HEC-RAS cross-sections 209175.5 to 209683.8) – Embankment toe and slope protection.
- Left (East) Bank Station 146+03 to Station 149+93 (HEC-RAS cross-sections 210918.9 to 211242.4) – Embankment toe and slope protection.
- Left (East) Bank Station 160+85 to Station 169+75 (HEC-RAS cross-sections 212334.2 to 213128.6) – Stream bank toe and slope and floodwall protection.
- Left (East) Bank Station 198+48 to Station 201+88 (HEC-RAS cross-sections 216028.2 to 216378.8) – Stream bank and embankment toe and slope protection.
- Right (West) Bank Station 157+91 to Station 196+81 (HEC-RAS cross-sections 211918.1 to 215862.7) – Embankment toe and slope protection.
- Right (West) Bank Station 258+49 to Station 267+29 (HEC-RAS cross-sections 222516.4 to 222724.2) – Embankment toe and slope protection.

3.1 Grand River Flood Flow Velocities

The riprap protection on the levee embankments and stream banks exposed to the flow of the Grand River must be capable of withstanding the flow velocity during flood events up to and including the 100-year flood as well as forces resulting from floating ice and debris impact. The flow velocities along the levee face during the 100-year flood were determined using the current Grand River hydraulic model developed for the Federal Emergency Management Agency (FEMA) for the City of Grand Rapids Flood Insurance Study (FIS) using the HEC-RAS River Analysis System computer program. The HEC-RAS model was obtained directly from FEMA and run for the 100-year flood discharge (50,000 cfs) using a program option that determined the flow velocity distribution in the main channel and overbank areas of the river. The river reach in the HEC-RAS model that includes the flood-protection works for the City extends from river cross-section 198117.8 downstream to cross-section 244283.5 upstream (note that the river cross-sections on the Grand River are measured in feet in the upstream direction from the mouth at Lake Michigan). The HEC-RAS model results are included in Attachment 2 to this report and show that the maximum flow velocity along the left (east) bank of the Grand River for the 100-year flood was 7.96 feet per second at cross-section 216034.2 just upstream of the dam at the 6th Street Bridge Park. The maximum flow velocity along the right (west) bank was 7.95 feet per second at cross-section 208814.4 located immediately downstream of the Wealthy Street Bridge. Each section of the stream banks on both sides of

the river were evaluated for stream velocity and compared to the type of stream bank protection currently in place including concrete flood walls; concrete retaining walls with natural stream bank slopes above the wall and with and without earth berms; full-height natural stream banks; embankment slopes protected by riprap; and vegetated embankment slopes not protected by riprap. The distinction is made in this report between natural stream banks where no man-made flood protection measures have been constructed and erosion damage would not endanger the flood protection system and embankment sections where earth berms have been constructed on the natural stream bank and erosion damage could result in flooding behind the embankment.

Several government agencies have published guidelines for vegetative stream bank stabilization, including:

- *Illinois Urban Manual* published by the Association of Illinois Soil and Water Conservation Districts
- *Virginia Erosion & Sediment Control Handbook,* Standard & Specification 3.22, published by the Virginia Department of Conservation and Recreation
- *Approaches to the Design of Biotechnical Streambank Stabilization* published by the Joint Transportation Research Program, Purdue University

These guidelines indicate that vegetative stream bank protection is generally effective up to a stream velocity of about 5 feet per second. However, Table 3.22-A in the *Virginia Erosion & Sediment Control Handbook* also notes that where the frequency of bankfull flow is less than 1 time per year, vegetated streambank stabilization can have a maximum allowable velocity of 6 feet per second. Table 2 in *Approaches to the Design of Biotechnical Streambank Stabilization* indicates that moderate to dense vegetation (turf) can have permissible velocities from 4 to 8 feet per second. For Grand Rapids, the earth berms that are set back from the top of natural stream bank slopes are vegetated and not exposed to stream velocities greater than 5 feet per second, except for an area of streambank near the Water Resource Recovery Facility (WRRF) (streambank Type 10) between stream cross-section nos. 201740.0 and 203398.8 on the left (east) bank and just downstream of the first railroad bridge between cross-section nos. 205904.0 and 206315.8 on the right (west) bank (see Table 1). In these areas, the streambanks are heavily vegetated and almost impenetrable for inspection. Based on a site inspection on the left bank just upstream of the WRRF and site observations of the right bank, the vegetation consisted of the following tree, brush, and vine species with thickly intertwined roots:

- Boxelder (*Acer negundo*)
- Silver maple (*Acer saccharinum*)
- Eurasian honeysuckle (*Lonicera* spp.)
- Northern catalpa (*Catalpa speciose*)
- Common buckthorn (*Rhamnus cathartica*)
- Virginia creeper (*Parthenocissus quinquefolia*)

As further confirmation of the stability of the Type 10 streambanks, including those where the stream velocity along the bank exceeds 5 feet per second for the 100-year flood, FTC&H reviewed U.S. Geological Survey (USGS) topographic maps for changes to the location of the stream banks. No apparent changes were detected on maps that were issued by the USGS in 1914, 1958, 1962, 1967, 1969, 1972, 1980, 1981, 1984, 1996, 2011, and 2014. Lastly, for the reach to Type 10 streambanks along the left (east) bank of the river, FTC&H researched historic records for reports of streambank collapse and damage to Market Street between the WRRF and the first railroad bridge, but did not find any reports indicating problems with stream bank stability in this area.

The HEC-RAS model of the Grand River was run with an option allowing the stream channel and overbank areas to be divided into vertical sections for evaluation of stream velocity. For this study, the stream channel and left and right overbank areas were divided into 10 sections each. The results of the HEC-RAS analysis are provided in

Appendix 2. A summary of the flow velocities at the left (east) and right (west) stream banks is provided in Table 1.

Table 1
Stream Velocities at the Stream Banks
100-Year Flood
Grand River at Grand Rapids, Michigan

HEC-RAS Cross-Section No. *	Stream Velocity (feet/second)		Stream Bank Section Type (see Figure 2)	
	Left (East) Bank	Right (West) Bank	Left (East) Bank	Right (West) Bank
200305.2 D	4.76	4.93	I-196 West Bridge (downstream face)	
200305.2 U	4.86	5.03	I-196 West Bridge (upstream face)	
200340.0	4.17	4.31	Type 2	Type 2
200408.8	4.21	4.35	Type 2	Type 2
200443.2 D	4.90	5.06	I-196 East Bridge (downstream face)	
200443.2 U	4.95	5.10	I-196 East Bridge (upstream face)	
200477.6	4.26	4.40	Type 19	Type 1
200751.0	4.41	4.51	Type 19	Type 1
201024.4	4.25	4.31	Type 19	Type 1
201382.2	4.54	4.57	Type 19	Type 1
201740.0	4.83	4.83	Type 10	Type 1
202097.9	5.36	5.36	Type 10	Type 1
202531.5	5.48	5.49	Type 10	Type 1
202965.1	5.56	5.59	Type 10	Type 1
203398.8	5.61	5.64	Type 10	Type 1
203832.4	5.90	5.90	Type 1	Type 1
204250.5	5.72	5.76	Type 1	Type 1
204668.7	5.26	5.34	Type 1	Type 1
205080.5	5.22	5.24	Type 1	Type 1
205492.2	5.13	5.09	Type 1	Type 1
205904.0	4.91	4.83	Type 13	Type 10
206315.8	4.94	4.84	Type 13	Type 10
206651.9	5.11	5.05	Type 16	Type 10
206998.0	4.92	4.86	Type 13	Type 10
207324.2	4.65	4.55	Type 13	Type 10
207332.5 D	6.59	3.38	Railroad Bridge (downstream face)	
207332.5 U	6.59	3.38	Railroad Bridge (upstream face)	
207340.5	4.64	4.55	Type 13	Type 10
208327.8	4.81	4.83	Type 15	Type 10
208777.1	6.03	5.89	Type 13	Type 13
208814.8 D	7.81	7.63	Wealthy Street Bridge (downstream face)	
208814.8 U	5.30	7.95	Wealthy Street Bridge (upstream face)	
208859.8	6.02	5.97	Type 13	Type 13
209175.5	5.16	5.06	Type 20	Type 13
209422.2	3.79	3.82	Type 4	Type 13
209656.6	3.40	3.58	Type 18	Type 13
209683.8 D	4.15	4.66	Railroad Bridge (downstream face)	

Table 1
Stream Velocities at the Stream Banks
100-Year Flood
Grand River at Grand Rapids, Michigan

HEC-RAS Cross-Section No. *	Stream Velocity (feet/second)		Stream Bank Section Type (see Figure 2)	
	Left (East) Bank	Right (West) Bank	Left (East) Bank	Right (West) Bank
209683.8 U	4.44	4.80	Railroad Bridge (upstream face)	
209711.4	3.58	3.63	Type 18	Type 13
209996.9	5.06	4.79	Type 13	Type 15
210676.0	4.30	2.85	Type 19	Type 13
210918.9	4.30	4.27	Type 2	Type 13
211144.8	5.36	5.29	Type 2	Type 13
211242.4 D	6.42	6.34	U.S Route 131 Bridge (downstream face)	
211242.4 U	5.79	6.00	U.S Route 131 Bridge (upstream face)	
211348.6	4.82	5.00	Type 2	Type 13
211561.3	4.43	4.33	Type 2	Type 13
211664.8	4.27	4.29	Type 1	Type 13
211868.1	3.84	3.89	Type 13	Type 13
211918.1 D	5.83	6.05	Fulton Street Bridge (downstream face)	
211918.1 U	6.27	6.55	Fulton Street Bridge (upstream face)	
211964.7	3.90	3.99	Type 14	Type 18
212103.5	4.76	4.62	Type 20	Type 18
212334.2	4.72	4.81	Type 5	Type 18
212414.5	4.84	4.93	Type 18	Type 17
212431.8 D	6.08	5.30	Blue Pedestrian Bridge (downstream face)	
212431.8 U	6.10	5.27	Blue Pedestrian Bridge (upstream face)	
212446.8	4.73	4.86	Type 16	Type 19
212611.5	4.73	4.76	Type 16	Type 22
212980.5	5.05	5.06	Type 13	Type 3
213093.7	4.86	4.89	Type 14	Type 4
213128.6	**	**	Pearl Street Bridge	
213163.8	4.65	4.62	Type 3	Type 19
213213.0	4.39	4.31	Type 3	Type 19
213220.0	4.90	4.90	Type 3	Type 19
213489.9	4.69	4.70	Type 3	Type 19
213506.2	**	**	Interurban / Richard Gillette Bridge	
213522.5	4.61	4.70	Type 7	Type 21
213666.4	4.44	4.46	Type 7	Type 21
213851.6	4.40	4.38	Type 7	Type 21
213856.9	4.71	4.71	Type 7	Type 21
214151.6	4.74	4.64	Type 7	Type 21
214393.3	5.05	5.02	Type 7	Type 20
214399.5	5.33	5.30	Type 7	Type 20
214526.8	5.52	5.48	Type 7	Type 20
214566.8 D	6.73	7.48	Bridge St. / Michigan St. Bridge (downstream face)	

Table 1
Stream Velocities at the Stream Banks
100-Year Flood
Grand River at Grand Rapids, Michigan

HEC-RAS Cross-Section No. *	Stream Velocity (feet/second)		Stream Bank Section Type (see Figure 2)	
	Left (East) Bank	Right (West) Bank	Left (East) Bank	Right (West) Bank
214566.8 U	6.66	6.58	Bridge St. / Michigan St. Bridge (upstream face)	
214608.3	5.25	5.23	Type 6	Type 5
214711.5	4.97	5.09	Type 6	Type 5
214720.8	5.52	5.65	Type 6	Type 5
214870.9	5.27	5.20	Type 6	Type 5
215253.2	5.05	4.88	Type 23	Type 20
215284.2 D	6.31	3.78	I-196 East Bridge (downstream face)	
215284.2 U	6.32	3.98	I-196 East Bridge (upstream face)	
215315.2	5.09	4.82	Type 23	Type 2
215330.5	5.11	4.96	Type 23	Type 2
215358.1 D	6.14	5.96	I-196 West Bridge (downstream face)	
215358.1 U	6.15	5.97	I-196 West Bridge (upstream face)	
215385.6	5.12	4.97	Type 23	Type 1
215642.2	5.05	4.71	Type 9	Type 1
215862.7	4.78	4.84	Type 9	Type 1
216020.2	5.03	4.97	Type 9	Type 13
216034.2	7.96	2.90	Type 9	Type 13
216378.8	4.75	4.92	Type 9	Type 13
216832.0	5.16	5.18	Type 9	Type 13
216850.9 D	5.77	5.79	Newberry St. / 6th St. Bridge (downstream face)	
216850.9 U	5.69	5.64	Newberry St. / 6th St. Bridge (upstream face)	
216869.4	5.03	4.98	Type 9	Type 13
217611.5	5.35	5.64	Type 9	Type 15
218588.5	4.50	5.54	Type 9	Type 13
219354.2	4.68	5.72	Type 3	Type 13
219767.8	5.00	6.21	Type 3	Type 13
219802.8 D	5.47	7.66	Leonard Street Bridge (downstream face)	
219802.8 U	4.87	7.90	Leonard Street Bridge (upstream face)	
219837.8	5.16	6.23	Type 8	Type 13
220387.9	5.34	6.57	Type 8	Type 13
221221.6	5.03	6.18	Type 9	Type 13
222516.4	4.29	4.10	Type 11	Type 12
222717.4	4.48	4.20	Type 11	Type 12
222724.2 D	4.59	4.08	Railroad Bridge (downstream face)	
222724.2 U	4.42	3.82	Railroad Bridge (upstream face)	
222730.9	4.29	4.10	Type 11	Type 1
222995.3	4.10	3.67	Type 10	Type 1
223275.7	4.37	3.81	Type 10	Type 3
223733.8	4.57	4.29	Type 10	Type 3

Table 1
Stream Velocities at the Stream Banks
100-Year Flood
Grand River at Grand Rapids, Michigan

HEC-RAS Cross-Section No. *	Stream Velocity (feet/second)		Stream Bank Section Type (see Figure 2)	
	Left (East) Bank	Right (West) Bank	Left (East) Bank	Right (West) Bank
223766.0 D	5.21	4.89	Ann Street Bridge (downstream face)	
223766.0 U	5.02	4.75	Ann Street Bridge (upstream face)	
223798.2	4.38	4.14	Type 10	Type 1
224424.1	4.32	4.22	Type 10	Type 1
225261.3	4.16	4.24	Type 11	Type 1

* The cross-section number refers to the feet upstream of the confluence of the Grand River with Lake Michigan

** Velocity computations were not conducted by HEC-RAS for bridges using "multiple openings" option.

In Table 1, high stream velocities along the stream bank are frequently found beneath the bridges crossing the Grand River. The stream banks underneath the bridges are protected by concrete bridge abutments and do not require additional stream bank protection beyond that provided in the bridge design. The areas of most concern from a stream velocity and erosion standpoint are embankment sections where earth berms have been constructed atop natural stream banks at the river's edge (river edge Type 10, see Figure 2). Table 1 indicates that the embankment areas of the Grand River stream bank that are exposed to high water velocities during a 100-year flood and subject to erosion that could cause flooding are found at the following locations:

Left (East) Bank

- Cross-section 210918.9 to cross-section 211242.4 D – U.S. Route 131 Bridge downstream face to approximately 100 feet downstream of the bridge.
- Cross-section 216832.0 to cross-section 217611.5 – Approximately 20 feet downstream of the Newberry Street / 6th Street Bridge to about 775 feet upstream of the bridge.
- Cross-section 219837.8 to cross-section 221221.6 – Beginning about 580 feet upstream of the Leonard Street Bridge and extending about 850 feet along the embankment in the upstream direction.

Right (West) Bank

- Cross-section 212980.5 – Approximately 240 feet of stream bank immediately downstream of the Pearl Street Bridge.

The left (east) bank area of concern downstream of the U.S. Route 131 Bridge and the right (west) bank area downstream of the Pearl Street Bridge currently have riprap protection, which will be evaluated below. Although the areas along the left (east) bank upstream of the Newberry Street/6th Street Bridge and upstream of the Leonard Street Bridge are exposed to high velocity water, the banks are either lined with concrete retaining walls or dense vegetation and have not experienced any noticeable erosion during past flood events. The City will monitor these areas for possible problems in the future and will install riprap bank protection if necessary.

3.2 Grand River Levee Embankment Protection

Where riprap stream bank and embankment protection is provided in the as-built construction plans for GRFPS, it is specified as "heavy riprap" or just "riprap and broken masonry". Visual inspection of the riprap indicated that the riprap protection along the Grand River appears to conform to the MDOT *Standard Specifications for*

Construction, Section 916, Erosion and Sedimentation Control Materials. In the MDOT specifications, two sizes of riprap are identified as follows:

- Plain Riprap – natural stone and broken concrete with footprint dimensions ranging from 8 inches to 16 inches and an in-place thickness of at least 8 inches. Contractors may use smaller pieces to fill spaces between the larger pieces for better slope protection.
- Heavy Riprap – natural stone and broken concrete with a smallest footprint dimension of 16 inches, a maximum to minimum dimension ration of no greater than 3:1, and an in-place thickness of at least 8 inches.

The MDOT specifications do not indicate any stone size gradation, stone specific weight, stone durability requirements, bedding material requirements, and/or maximum slope requirements. The as-built plans for riprap covered slopes along the Grand River indicate that the existing riprap was either placed on prepared (i.e. graded and raked) slopes or atop geotextile filter fabric laid on prepared slopes. It should be noted that Michigan quarries sell riprap rock (generally limestone or dolomite) to contractors based on the two sizes in the MDOT specifications.

The evaluation of the adequacy of riprap protection depends on the resistance of individual riprap stones to displacement by water velocities. The calculations used to determine riprap adequacy rely on the riprap stone gradation and the properties of the riprap stone. Although the MDOT specifications do not provide guidance on riprap stone gradation and material characteristics, the MDEQ *Guidebook of Best Management Practices for Michigan Watersheds* provides guidance on riprap stream bank protection design. For this study, it was assumed that the MDEQ guidebook design parameters were used for the riprap stream bank protection used for the GRFPS.

Assuming that the MDOT riprap specifications conform to the MDEQ guidebook design parameters, an assumed riprap gradation was developed in which the MDOT riprap footprint dimension was designated to be the median riprap size (D_{50}). The D100 size (i.e. 100% of the riprap stone was finer by weight) was assumed to be 1.5 times the D_{50} particle size in accordance with the MDEQ guidelines. The particle size for MDOT cobblestone (3 inches to 12 inches) was assumed to be the D_{30} size (i.e. 30% of the riprap stone was finer by weight), and the particle size for MDOT coarse aggregate (¾ inch to 3 inches) was assumed to be the D_5 size (i.e.5% of the riprap stone was finer by weight). The assumed riprap gradations for the MDOT riprap types are listed in Table 2 and illustrated in Figure 3.

Table 2
Assumed Riprap Gradation Based on
MDOT Specifications and MDEQ Guidelines

Percent Lighter by Weight (%)	Weight of Stones (lbs)	
	Plain Riprap	Heavy Riprap
100	450	4,167
50	150	1,250
30	15	83
5	4	15

3.3 Riprap Evaluation

The USACE provides design guidance for levees including embankment protection in their Engineer Manual (EM) 1110-2-1913, *Design and Construction of Levees*, and EM 1110-2-1601, *Hydraulic Design of Flood Control Channels*. According to EM 1110-2-1601, Section 3.7, the riprap stone size should be determined using the following equation:

$$D_{30} = S_f \, C_S \, C_V \, C_T \, d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{1/2} \frac{V}{\sqrt{K_1 \, g \, d}} \right]^{2.5} \quad (1)$$

Where: D_{30} = riprap size of which 30 percent is finer by weight, length

S_f = safety factor, assumed to be 1.5 to account for ice and debris impact

C_S = stability coefficient for incipient failure (see calculation below)

C_V = vertical velocity distribution coefficient

= 1.0 for straight channels

= 1.283 – 0.2 log (R/W), outside of bends for (R/W) ≤ 26, or = 1.0 if (R/W) > 26

where: R = centerline radius of bend in the main channel

W = water-surface width of bend in the main channel

C_T = thickness coefficient (see calculation below)

d = local depth of flow, ft (see calculation below)

γ_w = unit weight of water

= 62.4 lb/ft^3

γ_s = unit weight of riprap stone

= 165 lb/ft^3 (assumed limestone)

V = local depth-averaged velocity

= maximum velocity for each riprap protected section of stream bank and embankment from HEC-RAS results in Table 1

K_1 = side slope correction factor (see calculation below)

g = gravitational constant

= 32.16 ft/s^2

3.3.1 Stream Bank and Embankment Riprap Evaluation

The Grand River stream banks and embankments have partial or full height riprap protection in the areas identified in Item 3.0 that were constructed at different times by different contractors and now make up a portion of the GRFPS. For the analysis of the riprap adequacy, it was assumed that all of the riprap was full height on the embankment or stream bank slope. The following paragraphs discuss the determination of the variables used in Equation 1 for the full height riprap section evaluation.

C_S, Stability Coefficient Calculation

The values of the stability coefficient for incipient failure, C_S, tabulated in EM 1110-2-1601 are only applicable when D_{85}/D_{15} = 1.7 to 5.2 where D_{85} and D_{15} are the riprap stone sizes for which 85% and 15% of the diameters are smaller, respectively. For plain riprap, referring to Figure 3, the riprap stone weight for which 85% of the individual stones weigh less (W_{85}) was approximately 330 lbs, while the riprap stone weight for which 15% of the individual stones weigh less (W_{15}) was about 6.5 lbs. For heavy riprap, the D_{85} and D_{15} stone weights were approximately 2,800 pounds and 28 pounds, respectively.

The equivalent stone diameters for the W_{85} and W_{15} stone weights, D_{85} and D_{15} respectively, were calculated using the following equation from EM 1110-2-1601, Section 3-2:

$$D_{\%} = \left(\frac{6\,W_{\%}}{\pi\,\gamma_s}\right)^{1/3} \qquad (2)$$

For the D_{85} riprap stone size:

$$D_{85} = \left(\frac{6\,W_{85}}{\pi\,\gamma_s}\right)^{1/3} = \left(\frac{6\,W_{85}}{\pi\,(165)}\right)^{1/3}$$
$$= 1.56\ ft.plain\ riprap$$
$$= 3.19\ ft.heavy\ riprap$$

For the D_{15} riprap stone size:

$$D_{15} = \left(\frac{6\,W_{15}}{\pi\,\gamma_s}\right)^{1/3} = \left(\frac{6\,W_{85}}{\pi\,(165)}\right)^{1/3}$$
$$= 0.42\ ft.plain\ riprap$$
$$= 0.69\ ft.heavy\ riprap$$

Therefore:

$$\left(\frac{D_{85}}{D_{15}}\right)_{Plain} = \frac{1.56}{0.42} = 3.71 \qquad \left(\frac{D_{85}}{D_{15}}\right)_{Heavy} = \frac{3.19}{0.69} = 4.62$$

As calculated above, the ratios of D_{85}/D_{15} ratios for the as-built riprap are in the acceptable range for the stability coefficient for incipient failure. Therefore, because the D_{85}/D_{15} ratios were within the required range, the value of C_S = 0.30 for angular rock was used.

C_V, Vertical Velocity Distribution Coefficient

The Grand River is relatively straight through Grand Rapids except for a westward bend downstream of Fulton Street and a southward bend downstream of the southern I-196 crossing. There is no appreciable riprap protection at either of the bend locations. Therefore, the value of C_V was selected for straight channels:

$$C_V = 1.00$$

C_T, Thickness Coefficient Calculation

The thickness coefficient, C_T, is determined based on either the D_{100} or the D_{50} riprap stone diameter. From Figure 3, the W_{50} riprap stone weight was found to be 150 lbs for plain riprap and 1,250 lbs for heavy riprap while the W_{100} riprap stone weight was 450 lbs and 4,167 lbs, respectively. Using Equation 2 above, the D_{50} and D_{100} riprap stone sizes were calculated as follows:

$$D_{50} = \left(\frac{6\,W_{50}}{\pi\,\gamma_s}\right)^{1/3} = \left(\frac{6\,W_{50}}{\pi\ (165)}\right)^{1/3} = 1.20\ ft. and\ 2.44\ ft.$$

$$D_{50} = \left(\frac{6\,W_{100}}{\pi\,\gamma_s}\right)^{1/3} = \left(\frac{6\,W_{100}}{\pi\ (165)}\right)^{1/3} = 1.73\ ft. and\ 3.64\ ft.$$

According to EM 1110-2-1601, the value of C_T is based on a riprap layer thickness of either 1.0 D_{100}(max) or 1.5 D_{50}(max), whichever is greater. Thus, for the range of D_{50} and D_{100} riprap stone sizes:

$$1.0\ D_{100} = 1.73\ ft. and\ 3.64\ ft.$$

or

$$1.5\ D_{50} = 1.80\ ft. and\ 3.66\ ft.$$

According to the MDOT specifications, both plain and heavy riprap should have a minimum in-place thickness of 8 inches; however, according to the as-built plans, the riprap layer thickness was typically 16 inches. Thus, the ratio N of the actual riprap layer thickness to the maximum layer thickness provided by either 1.0 D_{100} or 1.5 D_{50} was:

$$N = \frac{Actual\ Riprap\ Layer\ Thickness}{1.5\ D_{50}} = \frac{1.33}{1.80} = 0.74\ for\ plain\ riprap$$

$$N = \frac{1.33}{3.66} = 0.36\ for\ heavy\ riprap$$

From Plate B-40 in Appendix B of EM 1110-2-1601 and assuming a value of D_{85}/D_{15} = 3.71 for MDOT plain riprap, a value of N = 0.74 was off the chart and the value of C_T was assumed to be that for a value of N=1.0 yielding C_T = 1.0. For MDOT heavy riprap with D_{85}/D_{15} = 4.62, the value of N = 0.36 was also off the chart; therefore, the same assumption was made, and the value of C_T = 1.0.

d, Local Depth of Flow Calculation

The areas of the Grand River with stream bank or embankment riprap are fairly steep with estimated slopes of 2H:1V. The depth of flow varies along the riprap protected stream banks and embankments.

In accordance with EM 1110-2-1601, the local depth of flow, d, is to be determined at a point 20% of the slope length from the toe of levee embankment slope. Referring to Figure 4, the angle for a 2H:1V slope is 26.57°.

From trigonometry, sin = b/c , from which c = b/sin is derived. A point 20% of the slope length from the toe of levee is illustrated by the length c' = 0.20 c. The height of the point 20% of the slope length from the toe of the levee measured from the bottom of the riprap protection is given by b' = c' sin (26.57°). Therefore, the local depth of flow was calculated as follows:

$$c = \frac{b}{\sin(26.57°)}$$

$$c' = 0.20\, c$$

$$b' = c' \sin(26.57°)$$

$$d = b - b'$$

For each of the riprap protected stream bank and embankment areas identified in Item 3.0, the local depth of flow, d, was calculated using the above equations and the average depth of flow along the protected stream banks and embankments from the HEC-RAS model results (Appendix 2). The results are shown in Table 3.

Table 3
Local Depth of Flow for Grand River
Riprap Protected Stream Banks and Embankments
Grand Rapids, Michigan

Riprap Protected Stream Reach	Average Depth of Flow, b (feet)	Local Depth of Flow, d (feet)
Left (East) Bank		
Station 129+47 to Station 133+77	23.10	18.48
Station 146+03 to Station 149+93	25.09	20.07
Station 160+85 to Station 169+75	22.40	17.92
Station 198+48 to Station 201+88	16.34	13.07
Right (West) Bank		
Station 157+91 to Station 196+81	20.64	16.51
Station 258+49 to Station 267+29	13.79	11.03
Station 395+79 to Station 399+79	15.98	12.78

K1, Side Slope Correction Factor Calculation

The side slope correction factor, K1, was calculated using the following equation from EM 1110-2-1601:

$$K_1 = \sqrt{1 - \frac{sin^2\theta}{sin^2\emptyset}} \quad (3)$$

where: θ = angle of side slope with horizontal (previously calculated to be 26.57°)

$\emptyset$ = angle of repose of riprap material (normally 40°)

Inserting the values of θ and $\emptyset$ in Equation 3 yields a value of $K_1 = 0.72$.

D30, Riprap Size Calculation

Inserting all of the values determined above in Equation 1 yields the D30 riprap sizes presented in Table 4:

Table 4
Summary of Calculations for D30 Particle Size
Riprap Embankment Protection
Grand River, Grand Rapids, Michigan

Location	S_f	C_S	C_V	C_T	d (feet)	γ_w (lb/ft^3)	γ_s (lb/ft^3)	V (ft/sec)	K_1	g (ft/sec^2)	D_{30} (feet)
Left (East) Bank											
Station 129+47 to Station 133+77	1.5	0.30	1.00	1.0	18.48	62.4	165.0	5.14	0.72	32.16	0.14
Station 146+03 to Station 149+93	1.5	0.30	1.00	1.0	20.07	62.4	165.0	6.40	0.72	32.16	0.23
Station 160+85 to Station 169+75	1.5	0.30	1.00	1.0	17.92	62.4	165.0	6.10	0.72	32.16	0.21
Station 198+48 to Station 201+88	1.5	0.30	1.00	1.0	13.07	62.4	165.0	7.95	0.72	32.16	0.45
Right (West) Bank											
Station 157+91 to Station 196+81	1.5	0.30	1.00	1.0	16.51	62.4	165.0	7.44	0.72	32.16	0.36
Station 258+49 to Station 267+29	1.5	0.30	1.00	1.0	11.03	62.4	165.0	4.19	0.72	32.16	0.09
Station 395+79 to Station 399+79	1.5	0.30	1.00	1.0	12.78	62.4	165.0	3.92	0.72	32.16	0.08

From Table 1 and Figure 3, the D30 weight of the individual stones for MDOT specification plain and heavy riprap as developed using the MDEQ guidelines is 15 lbs and 83 lbs, respectively. Using Equation 2, the estimated stone diameters were calculated as follows:

$$D_{30} = \left(\frac{6\,W_{30}}{\pi\,\gamma_s}\right)^{1/3} = \left(\frac{6\,W_{30}}{\pi\,(165)}\right)^{1/3}$$

$$= 0.56\ ft.plain\ riprap$$

$$= 0.99\ ft.heavy\ riprap$$

The D_{30} sizes of the MDOT specification plain and heavy riprap, as developed based on the MDEQ BMP guidelines, exceeds the sizes required for the riprap stream bank and embankment protection locations along the Grand River listed in Table 4. Therefore, the existing riprap on the GRFPS embankment is adequate for the velocities expected during the 100-year flood.

4.0 Conclusions

The GRFPS has riprap stream bank and embankment protection at several locations along the Grand River to prevent erosion of the stream banks and embankment levee slopes and to prevent damage due to ice and debris impact. The gradation of the stones used for the riprap was developed using the MDOT *Standard Specifications for Construction* and the MDEQ *Guidebook of Best Management Practices for Michigan Watersheds* and confirmed by visual inspection of the riprap layers as well as a review of as-built plans for the project. The available riprap design information was sufficient to evaluate the adequacy of the riprap layer for the conditions resulting from a 100-year flood on the Grand River. The riprap stone size analysis presented in this report indicates that the existing riprap adequately protects the GRFPS from the river velocities and ice and debris impact resulting from a 100-year flood.

There are also sections of the stream bank and embankment sections along the Grand River in Grand Rapids that are not protected by floodwalls or riprap. An evaluation of stream velocities along the banks for a 100-year flood indicated only two areas where stream velocities were considered high enough to present a possible erosion hazard. In these areas, dense stream bank vegetation and concrete retaining walls have protected the stream banks from erosion during past flood events. The City will monitor these areas during future flood events and provide riprap protection, if necessary, to prevent erosion.

5.0 References

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Figures

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Embankment_Flood Protection Project.mxd Date: 8/31/2017 9:14:11 AM User: MCL

Legend

- E1 - Knapp to Leonard
- E2 - Leonard to I-196
- E3 - Pedestrian (Gillett) Bridge to US 131
- E4 - US 131 to 50% distance to WRRF
- E5 - WRRF Boundary
- W1 - North of Indian Mill Creek
- W2 - Indian Mill Creek to I-196
- W3 - I-196 to Fulton
- W4 - Fulton to Butterworth Landfill
- Storm Water Pump Station

CITY LIMIT

W1

E1

E2

E3

E5

PALMER STREET PUMP STATION

CALEDONIA STREET PUMP STATION

Sources: Esri, H... China (Hong Ko... Community

City of Grand Rapids

Kent County, Michigan

Embankment Protection Analysis

PROJECT NO. G120330LMP

FIGURE NO. 1

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Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

fishbeck, thompson, carr & huber, inc.

engineers
scientist
architects
constructors

fTC&h

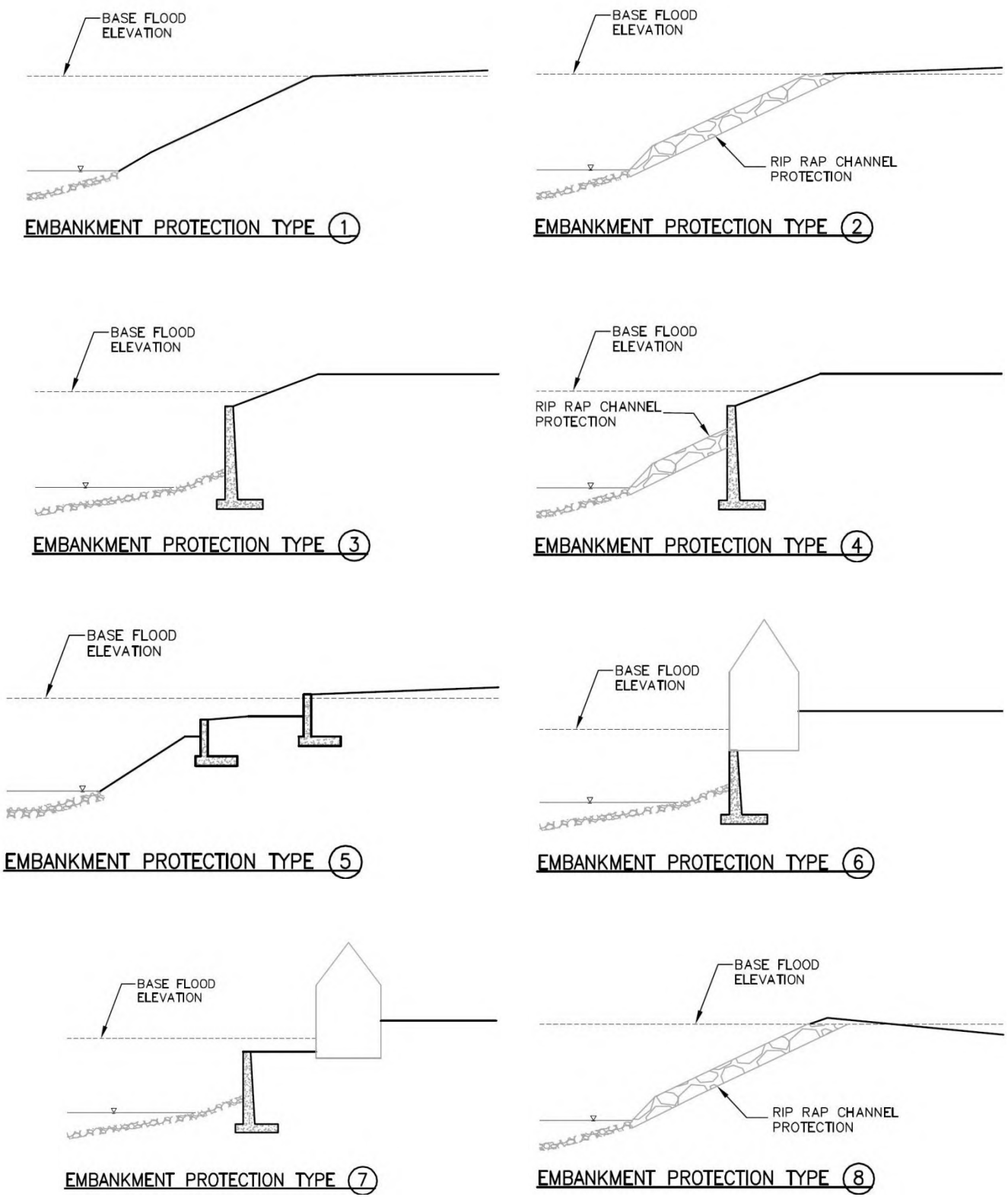


Fig. 2. Typical stream bank, embankment, and floodwall cross-sections, Grand Rapids, Michigan

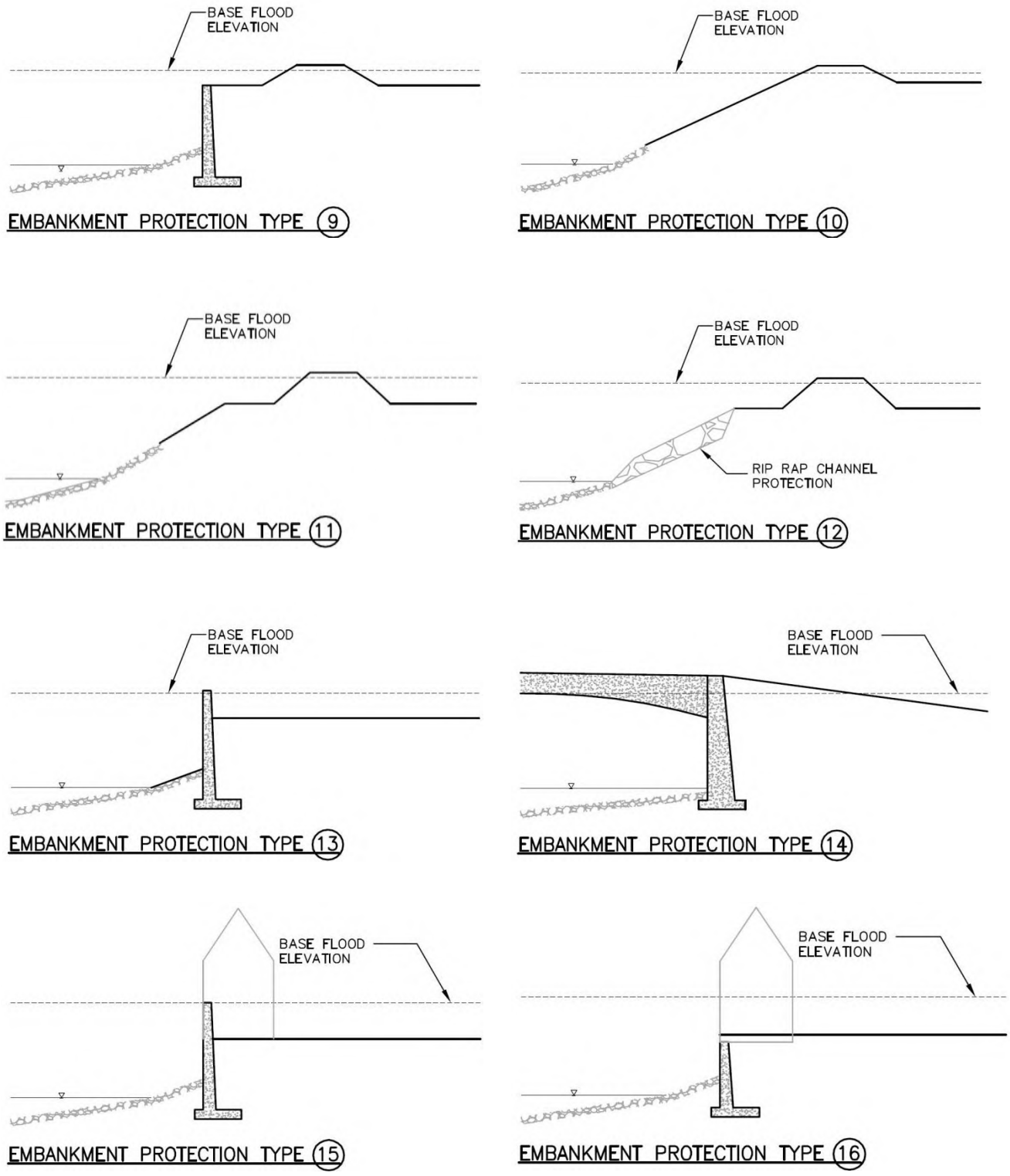


Fig. 2 (cntd). Typical stream bank, embankment, and floodwall cross-sections, Grand Rapids, Michigan

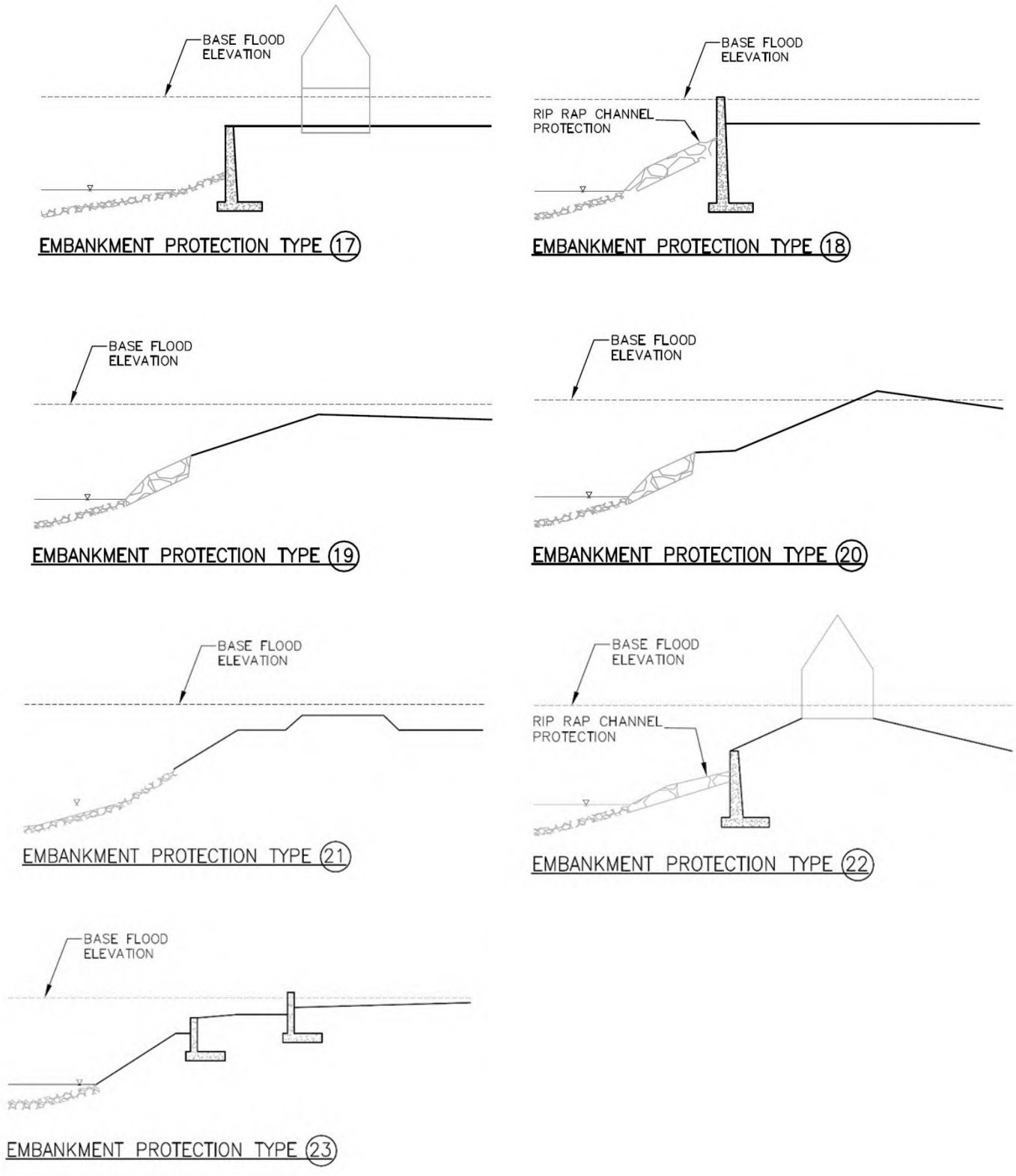


Fig. 2 (cntd). Typical stream bank, embankment, and floodwall cross-sections, Grand Rapids, Michigan

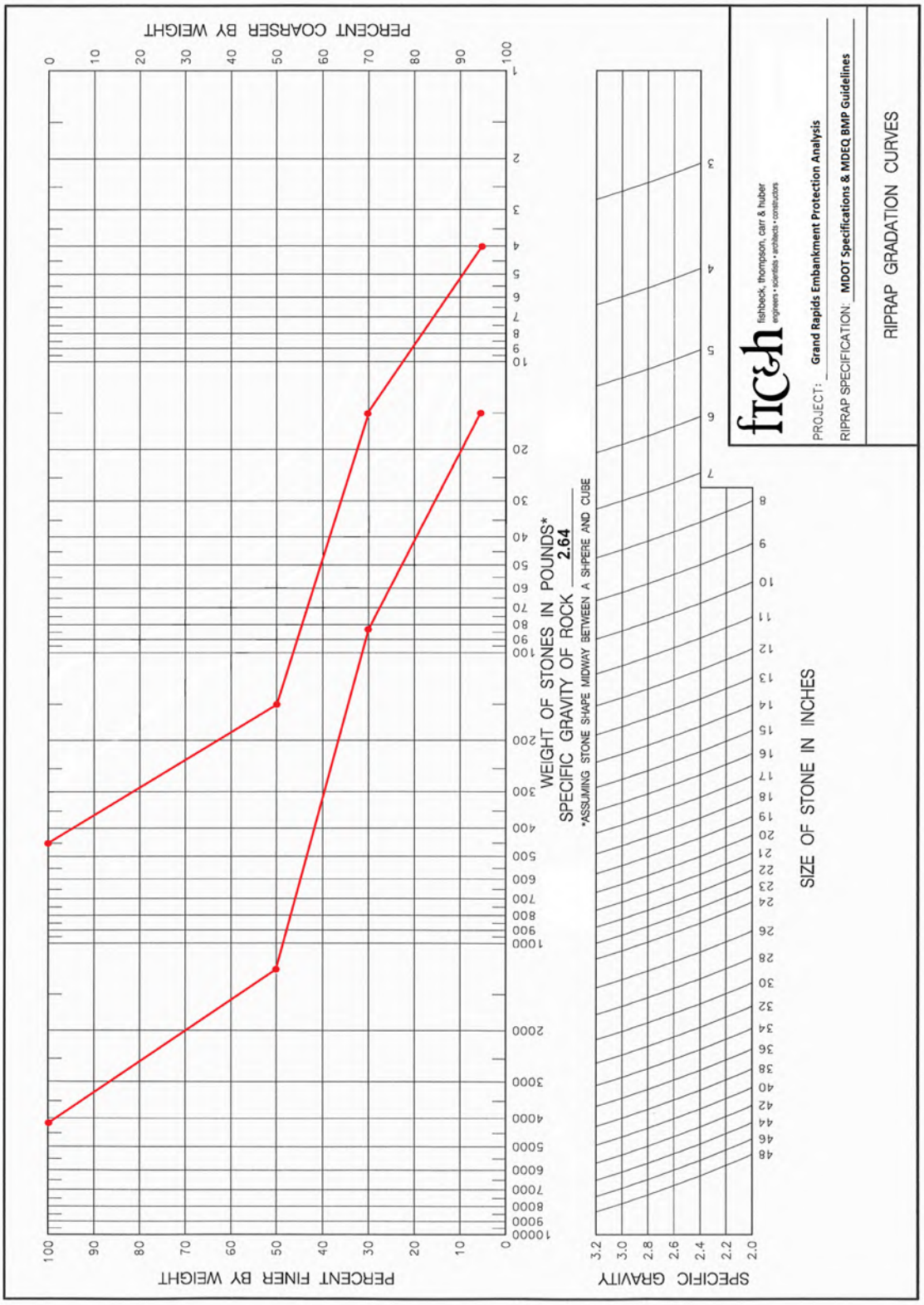

PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
WEIGHT OF STONES IN POUNDS*
SPECIFIC GRAVITY OF ROCK 2.64
*ASSUMING STONE SHAPE MIDWAY BETWEEN A SHPERE AND CUBE
SIZE OF STONE IN INCHES
SPECIFIC GRAVITY
fishbeck, thompson, carr & huber
engineers • scientists • architects • constructors
PROJECT: Grand Rapids Embankment Protection Analysis
RIPRAP SPECIFICATION: MDOT Specifications & MDEQ BMP Guidelines
RIPRAP GRADATION CURVES

FIGURE 3

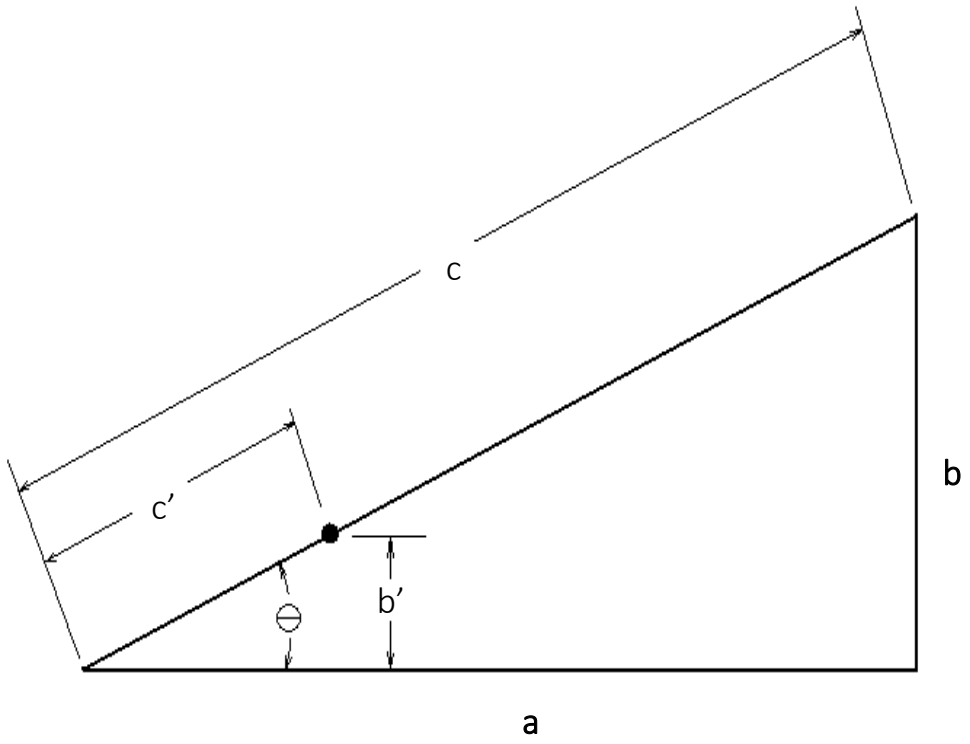


Fig. 4. Trigonometric Representation of the Grand River Stream Banks and Embankments.

Appendix 1

Embankment Protection Photographs



Fig. 1. EAST BANK. Riprap stream bank protection extending from the end of the floodwall upstream of Wealthy Street at the City traffic signals maintenance facility to upstream of the next railroad bridge.



Fig. 2. EAST BANK. View of the riprap protection on the stream bank at the City traffic signals maintenance facility looking upstream to the railroad bridge upstream of the Wealthy Street Bridge.



Fig. 3. EAST BANK. Close up view of the stream bank riprap protection at the City Department of Public Works maintenance facility south of U.S. Route 131 looking downstream.



Fig. 4. EAST BANK. Riprap stream bank protection beneath the U.S. Route 131 Bridge viewed looking downstream.



Fig. 5. EAST BANK. Beginning of riprap stream bank protection overgrown with trees on natural stream bank immediately upstream of the Fulton Street Bridge.



Fig. 6. EAST BANK. Riprap stream bank protection overgrown with trees and vegetation between the Fulton Street Bridge and the Blue Pedestrian Bridge.



Fig. 7. EAST BANK. View of riprap stream bank protection between the Blue Pedestrian Bridge and the Fulton Street Bridge viewed looking downstream from the Blue Pedestrian Bridge.



Fig. 8. EAST BANK. View of the water sculpture downstream of the Blue Pedestrian Bridge including riprap protection along the toe of the stream bank as viewed from the bridge.



Fig. 9. EAST BANK. Riprap protection along the toe of the stream bank slope at the upstream end of the water sculpture downstream of the Blue Pedestrian Bridge as viewed from the bridge.



Fig. 10. EAST BANK. Riprap protection around the public boat ramp immediately downstream of the dam at the 6th Street Bridge Park viewed from the west bank.



Fig. 11. EAST BANK. Riprap stream bank protection immediately downstream of the dam at the 6th Street Bridge Park viewed looking downstream.



Fig. 12. EAST BANK. View of the end of the public boat ramp at the 6th Street Bridge Park showing riprap protection between the end of the ramp and the beginning of a retaining wall section.



Fig. 13. EAST BANK. Stream bank slope atop retaining wall along the edge of the Grand River immediately upstream of the 6th Street Bridge in the Canal Park.



Fig. 14. EAST BANK. Vegetation growing along the base of the retaining wall along the Grand River at the Canal Park upstream of the 6th Street Bridge.



Fig. 15. EAST BANK. Stream bank between retaining wall along the Grand River and elevated sidewalk at the Canal Park in the vicinity of Walbridge Street and Monroe Avenue.



Fig. 16. EAST BANK. Heavy vegetation on natural stream bank with top elevation above the 100-year flood elevation immediately upstream of the Leonard Street Bridge.



Fig. 17. EAST BANK. Heavy vegetation on river-side slope of former railroad embankment along Grand River upstream of the Leonard Street Bridge.



Fig. 18. EAST BANK. Heavy vegetation on river-side slope of former railroad embankment between the Ann Street Bridge and the next downstream railroad bridge.



Fig. 19. EAST BANK. Vegetation on river-side slope of former railroad embankment along the Grand River at the Palmer Street Pump Station downstream of the Ann Street Bridge.



Fig. 20. EAST BANK. Vegetation on river-side slope of former railroad embankment along the Grand River just downstream of the Comstock Riverside Park.



Fig. 21. WEST BANK. Riprap stone protection along toe of slope between the Fulton Street Bridge and the blue pedestrian bridge in front of the L.V. Eberhard Center, Pew Campus, Grand Valley State University.



Fig. 22. WEST BANK. View of riprap protection along toe of stream bank from blue pedestrian bridge looking downstream.



Fig. 23. WEST BANK. View of riprap stream bank toe protection between blue pedestrian bridge and Fulton Street Bridge looking downstream.



Fig. 24. WEST BANK. Riprap stream bank toe protection between the Pearl Street Bridge and the blue pedestrian bridge viewed looking downstream from the Van Andel Museum Center carrousel deck.



Fig. 25. WEST BANK. Riprap stream bank toe protection upstream of the blue pedestrian bridge at the Van Andel Museum Center.



Fig. 26. WEST BANK. Riprap stream bank toe protection at the Van Andel Museum Center looking upstream to the Pearl Street Bridge.



Fig. 27. WEST BANK. Riprap stream bank toe protection at the Van Andel Museum Center looking upstream to the Pearl Street Bridge from the carrousel deck.



Fig. 28. WEST BANK. Concrete over riprap stone along the stream bank immediately downstream of the Interurban/Richard Gillette Bridge.



Fig. 29. WEST BANK. Riprap stream bank toe protection immediately upstream of the Interurban /Richard Gillette Bridge viewed from the bridge deck.



Fig. 30. WEST BANK. View of riprap stream bank toe protection at the Ah-Nab-Awen Park looking upstream from the Interurban/Richard Gillette Bridge.



Fig. 31. WEST BANK. View of riprap stream bank toe protection looking downstream from the Michigan Street Bridge.



Fig. 32. WEST BANK. View of stream bank looking downstream from the Michigan Street Bridge including riprap stream bank toe protection.



Fig. 33. WEST BANK. View of stream bank looking upstream from the Michigan Street Bridge at the Bridgewater Place complex. Note riprap at the toe of the stream bank.

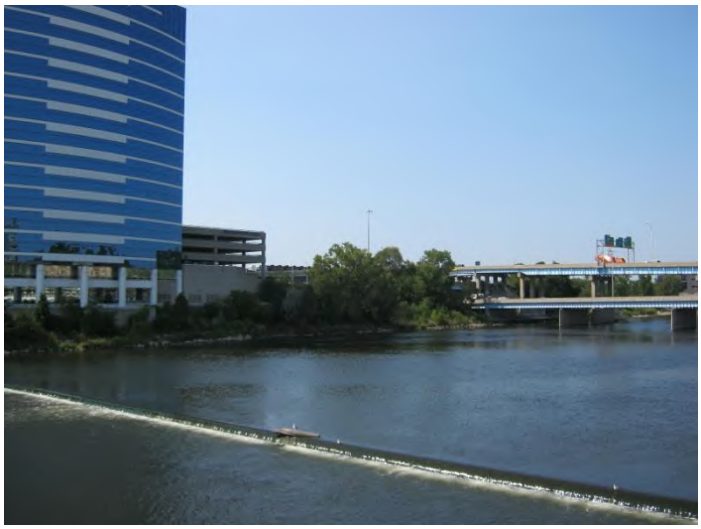


Fig. 34. WEST BANK. View of stream bank looking upstream from the Michigan Street Bridge to the I-196 Bridge at the Bridgewater Place complex. Note riprap protection at the toe of the stream bank.



Fig. 35. WEST BANK. Riprap stream bank toe protection immediately downstream of the fish ladder and upstream of the I-196 Bridge.

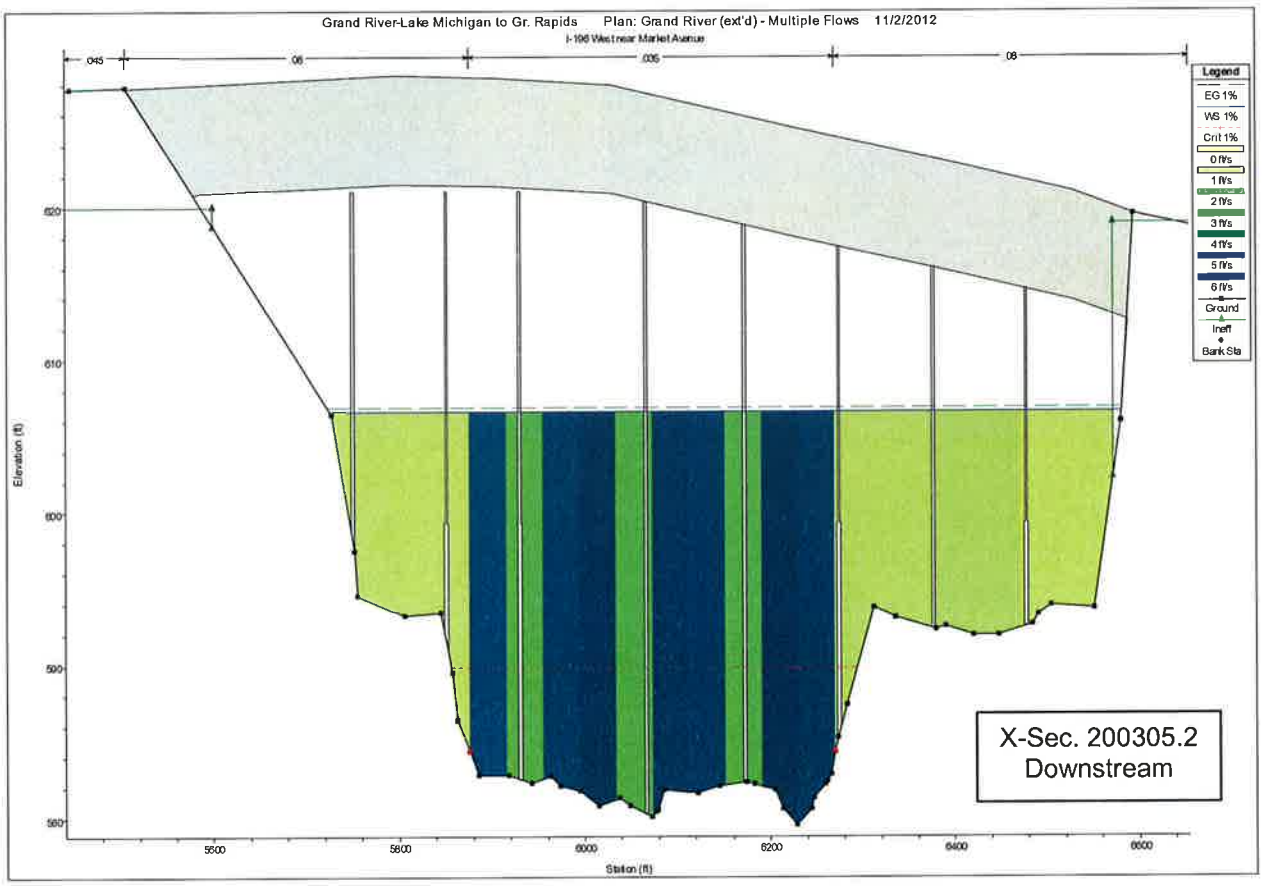


Fig. 36. WEST BANK. Riprap embankment protection at the north end of the Kent County highway maintenance facility yard immediately south of the railroad bridge and upstream of Leonard Street.

Appendix 2

Grand River HEC RAS Model Results

100-Year Flood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I-196 West near Market Avenue
045
06
035
08
Legend
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WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
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590
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6400
6600
Station (ft)
X-Sec. 200305.2
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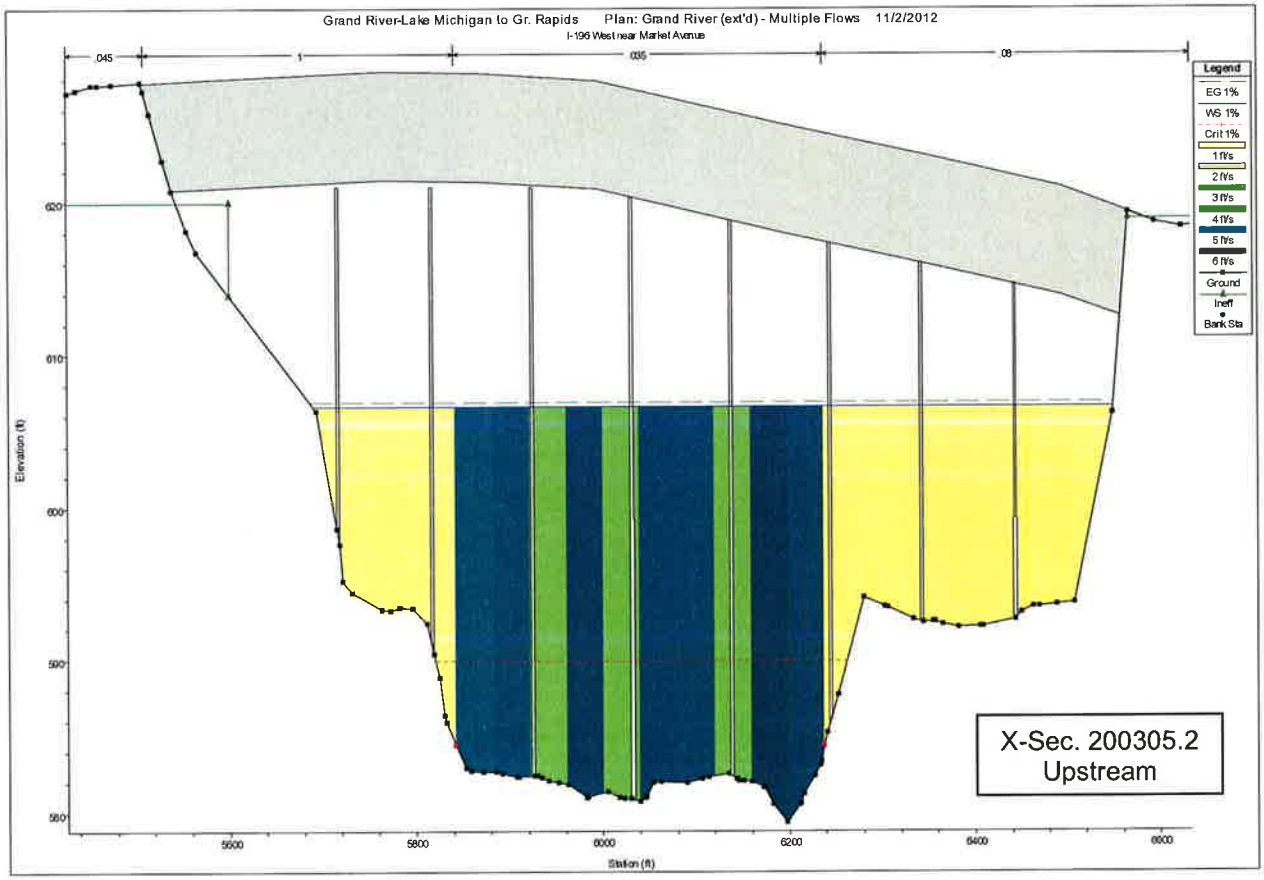
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035
08
Legend
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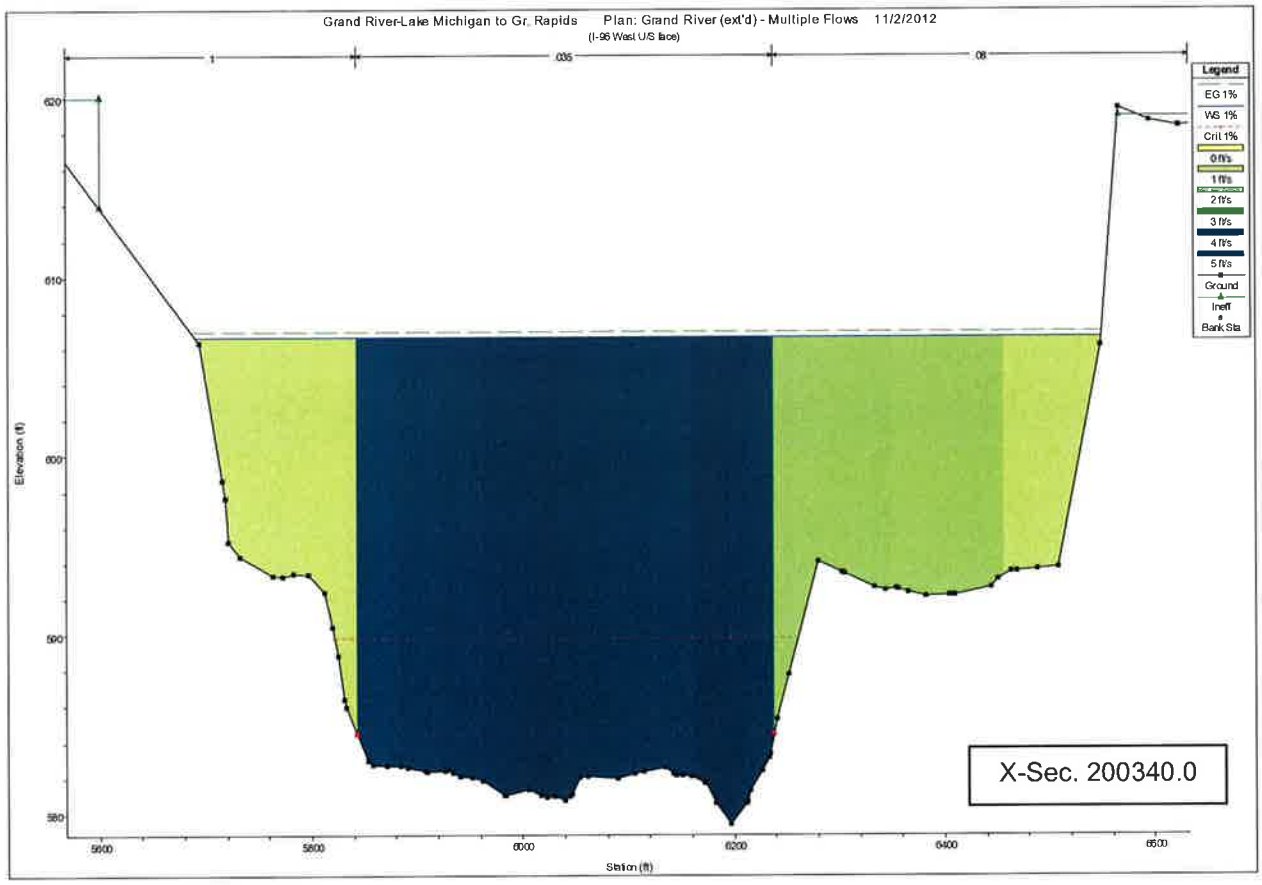
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
580
5600
5800
6000
6200
6400
6600
Station (ft)
X-Sec. 200305.2
Upstream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Crit 1%
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1 ft/s
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Bank Sta
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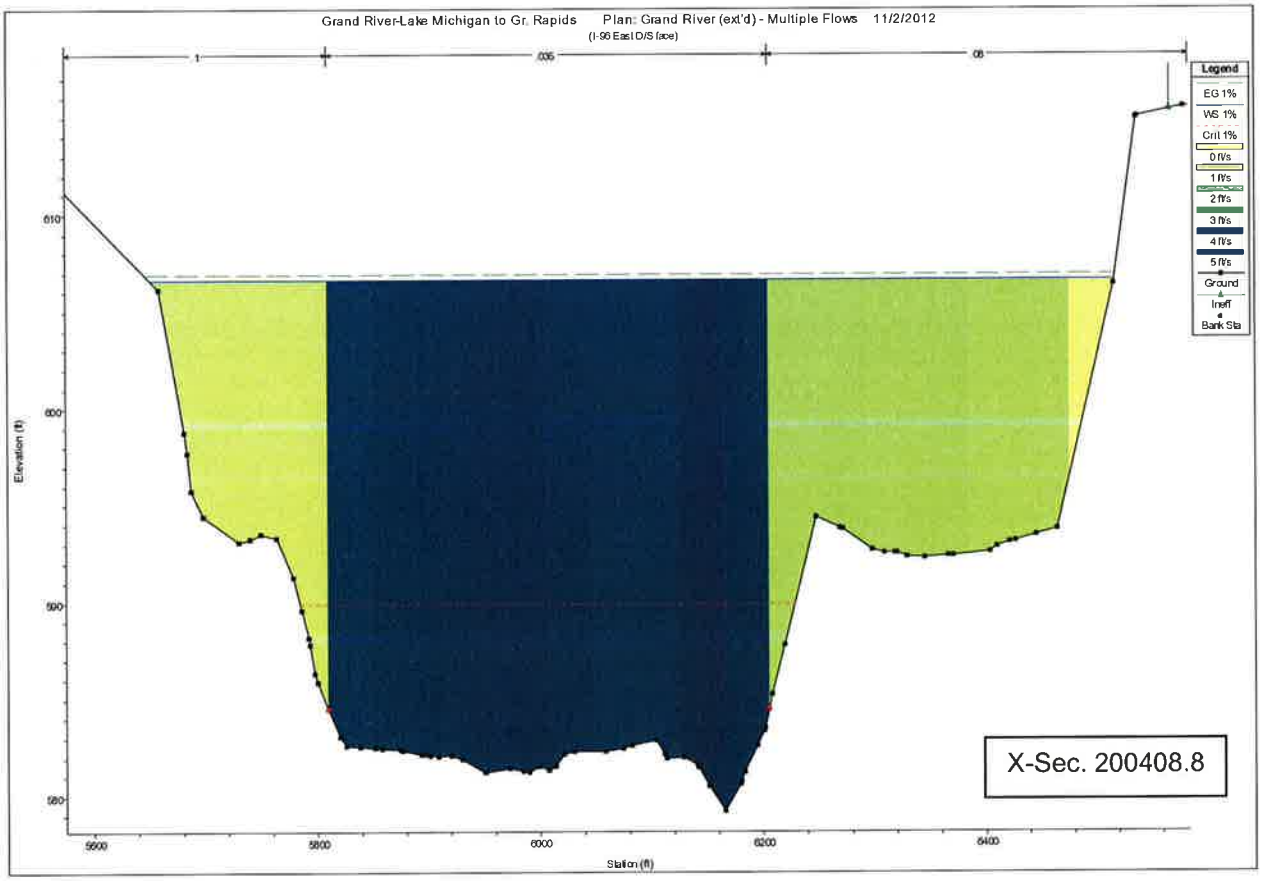
Elevation (ft)
Station (ft)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Bank Sta
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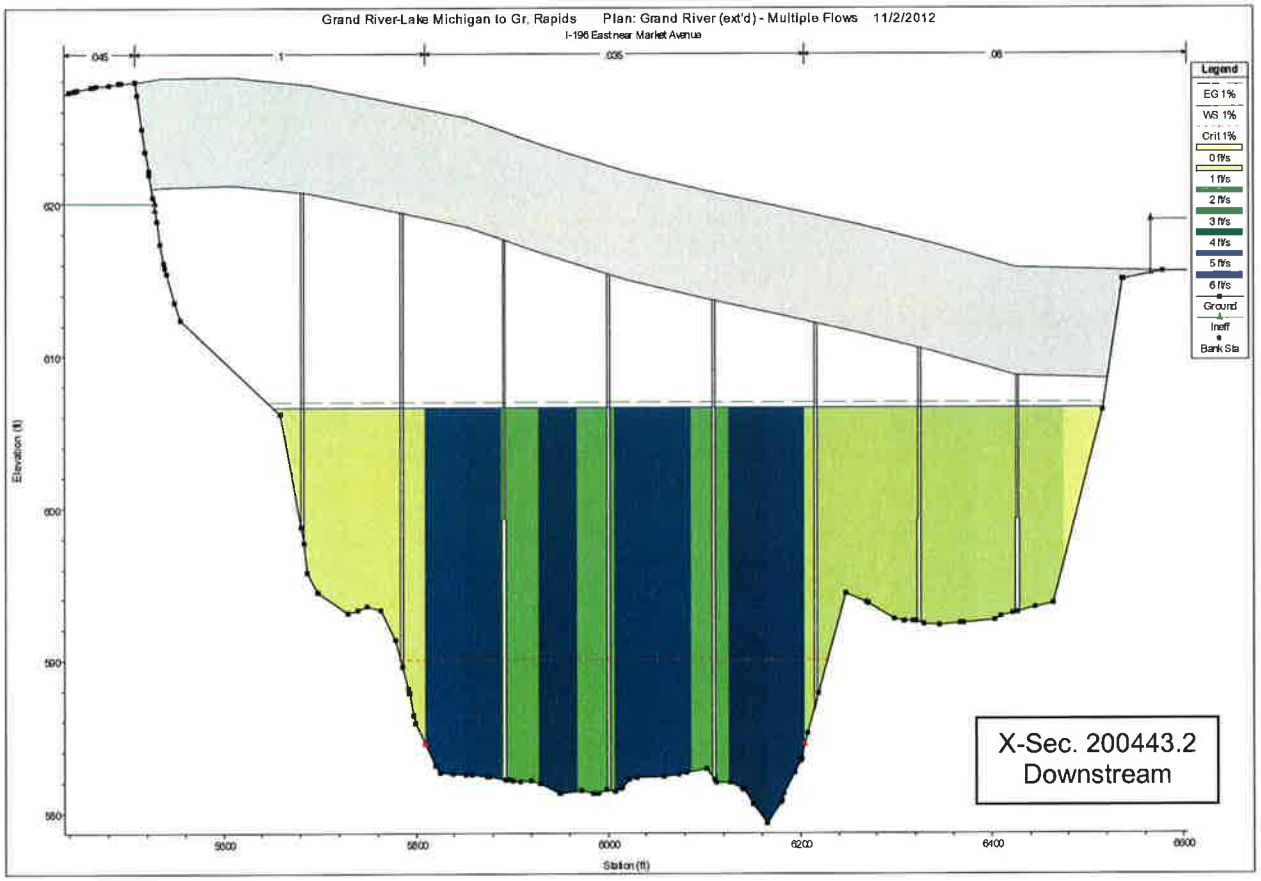
Elevation (ft)
Station (ft)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I-196 East near Market Avenue
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
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6 ft/s
Ground
Ineff
Bank Sta
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Station (ft)
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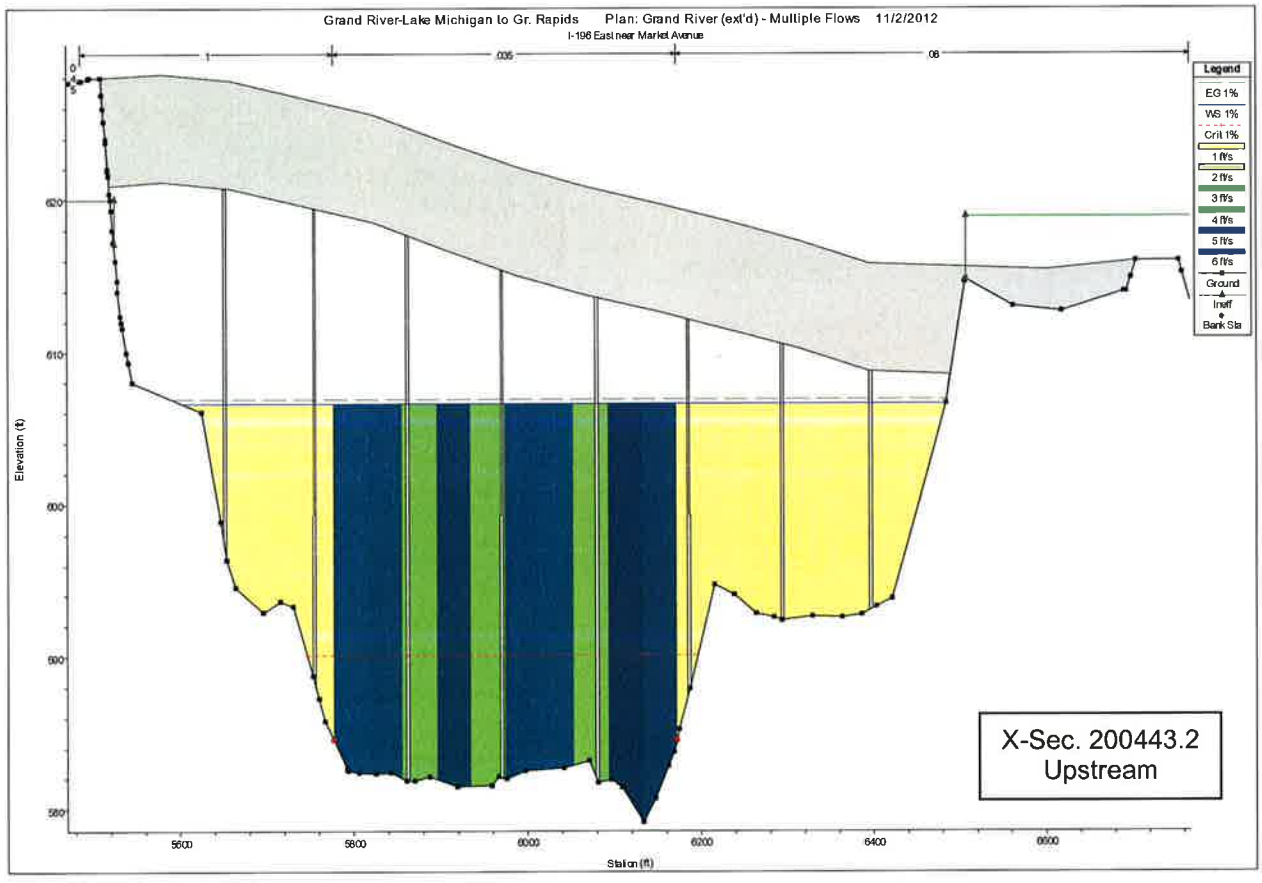
Downstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-196 East near Market Avenue
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WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
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6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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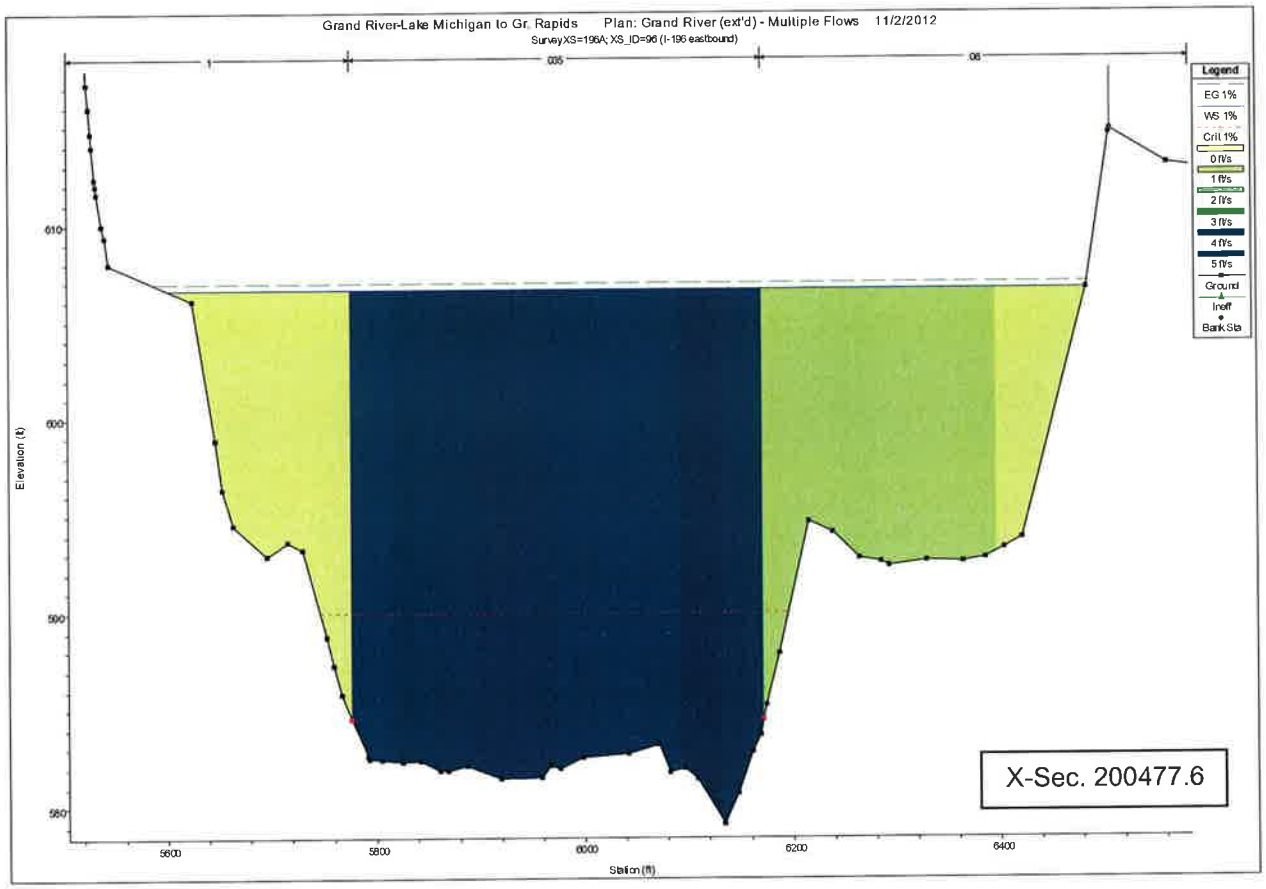
Upstream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WS 1%
Crit 1%
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Station (ft)
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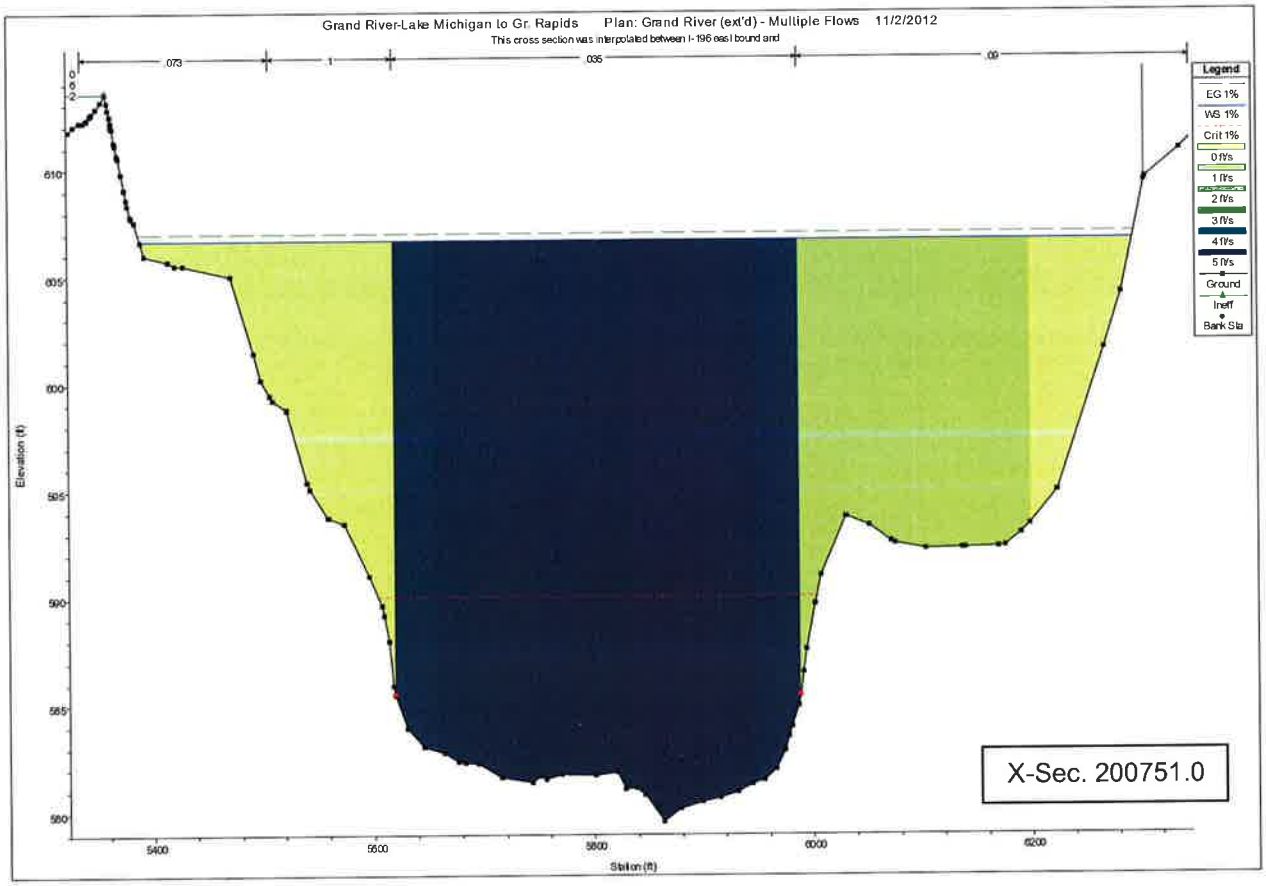
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Crit 1%
0 ft/s
1 ft/s
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Station (ft)
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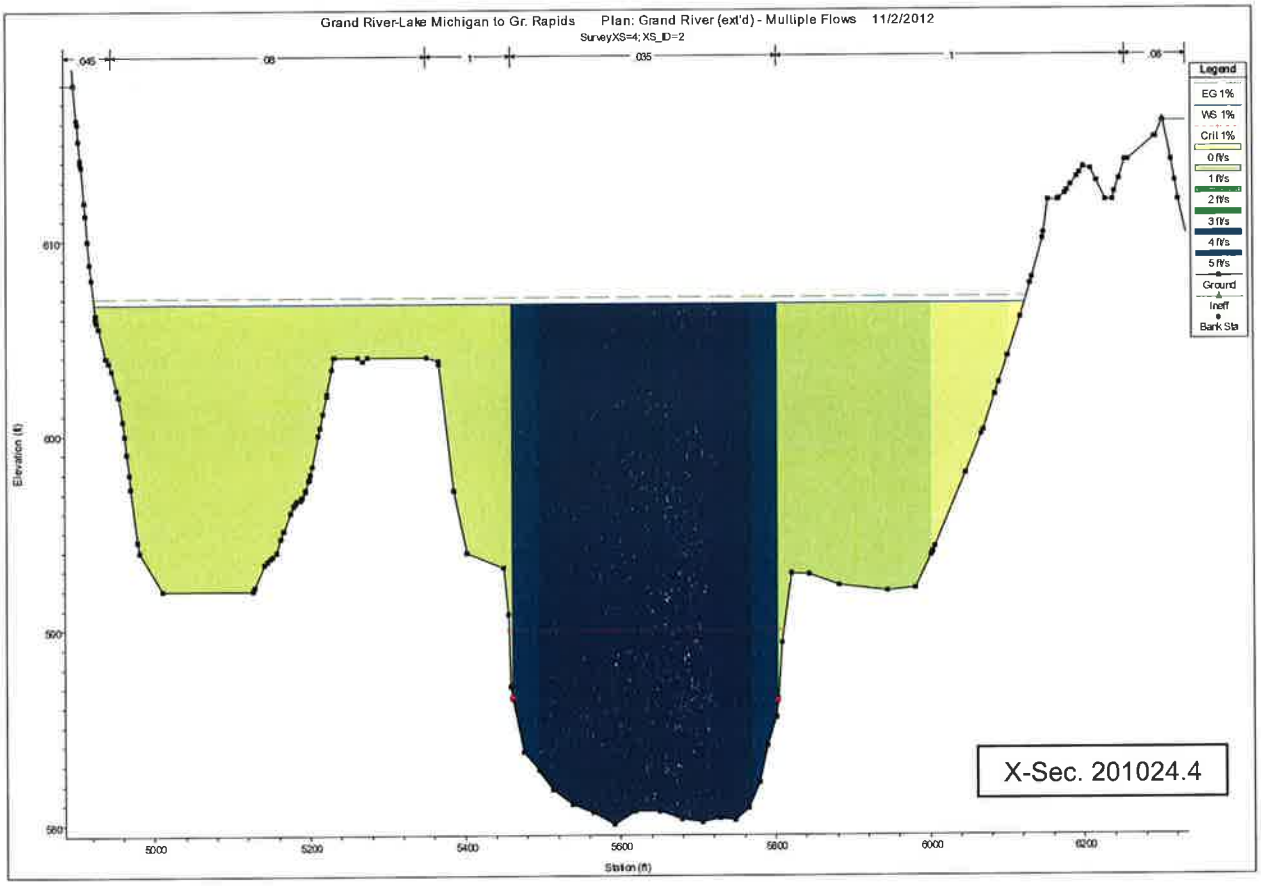
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Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
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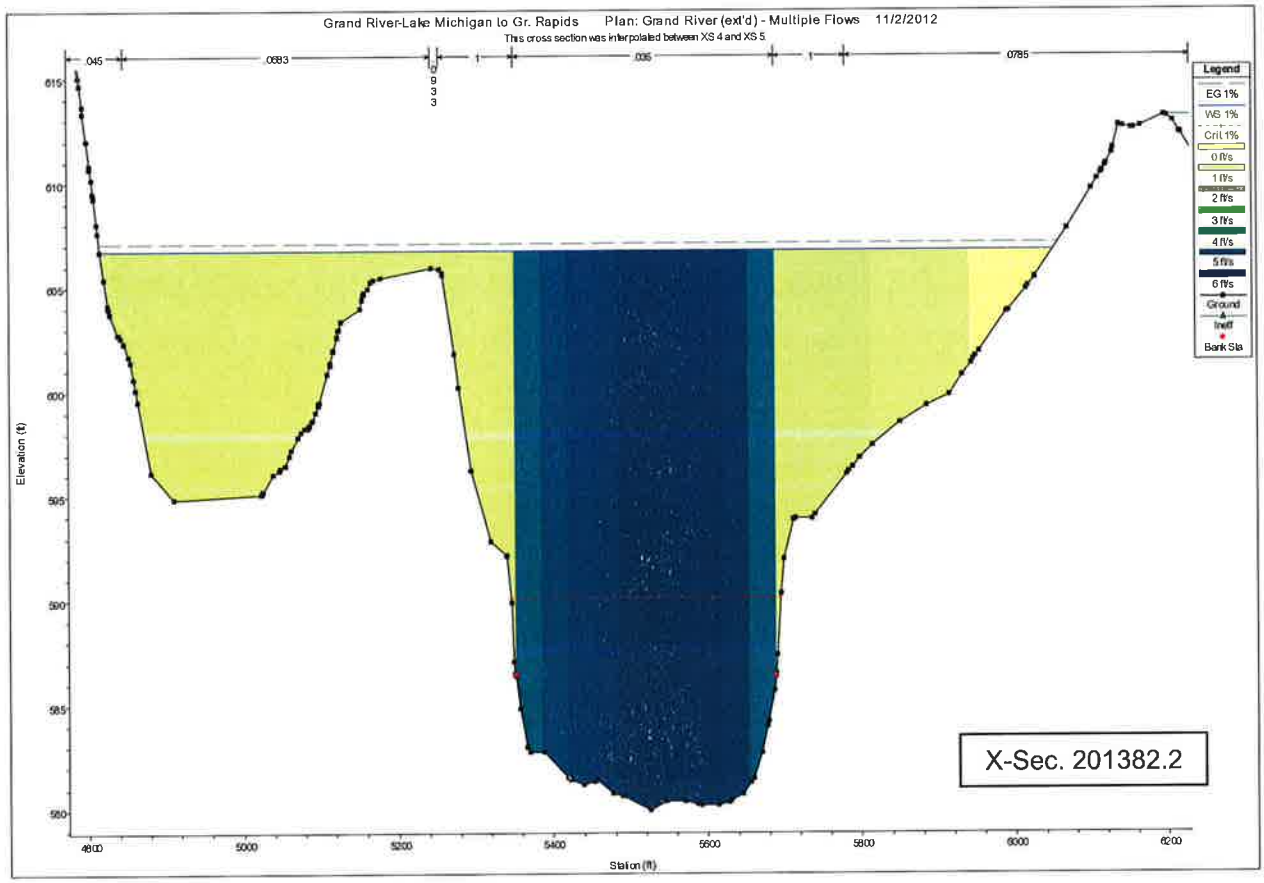
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Legend
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Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
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610
605
600
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5200
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Station (ft)
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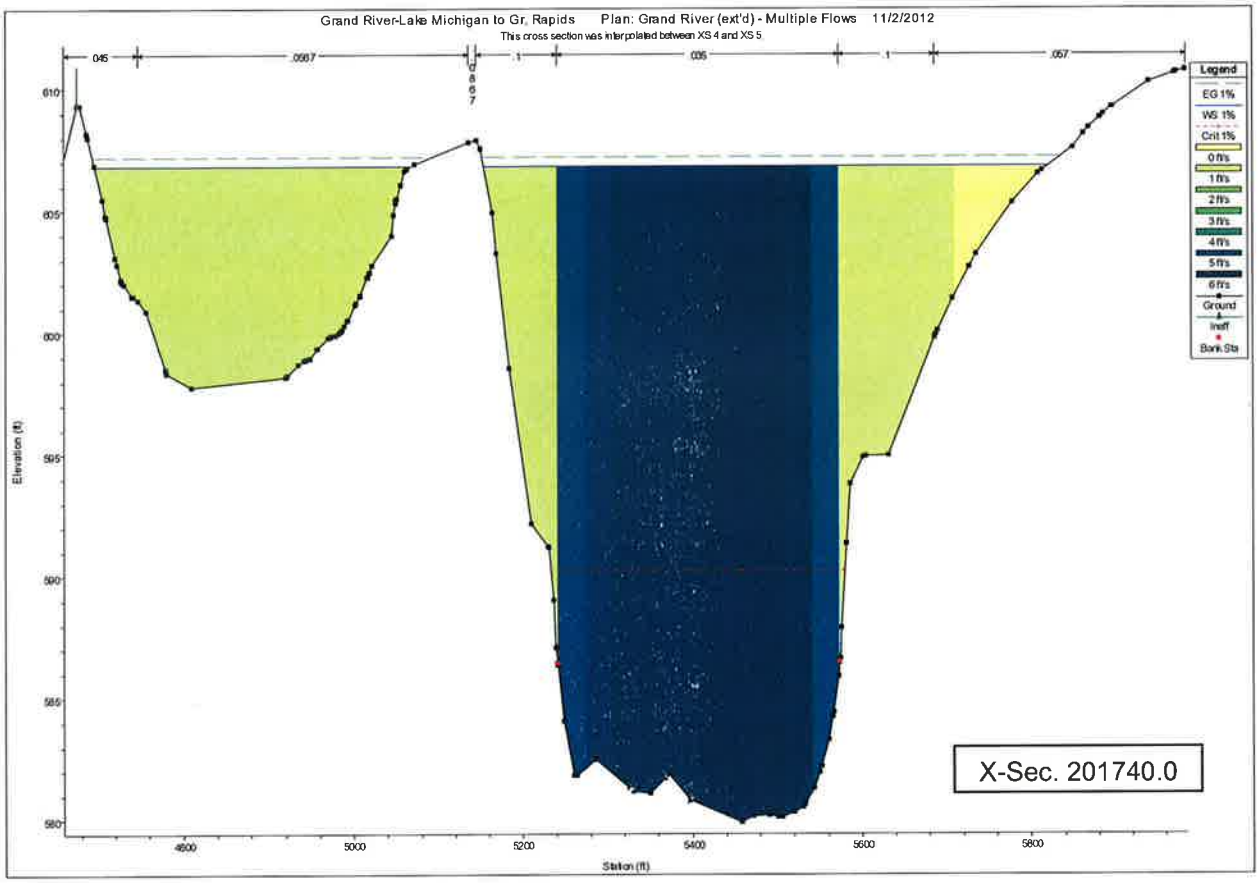
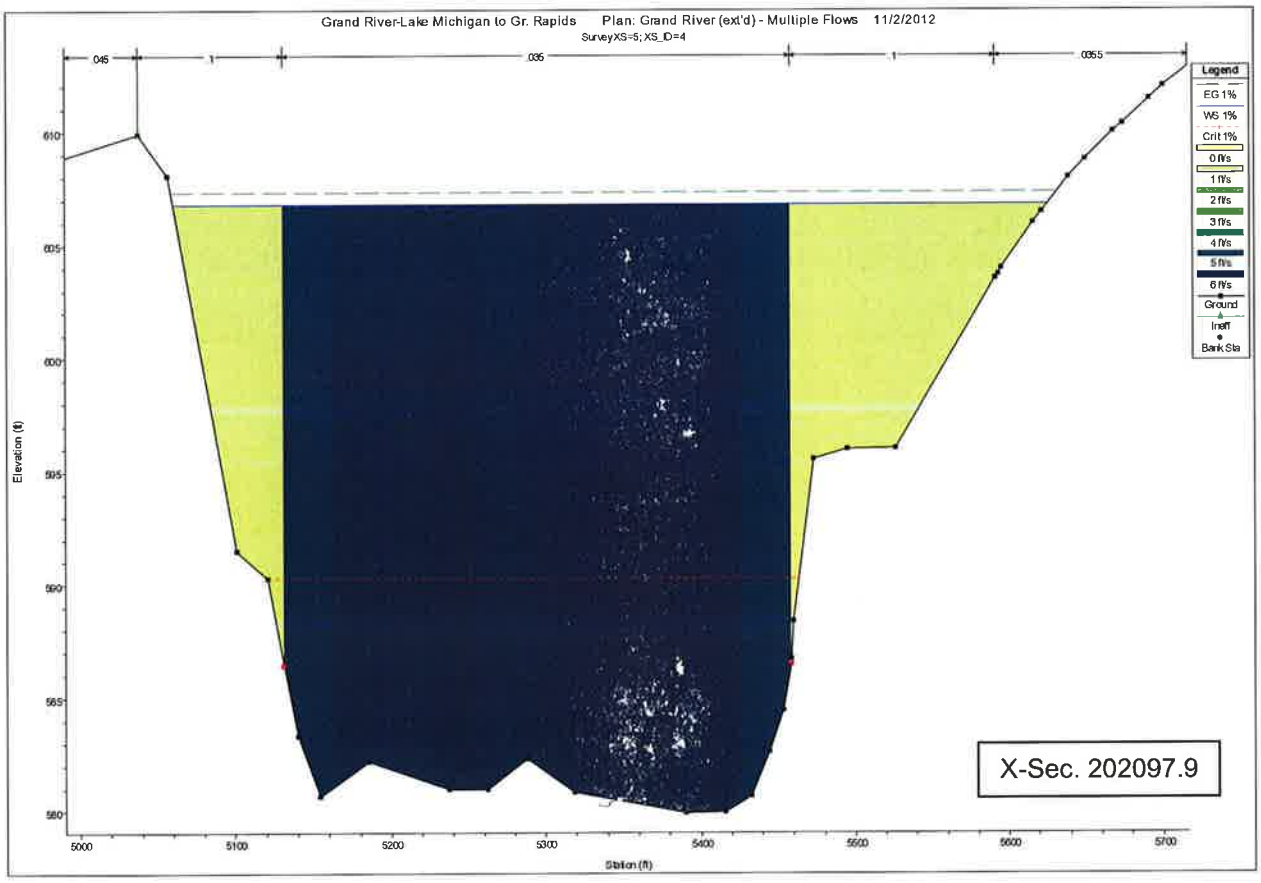
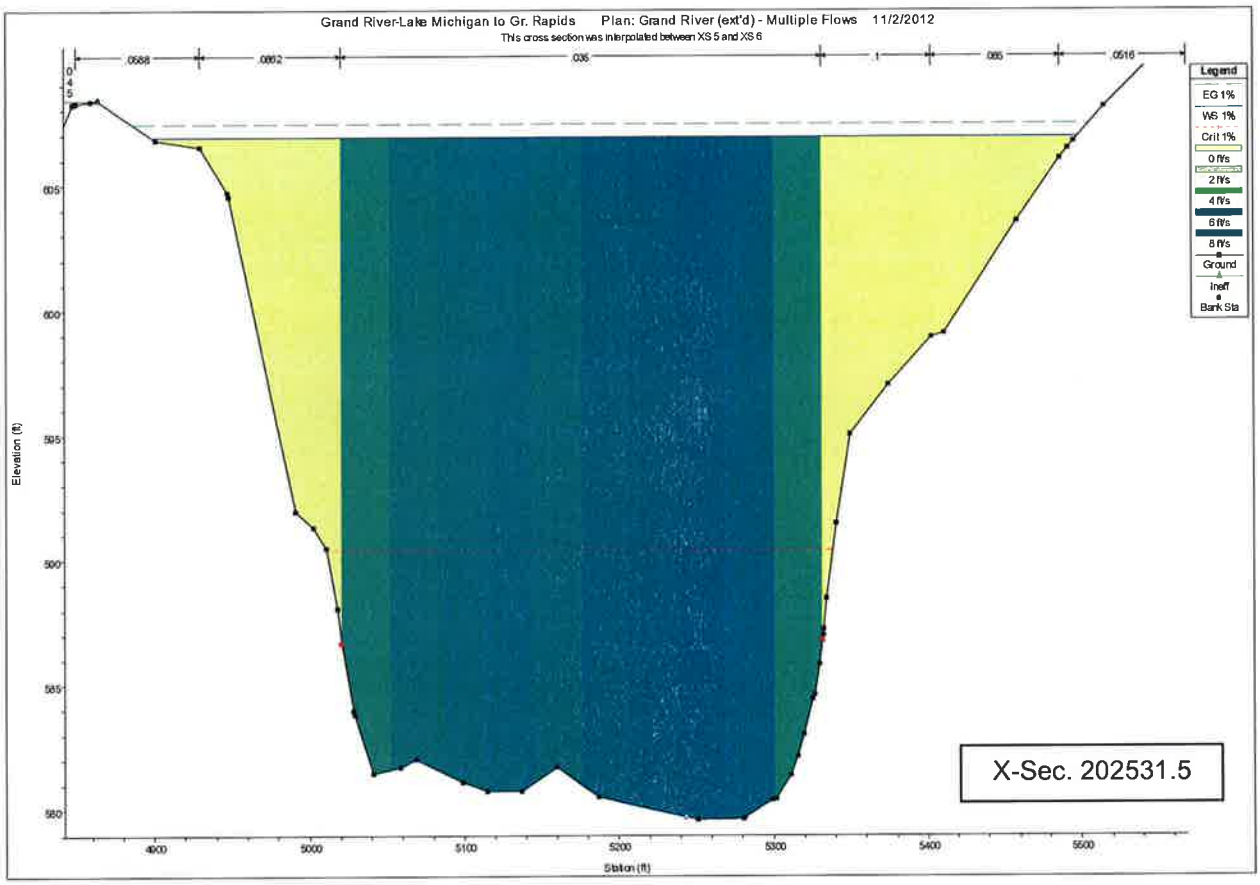
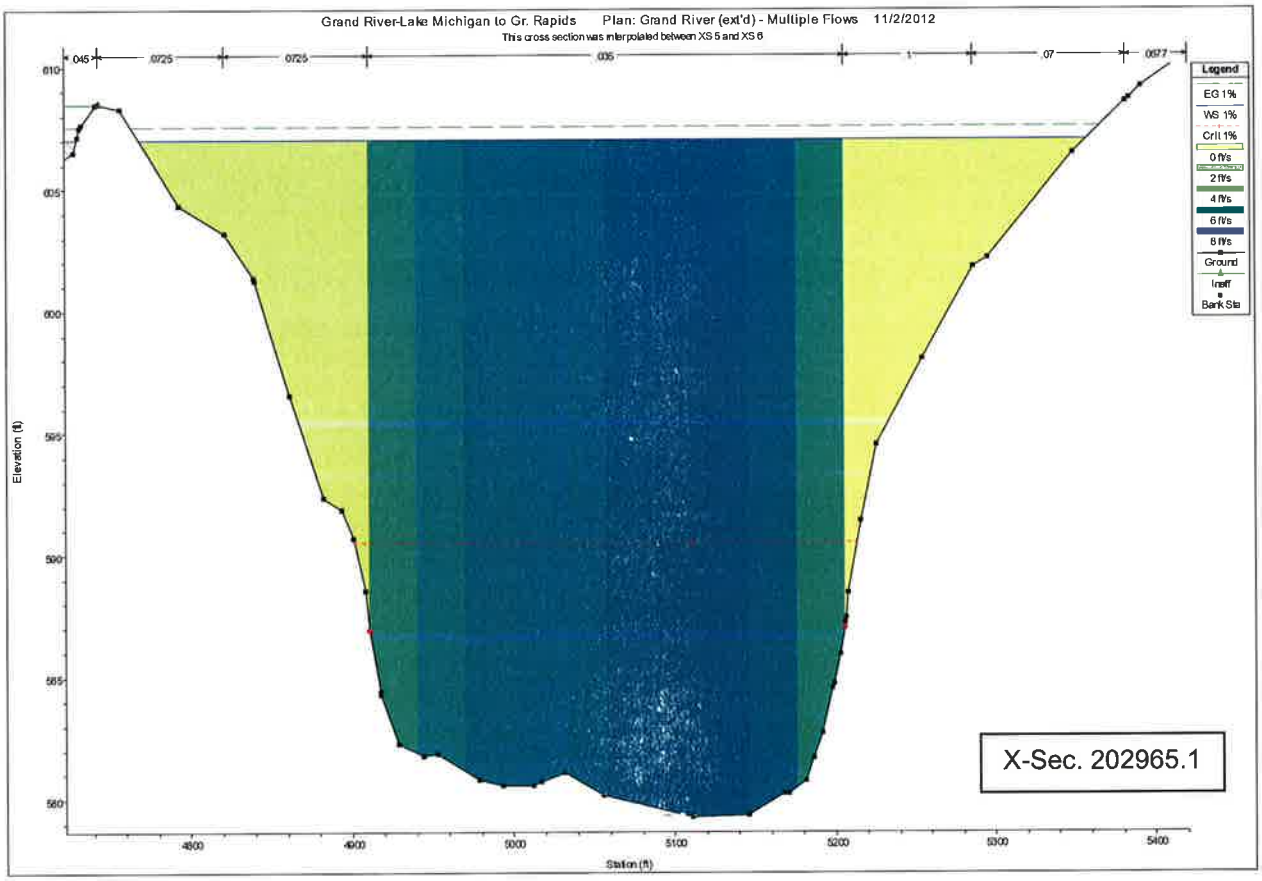
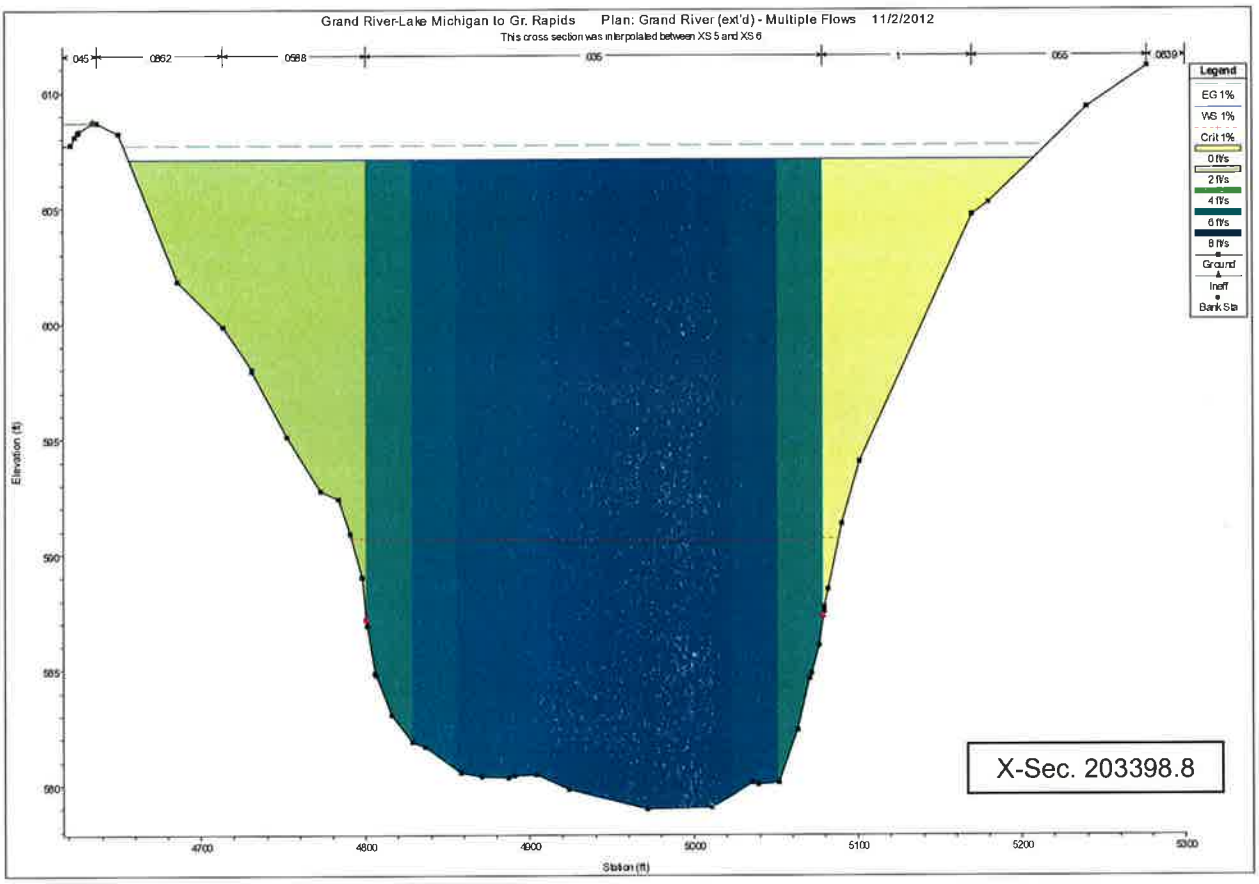
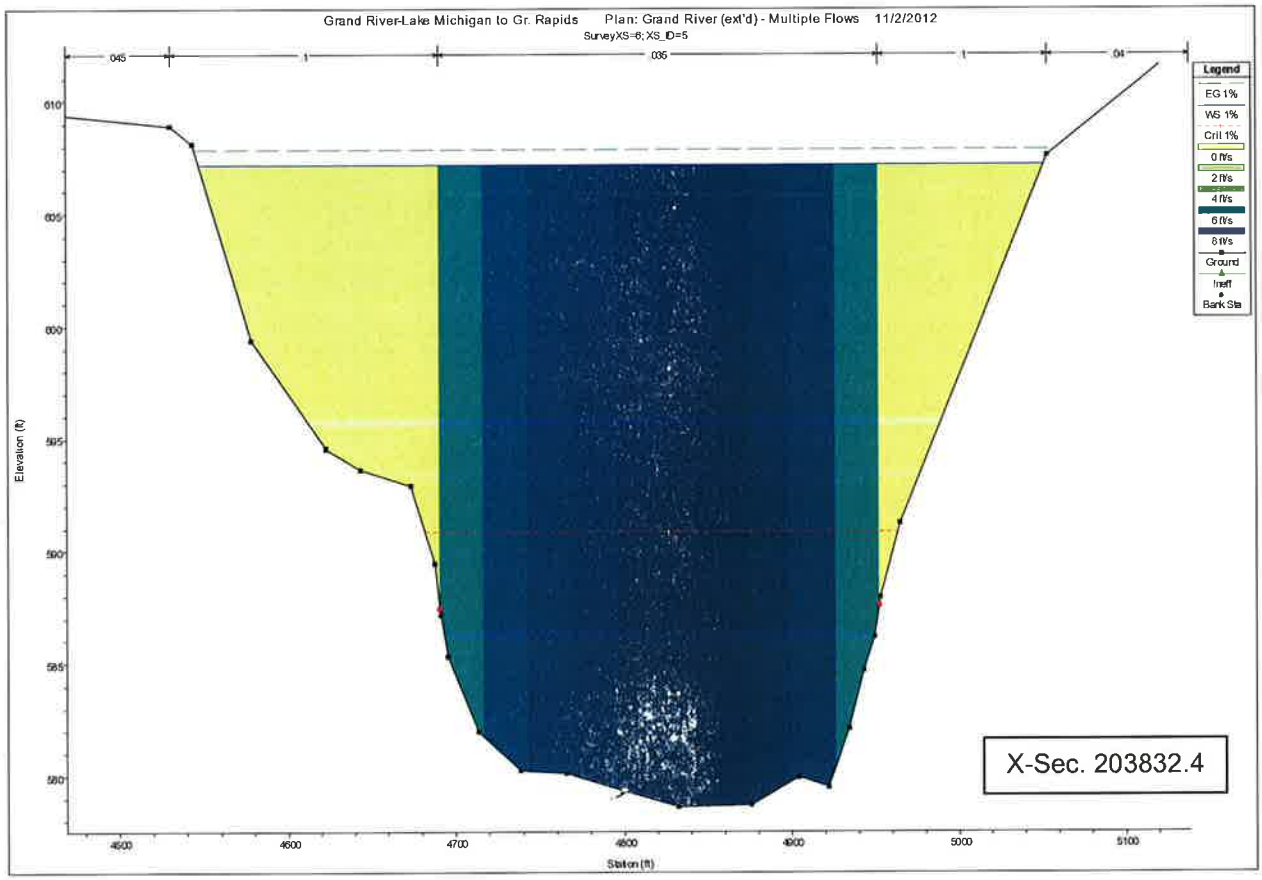

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 4 and XS 5
.045
.0667
.1
.035
.1
.057
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
4800
5000
5200
5400
5600
5800
Station (ft)
X-Sec. 201740.0

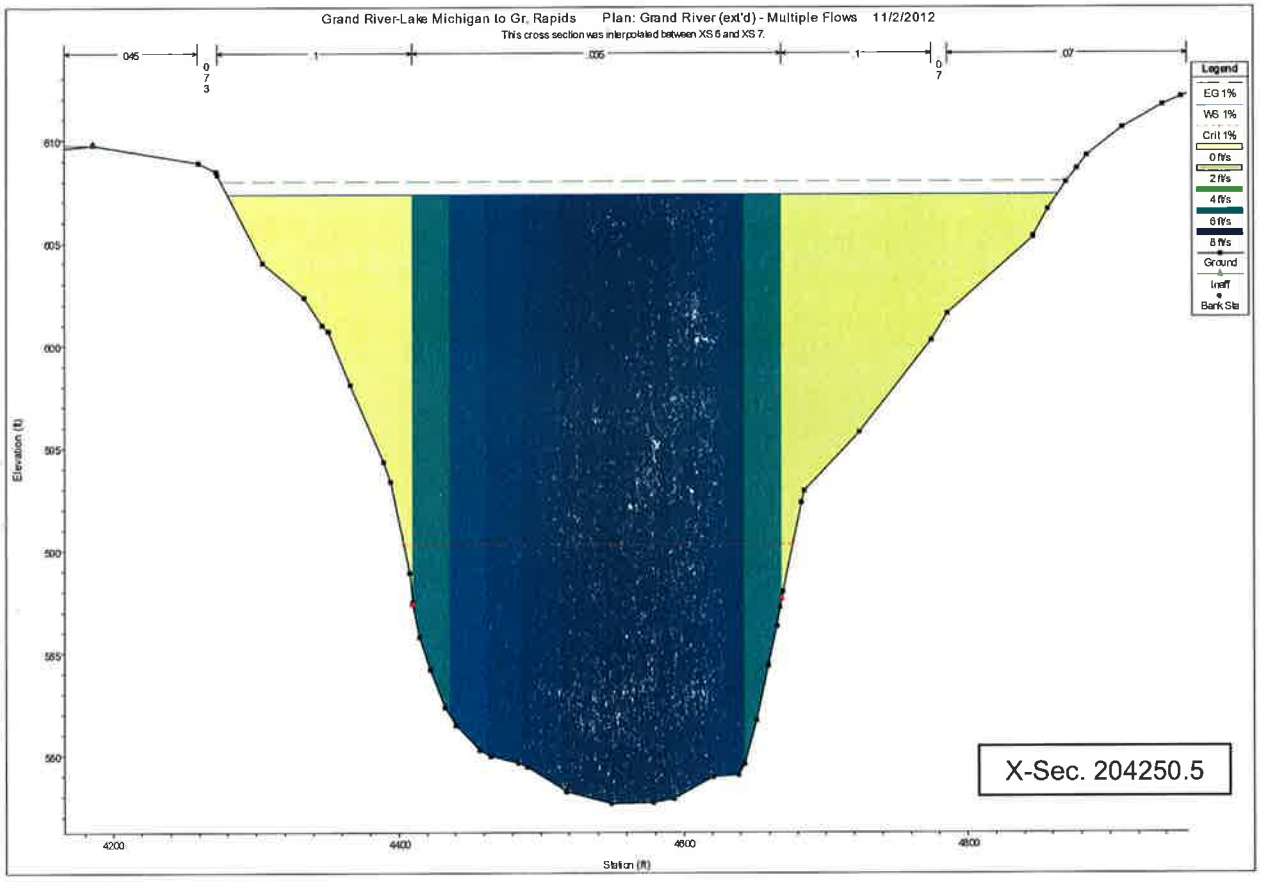

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=5; XS_ID=4
.045
.1
.035
.1
.0355
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
5000
5100
5200
5300
5400
5500
5600
5700
Station (ft)
X-Sec. 202097.9

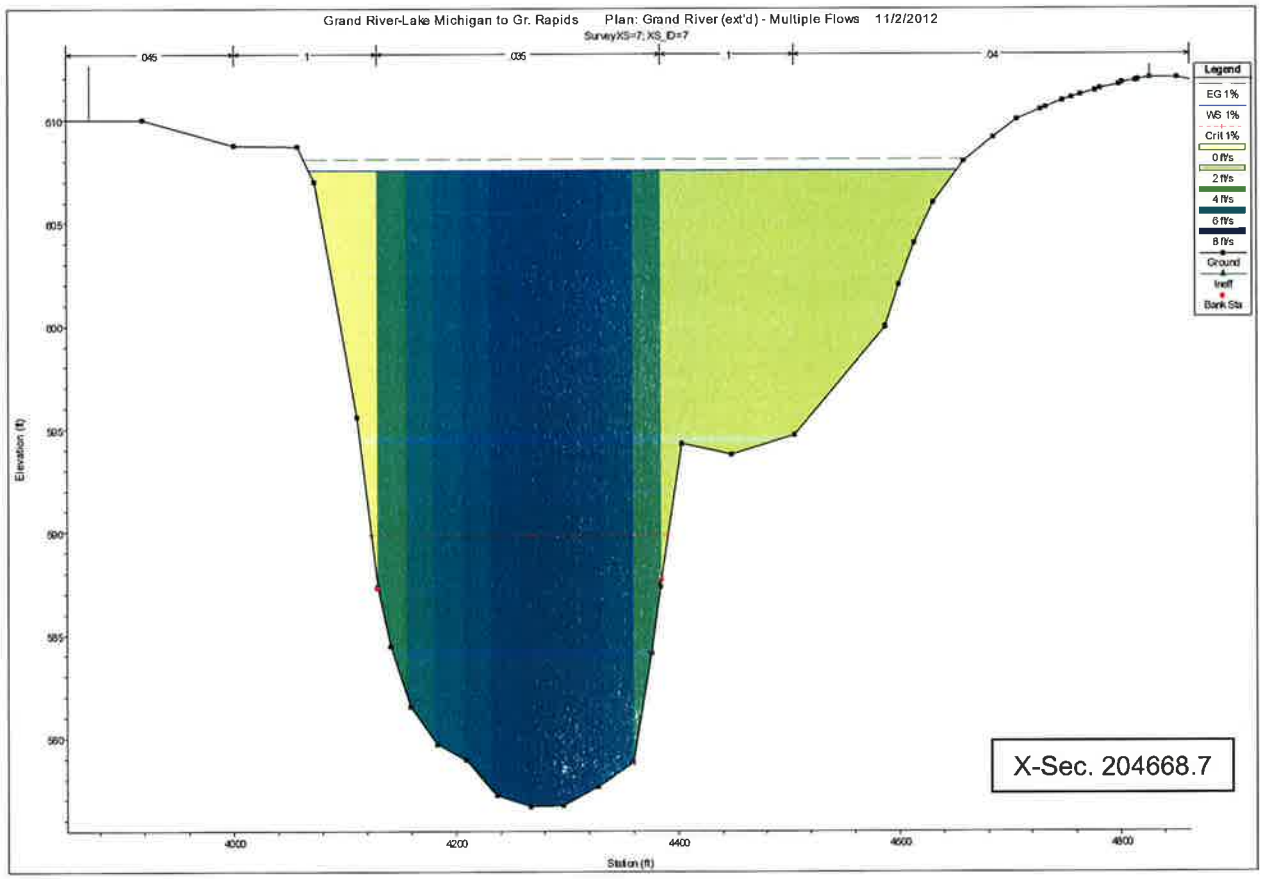

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 5 and XS 6
.0688
.0862
.035
.065
.0516
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 202531.5

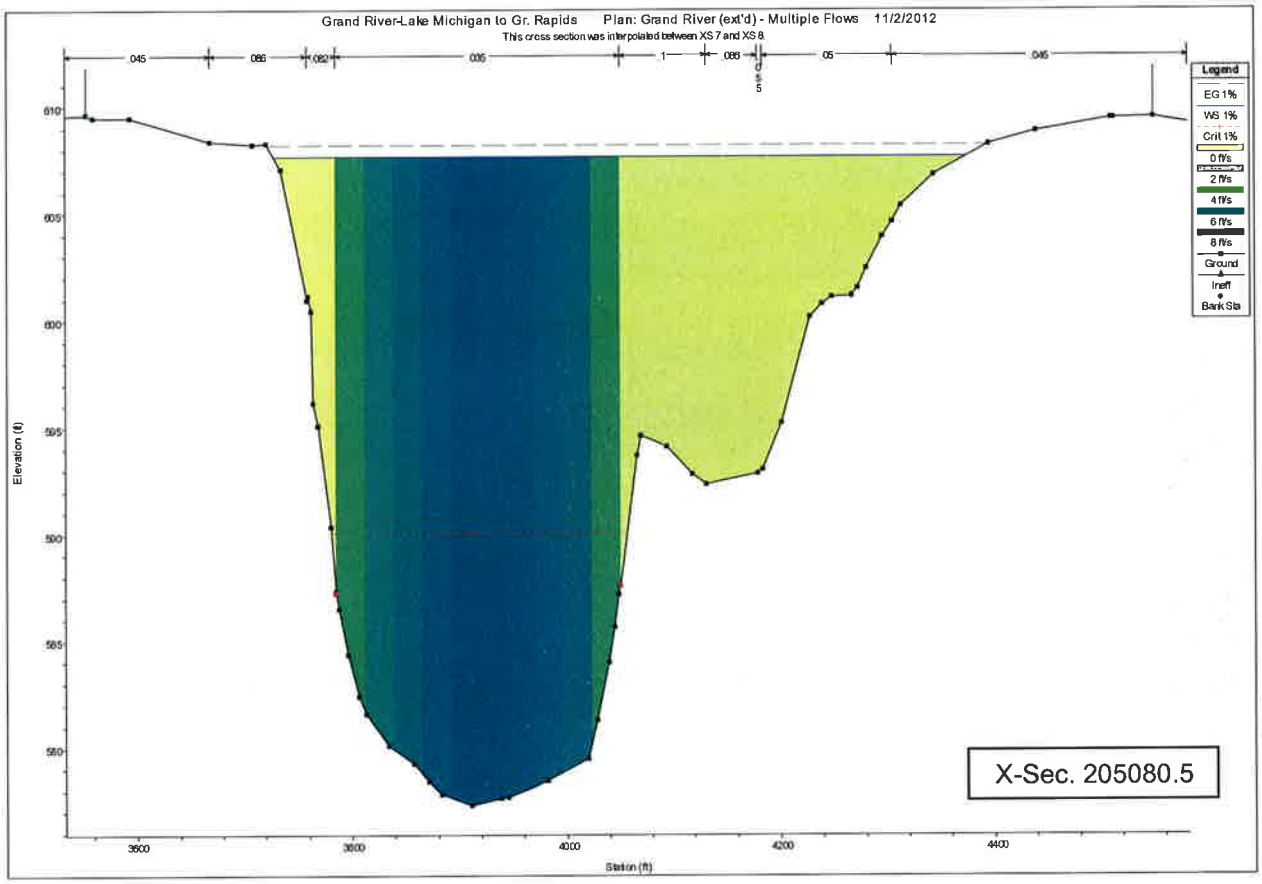

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 5 and XS 6
.045
.0725
.0725
.035
.07
.0927
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 202965.1

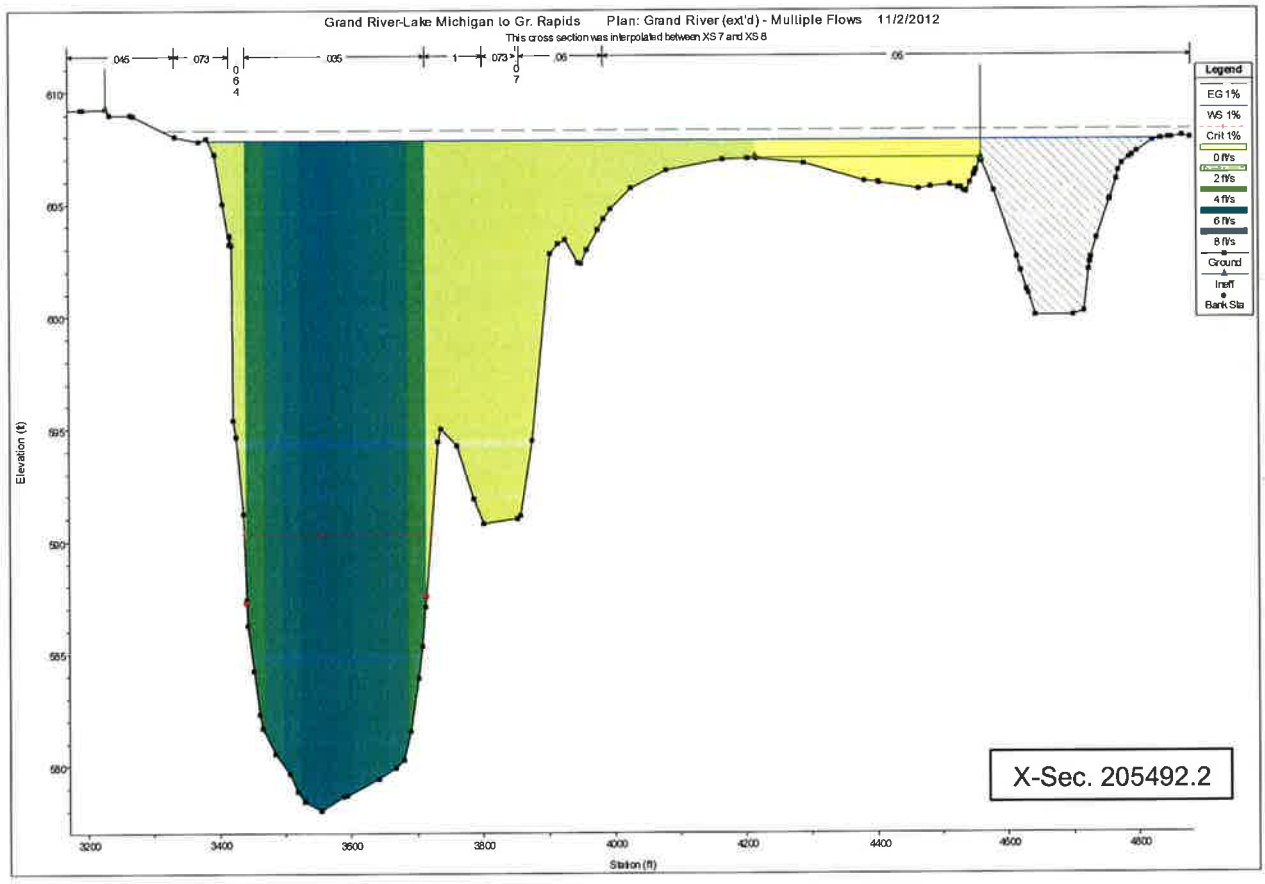

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 5 and XS 6
045
0862
0688
035
055
0639
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
4700
4800
4900
5000
5100
5200
5300
Station (ft)
X-Sec. 203398.8

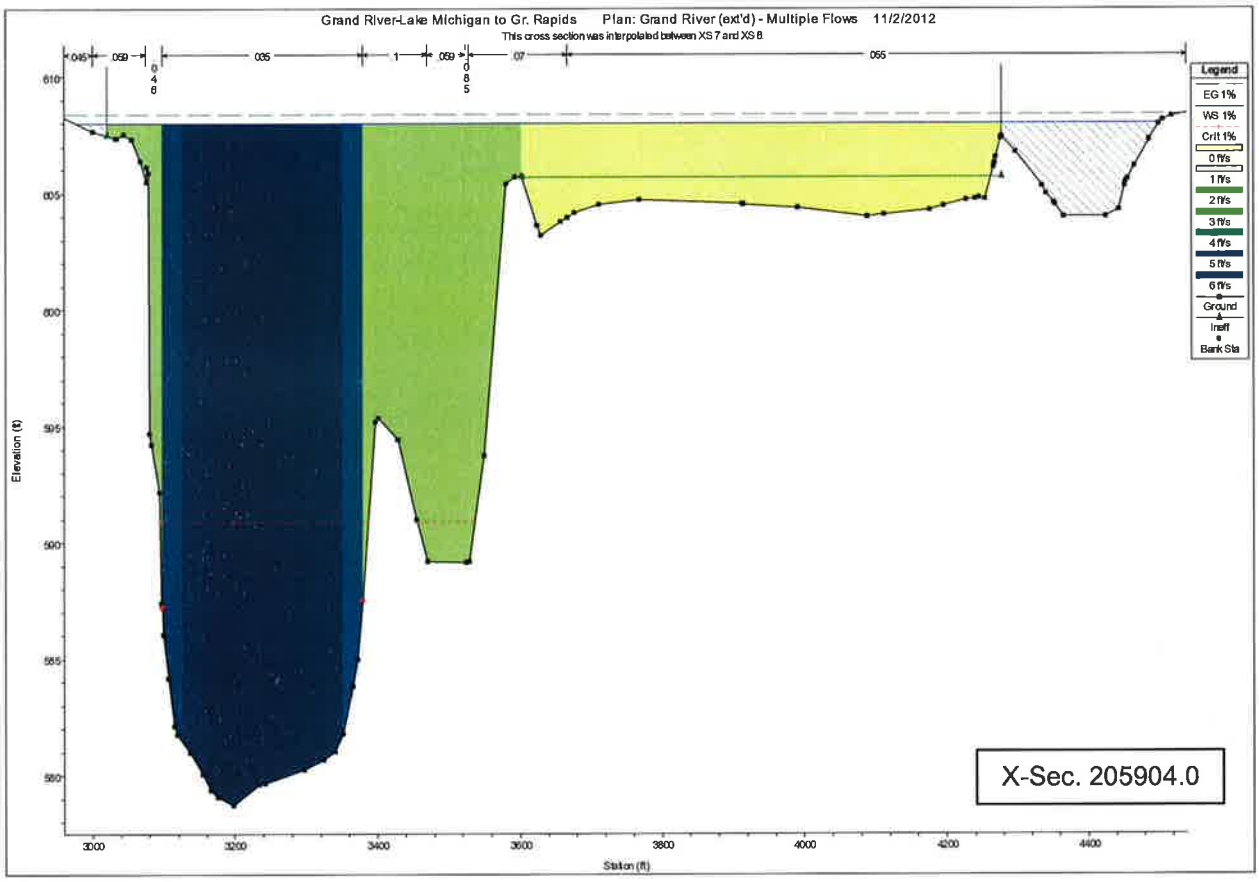

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=6; XS_ID=5
045
035
04
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
4500
4600
4700
4800
4900
5000
5100
Station (ft)
X-Sec. 203832.4

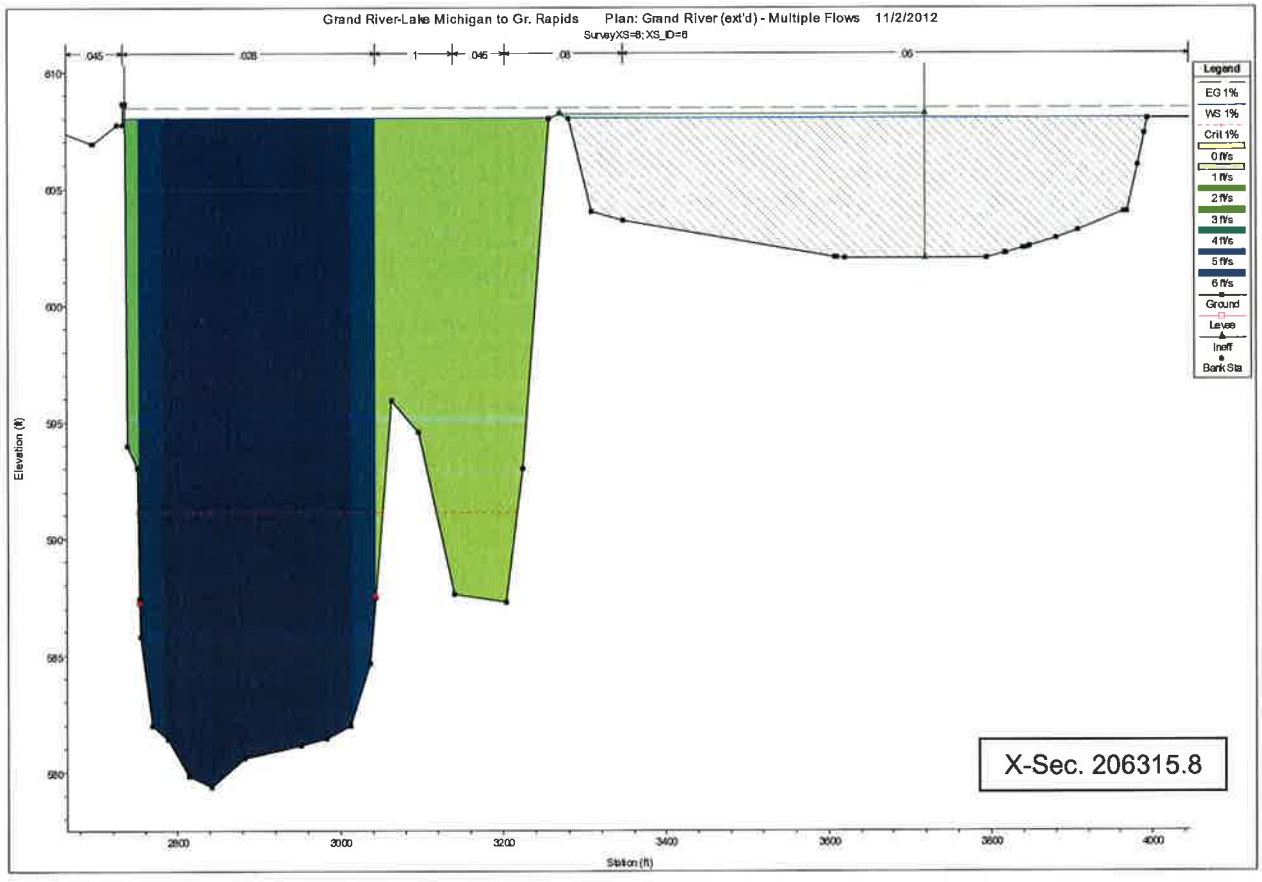

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 6 and XS 7.
045
035
07
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 204250.5

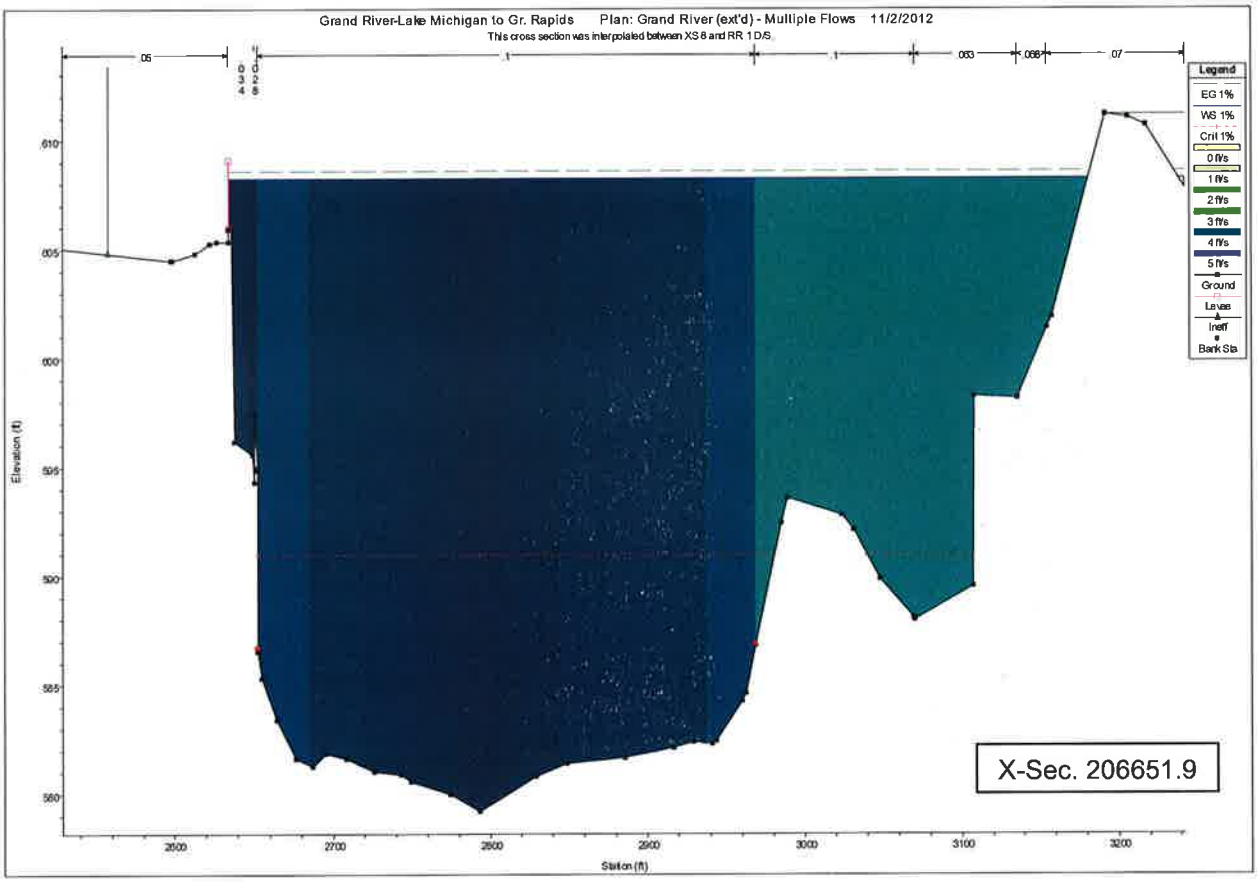

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=7; XS_ID=7
045
035
04
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 204668.7

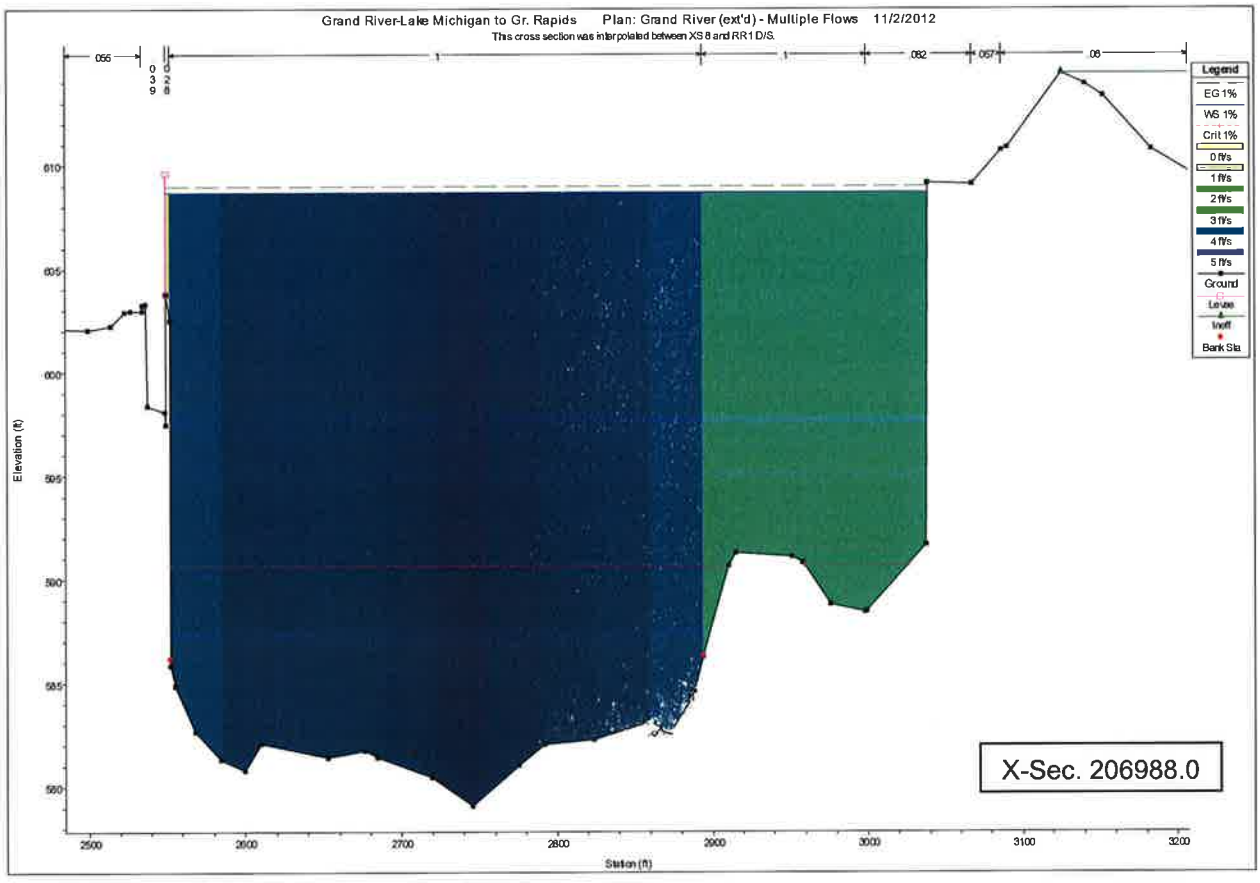

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 7 and XS 8
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 205080.5

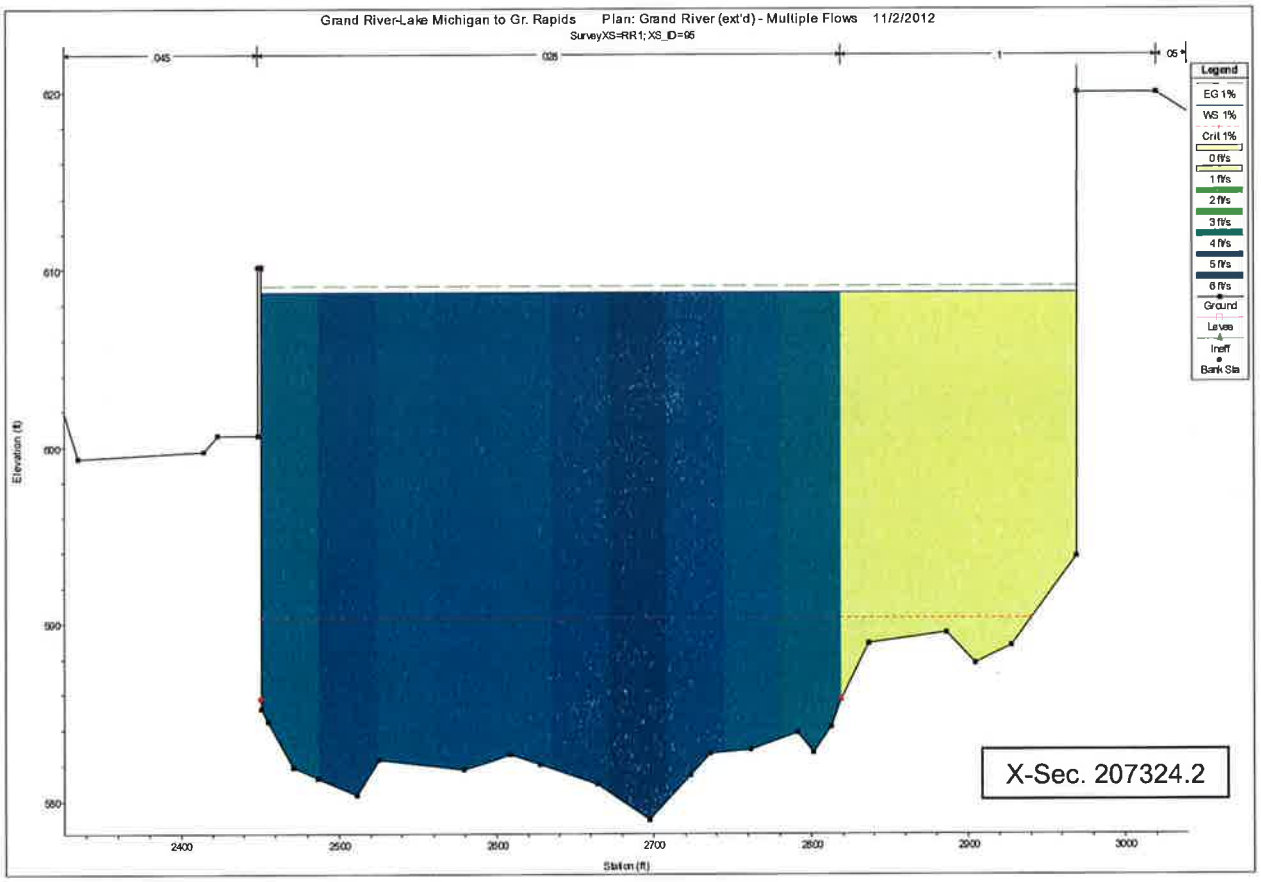

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 7 and XS 8
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 205492.2

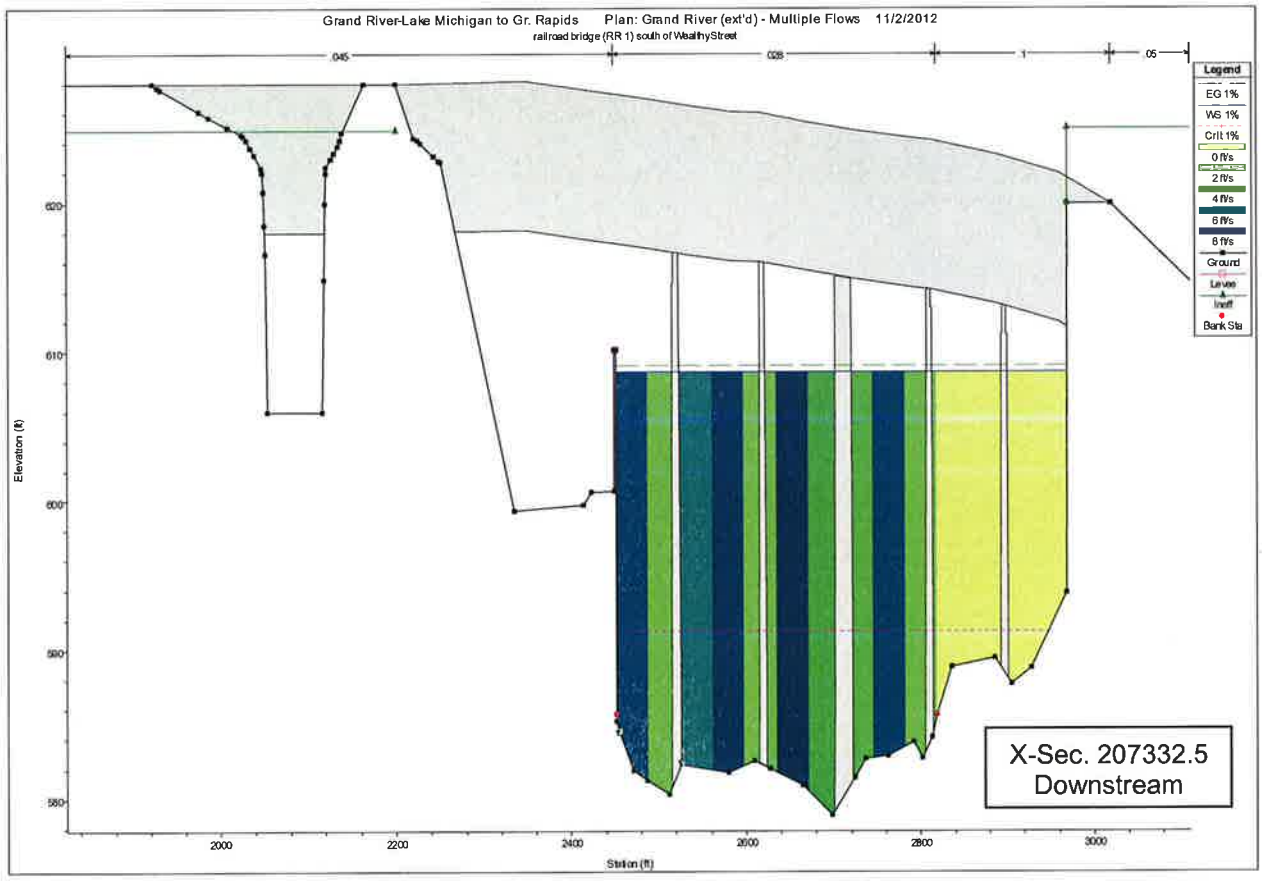

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 7 and XS 8
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 205904.0

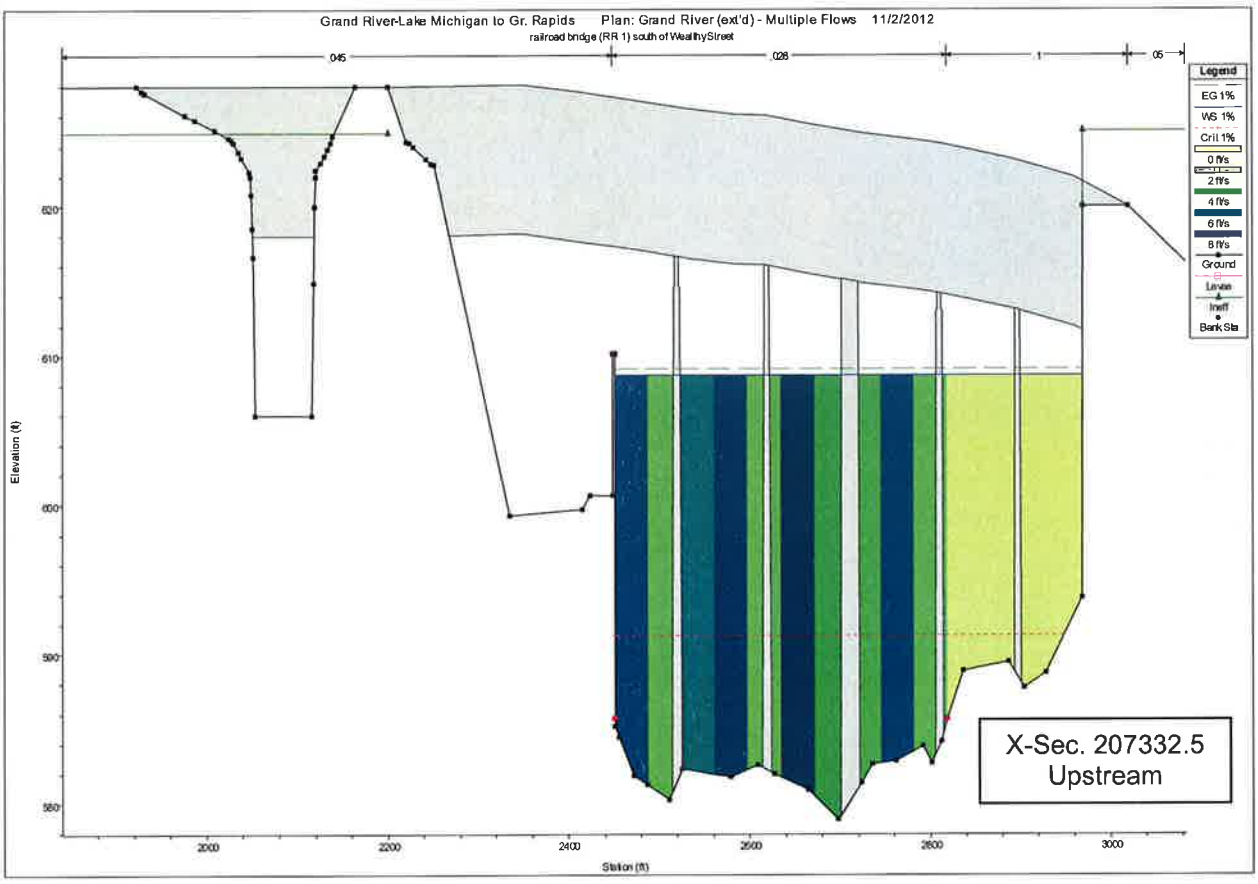

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=8; XS_ID=8
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 206315.8

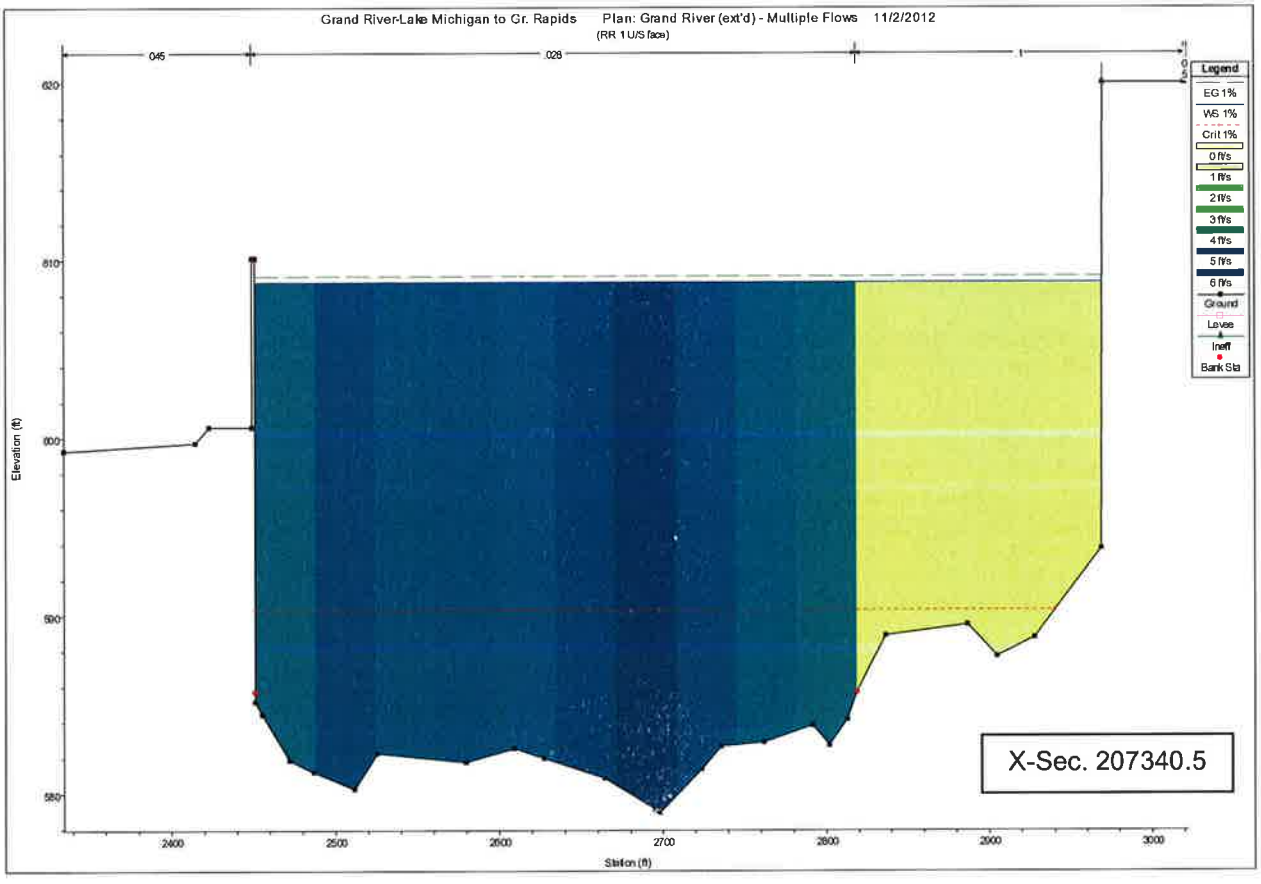

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 8 and RR 1 D/S
Legend
EG 1%
WS 1%
Crit 1%
0 f/s
1 f/s
2 f/s
3 f/s
4 f/s
5 f/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 206651.9

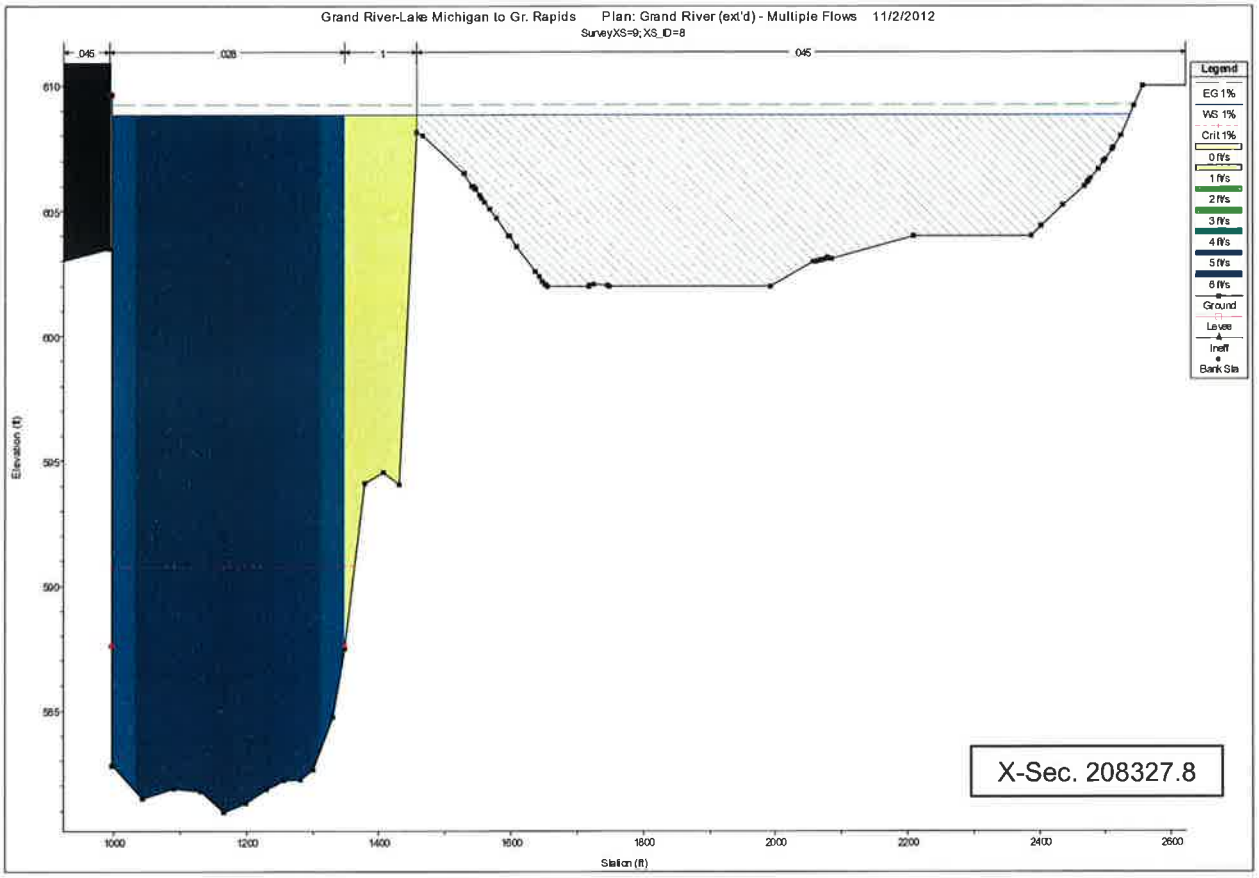

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
This cross section was interpolated between XS 8 and RR1 D/S.
Legend
EG 1%
WS 1%
Crit 1%
0 f/s
1 f/s
2 f/s
3 f/s
4 f/s
5 f/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 206988.0

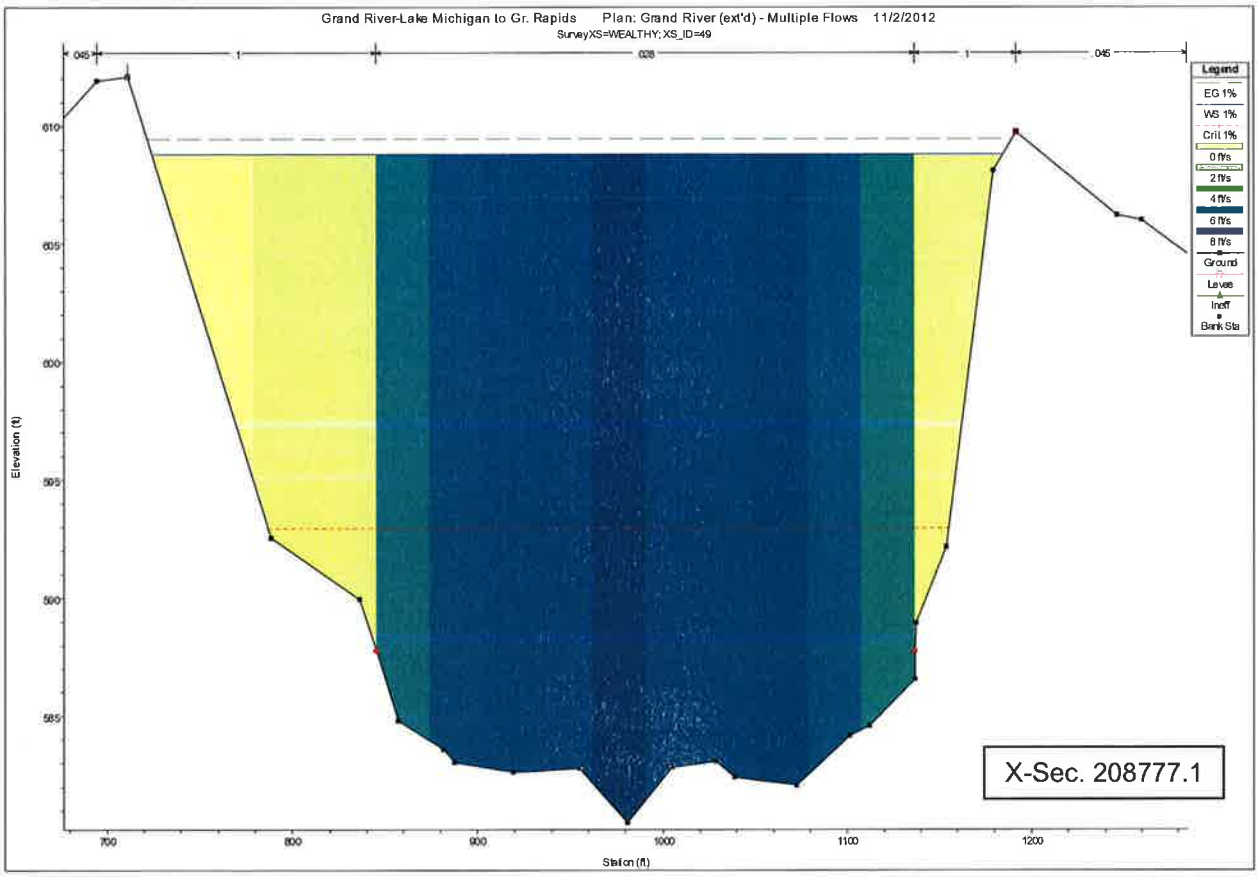

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=RR1; XS_ID=95
.045
.025
1
.05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
580
2400
2500
2600
2700
2800
2900
3000
Station (ft)
X-Sec. 207324.2

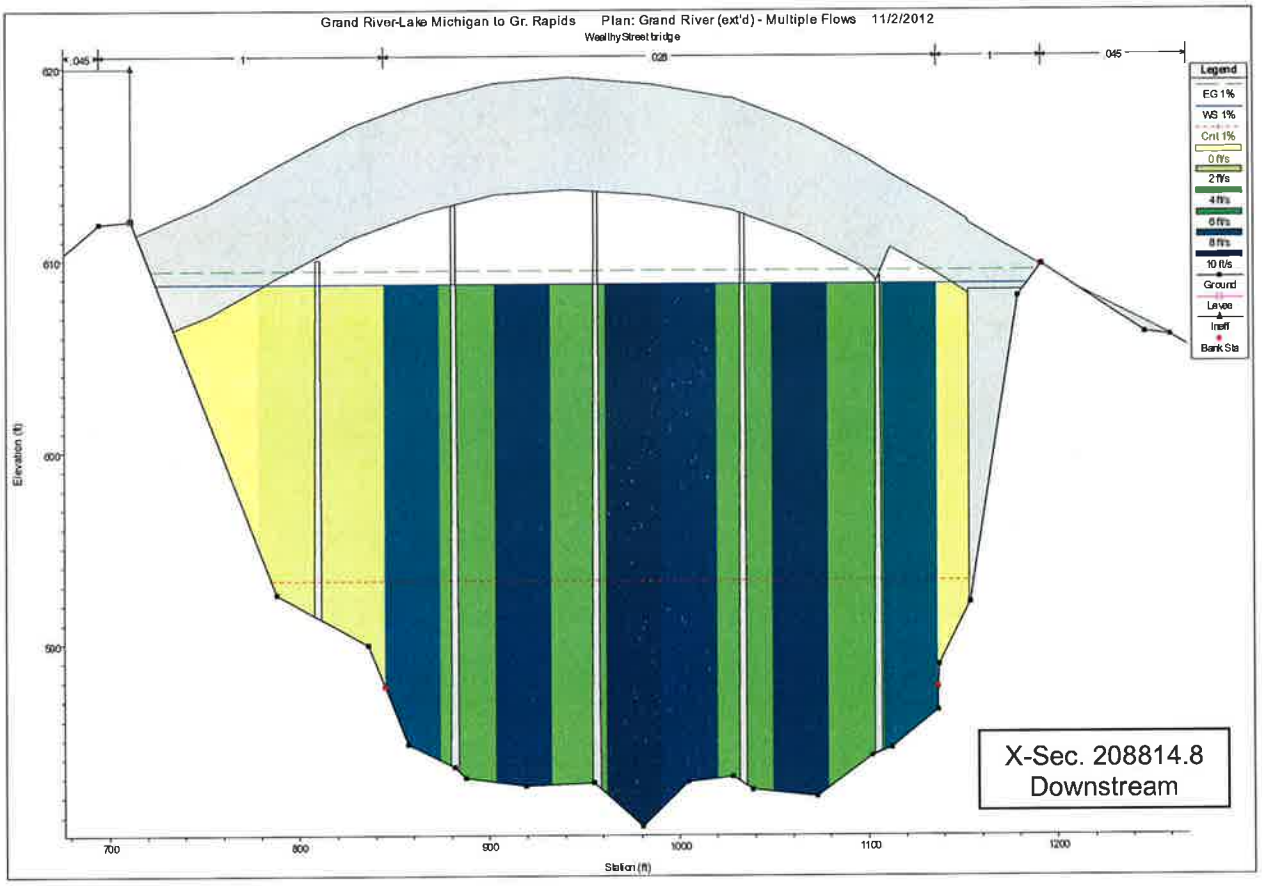

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
railroad bridge (RR 1) south of Wealthy Street
.045
.025
1
.05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
580
2000
2200
2400
2600
2800
3000
Station (ft)
X-Sec. 207332.5
Downstream

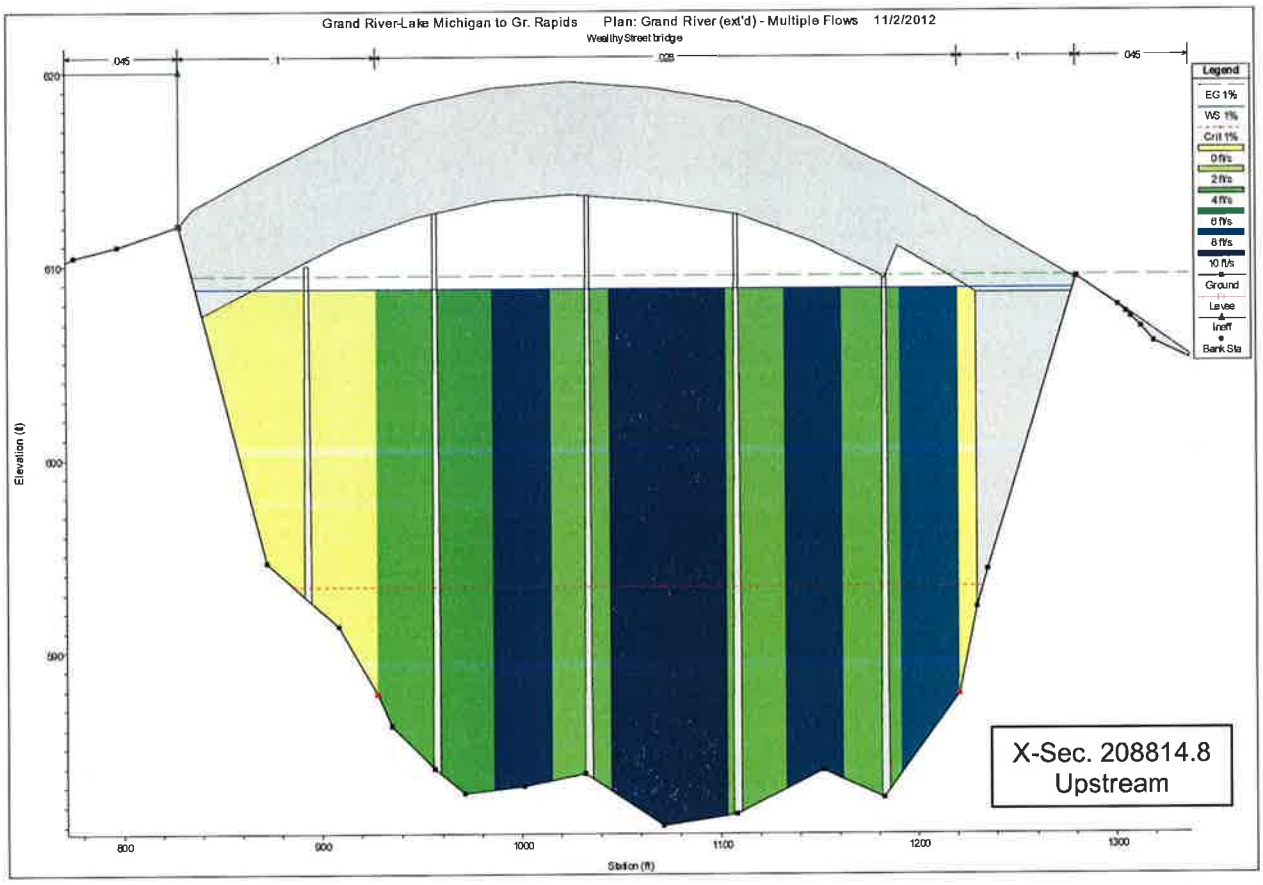

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
railroad bridge (RR 1) south of Wealthy Street
045
028
05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
580
2000
2200
2400
2600
2800
3000
Station (ft)
X-Sec. 207332.5
Upstream

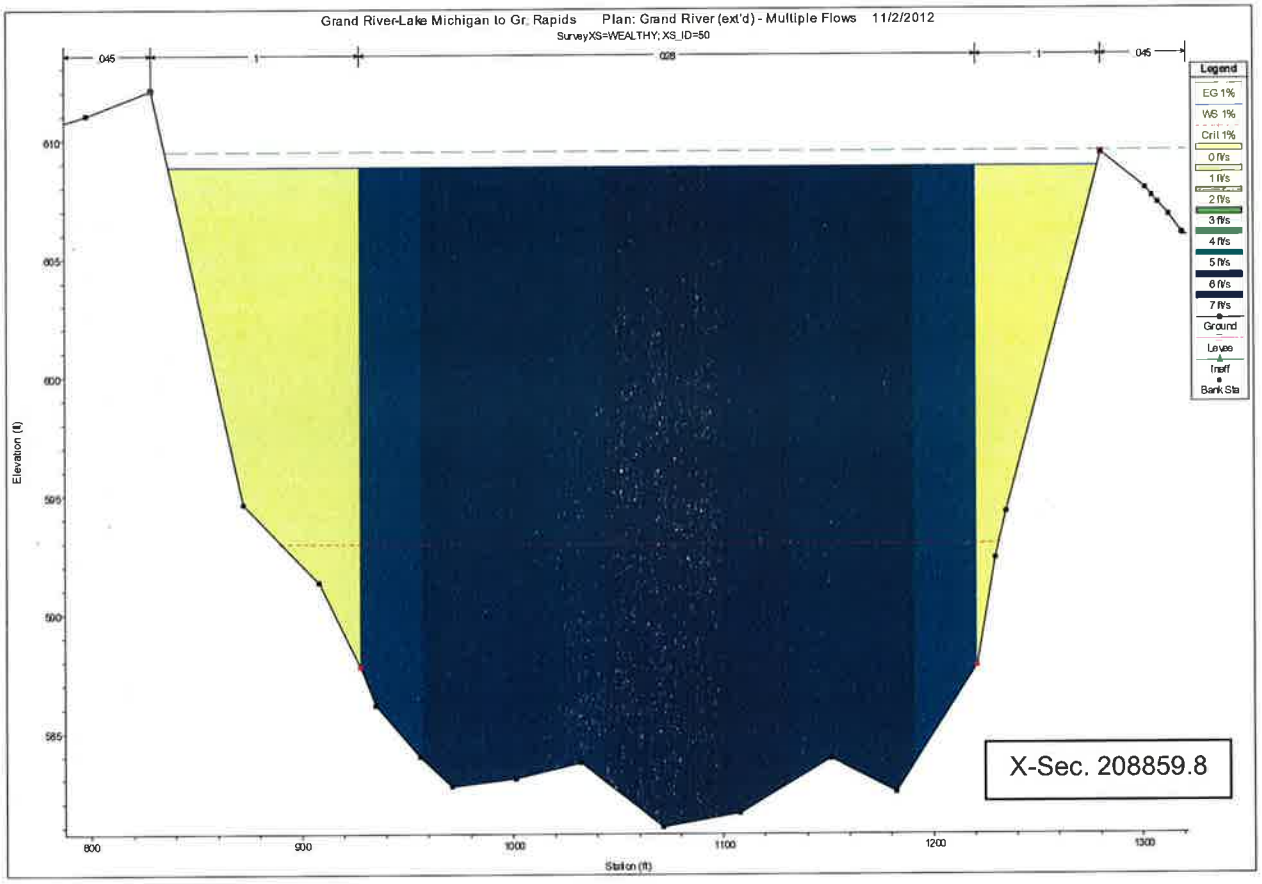

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(RR 1 U/S face)
045
028
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
600
590
580
2400
2500
2600
2700
2800
2900
3000
Station (ft)
X-Sec. 207340.5

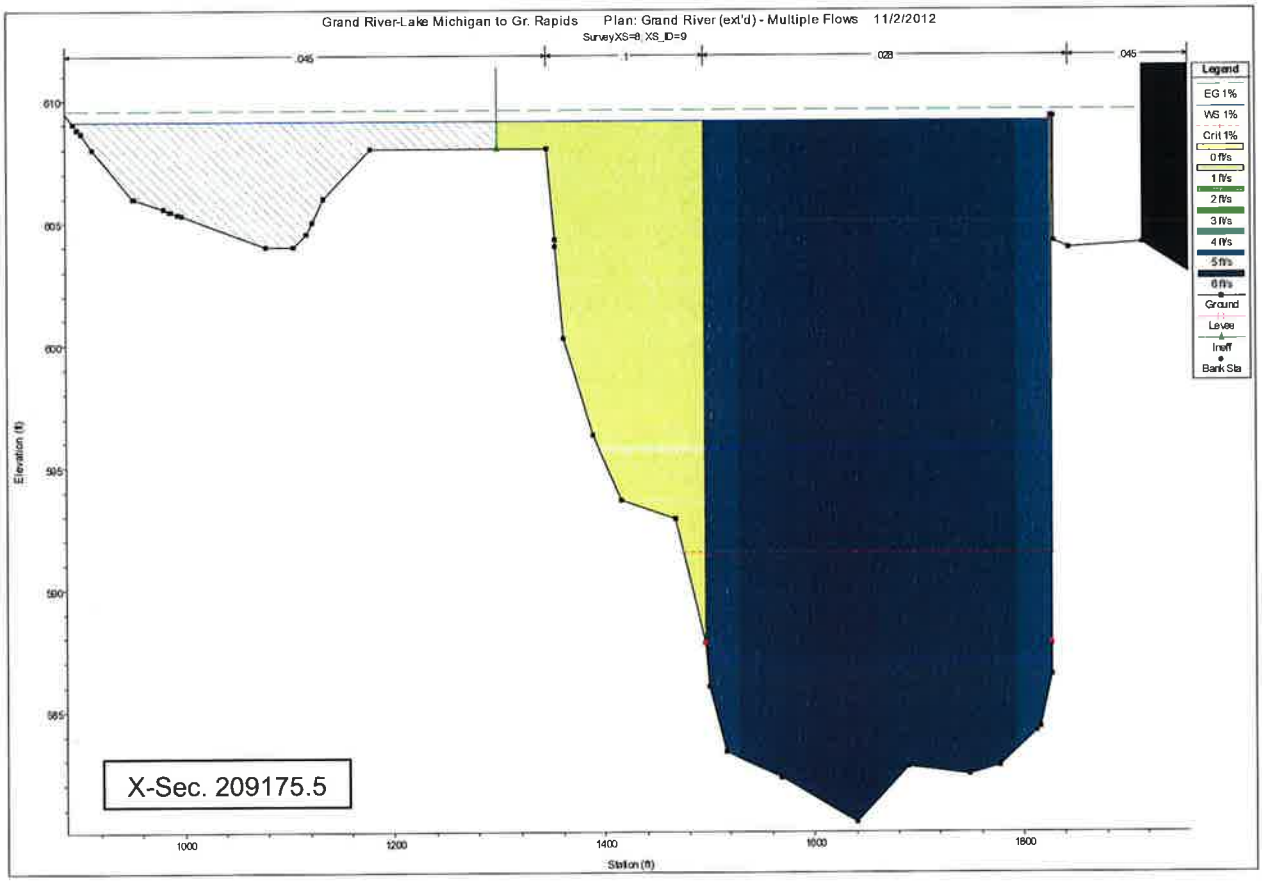

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=9; XS_ID=8
.045
.028
1
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
1000
1200
1400
1600
1800
2000
2200
2400
2600
Station (ft)
X-Sec. 208327.8

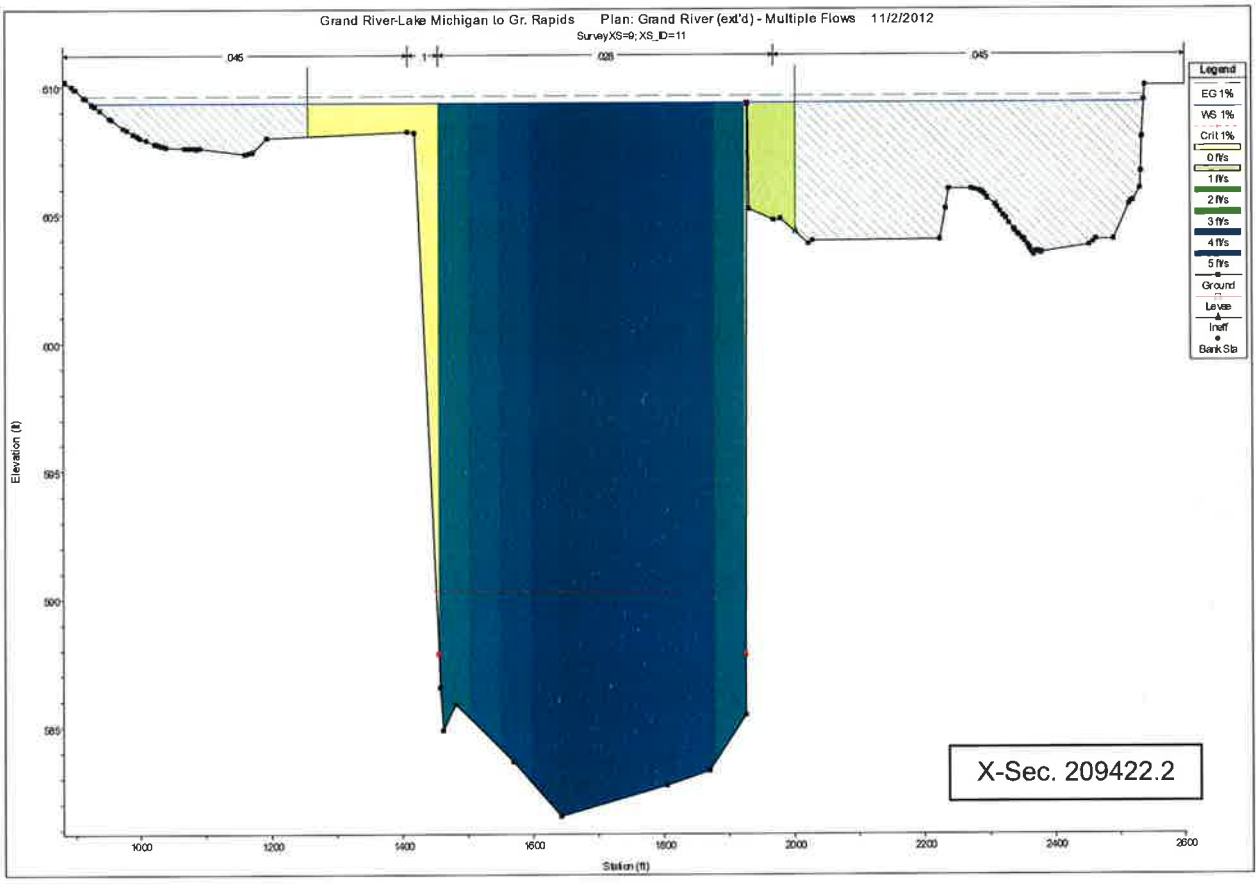

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=WEALTHY; XS_ID=49
.045
1
.028
1
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
700
800
900
1000
1100
1200
Station (ft)
X-Sec. 208777.1

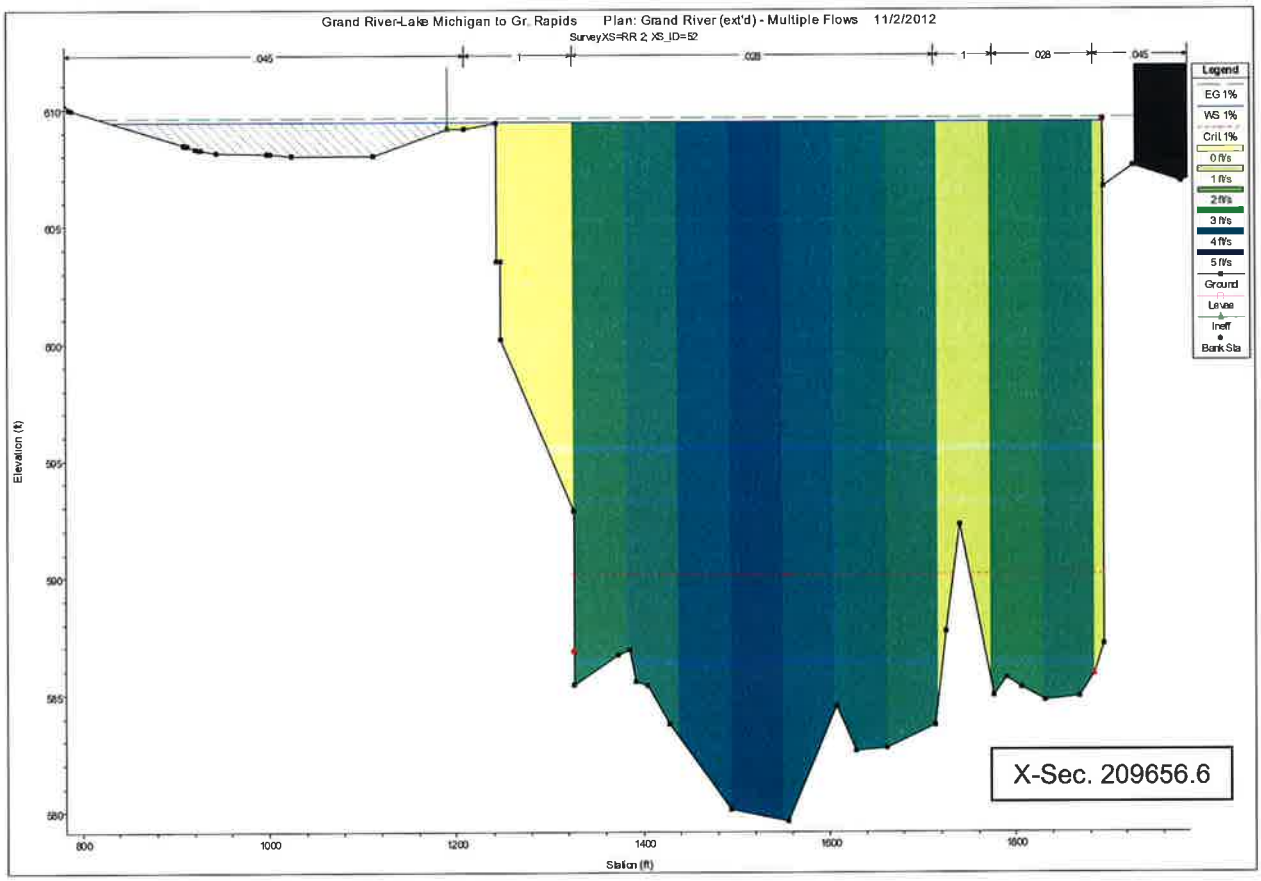

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Wealthy Street bridge
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
700
800
900
1000
1100
1200
Station (ft)
X-Sec. 208814.8
Downstream

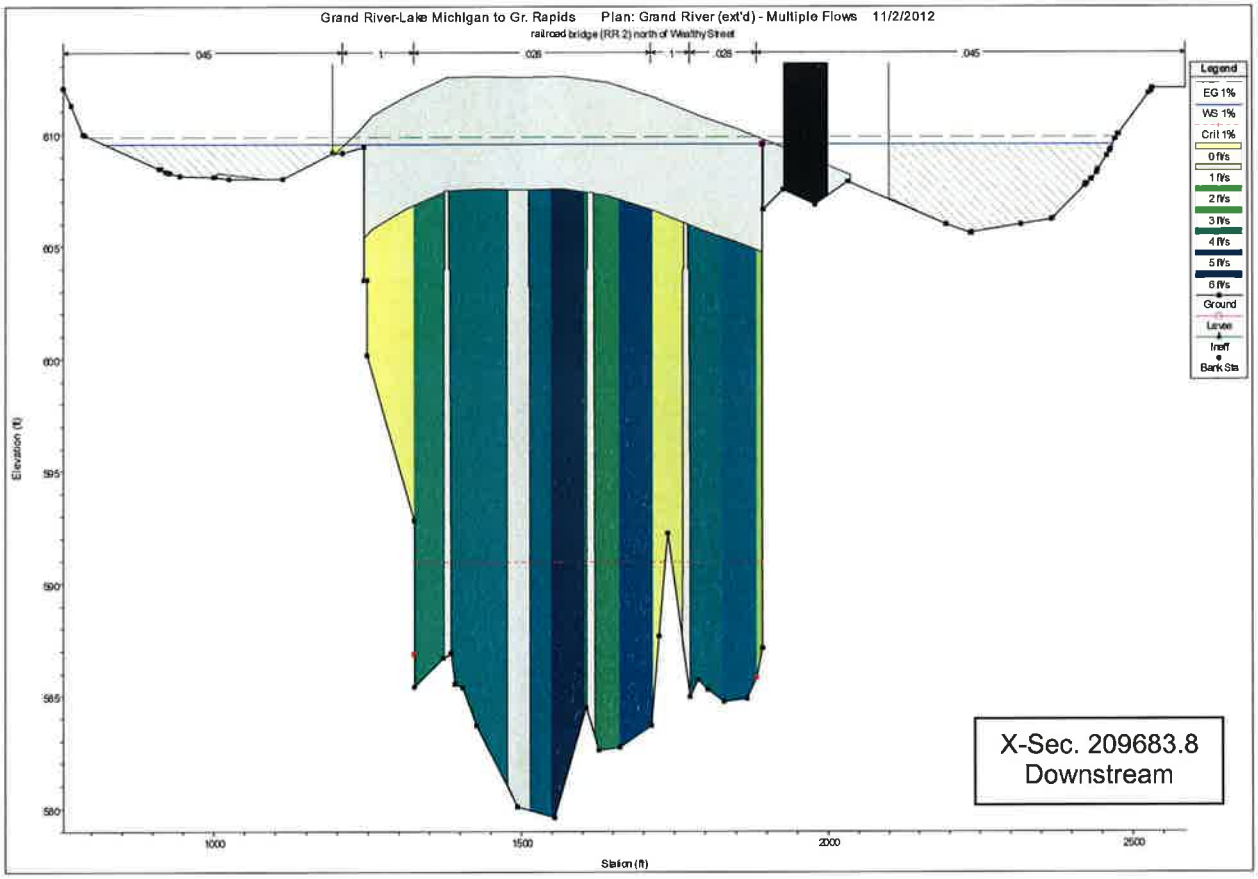

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Wealthy Street bridge
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
800
900
1000
1100
1200
1300
Station (ft)
X-Sec. 208814.8
Upstream

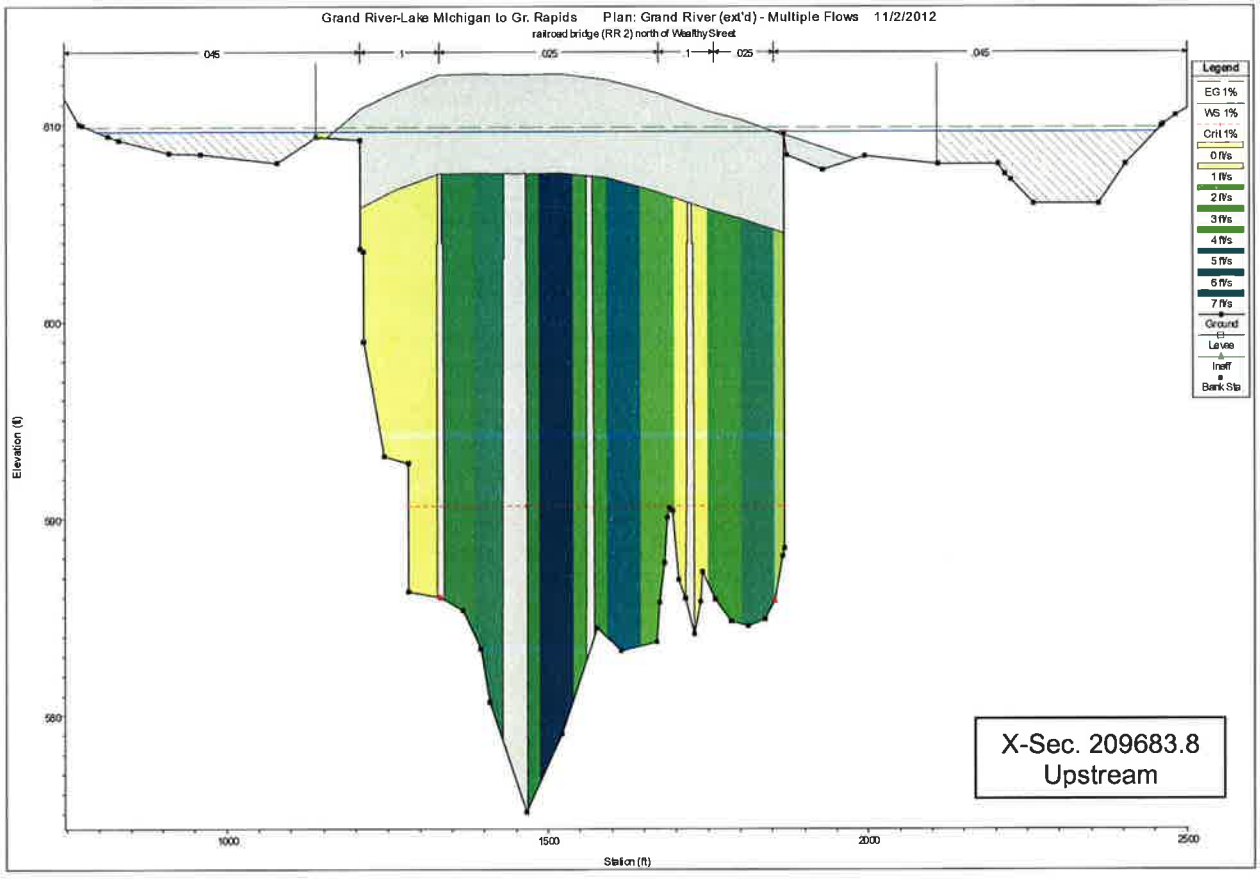

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=WEALTHY; XS_ID=50
.045
1
.028
1
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
800
900
1000
1100
1200
1300
Station (ft)
X-Sec. 208859.8


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=8_XS_ID=9
.045
1
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 209175.5


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=9; XS_ID=11
.045
1
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
1000
1200
1400
1600
1800
2000
2200
2400
2600
Station (ft)
X-Sec. 209422.2


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=RR 2; XS_ID=52
.045
1
.028
1
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 209656.6


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
railroad bridge (RR 2) north of Wealthy Street
.045
1
.025
1
.025
.045
Legend
EG 1%
WS 1%
Crit 1%
0 f/s
1 f/s
2 f/s
3 f/s
4 f/s
5 f/s
6 f/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
1000
1500
2000
2500
Station (ft)
X-Sec. 209683.8
Downstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
railroad bridge (RR 2) north of Wealthy Street
.045
1
.025
1
.025
.045
Legend
EG 1%
WS 1%
Crit 1%
0 f/s
1 f/s
2 f/s
3 f/s
4 f/s
5 f/s
6 f/s
7 f/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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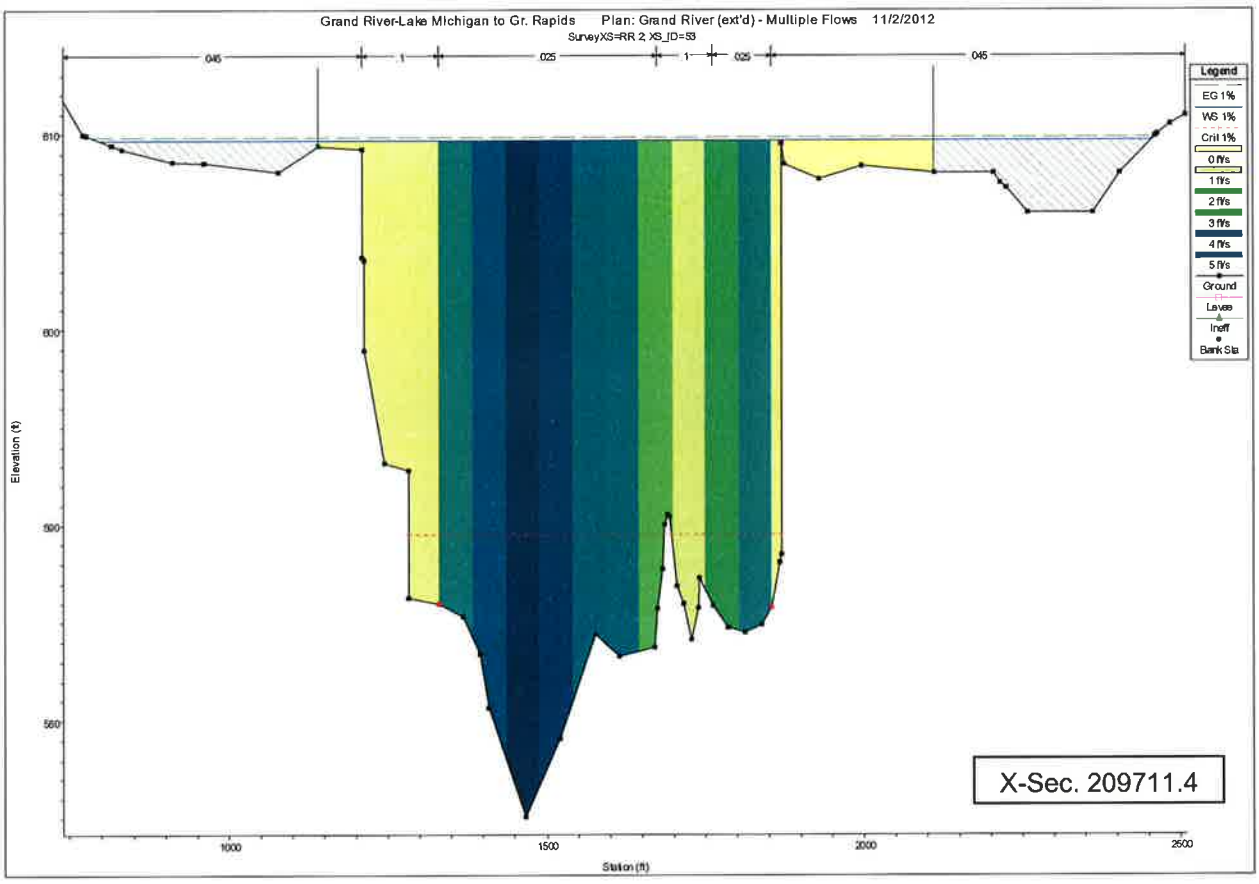
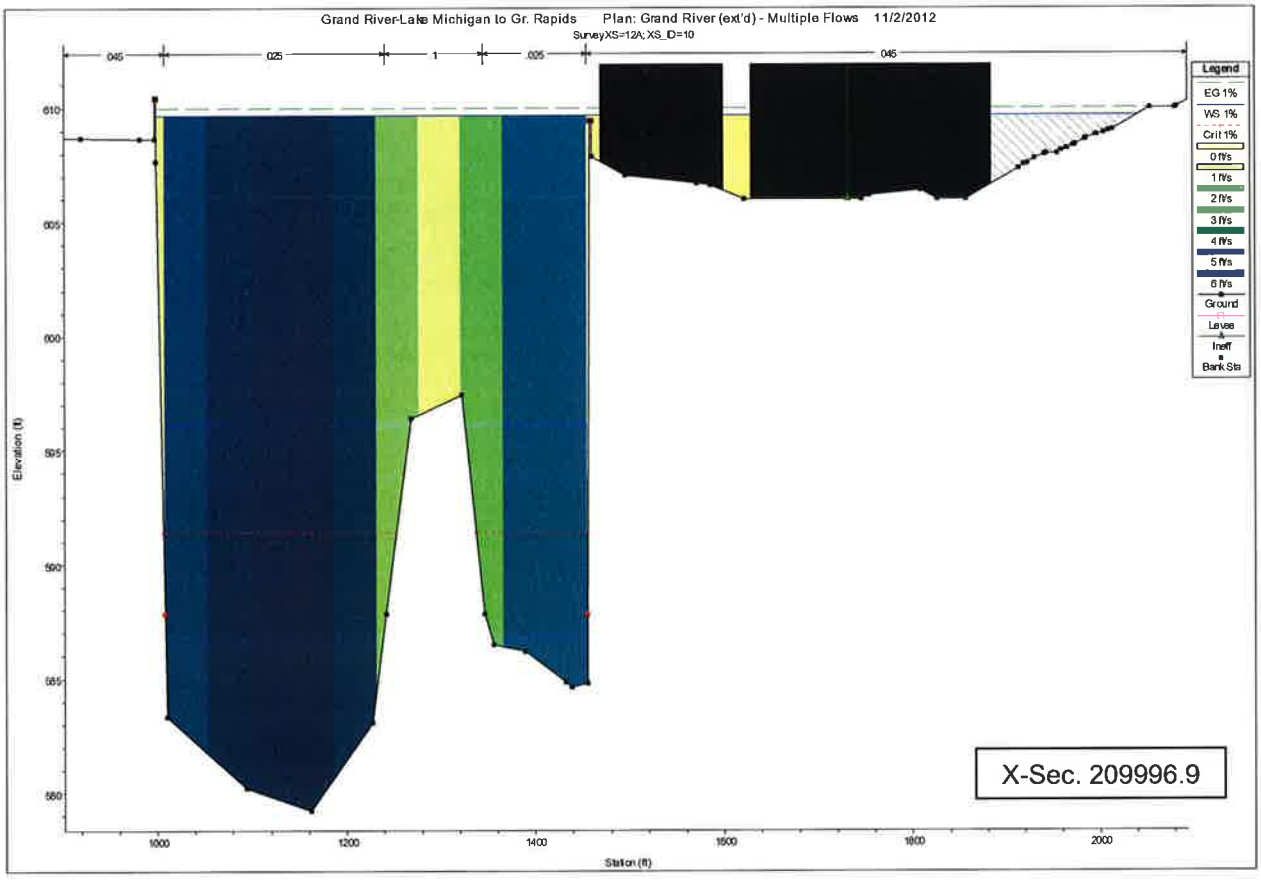
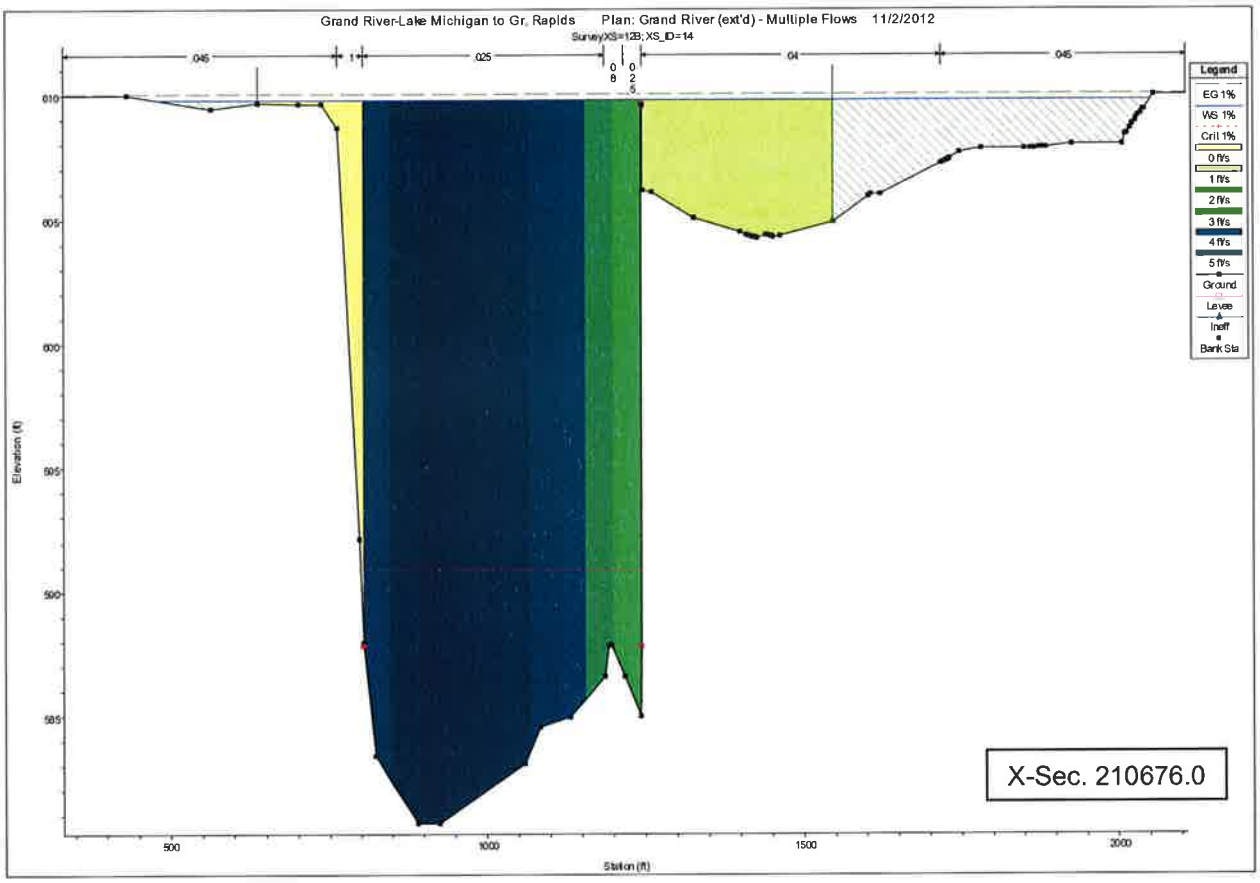
600
590
580
1000
1500
2000
2500
Station (ft)
X-Sec. 209683.8
Upstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=RR 2 XS_ID=53
045
1
025
1
025
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
600
590
580
1000
1500
2000
2500
Station (ft)
X-Sec. 209711.4


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=12A; XS_ID=10
045
025
1
025
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
1000
1200
1400
1600
1800
2000
Station (ft)
X-Sec. 209996.9


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=12B; XS_ID=14
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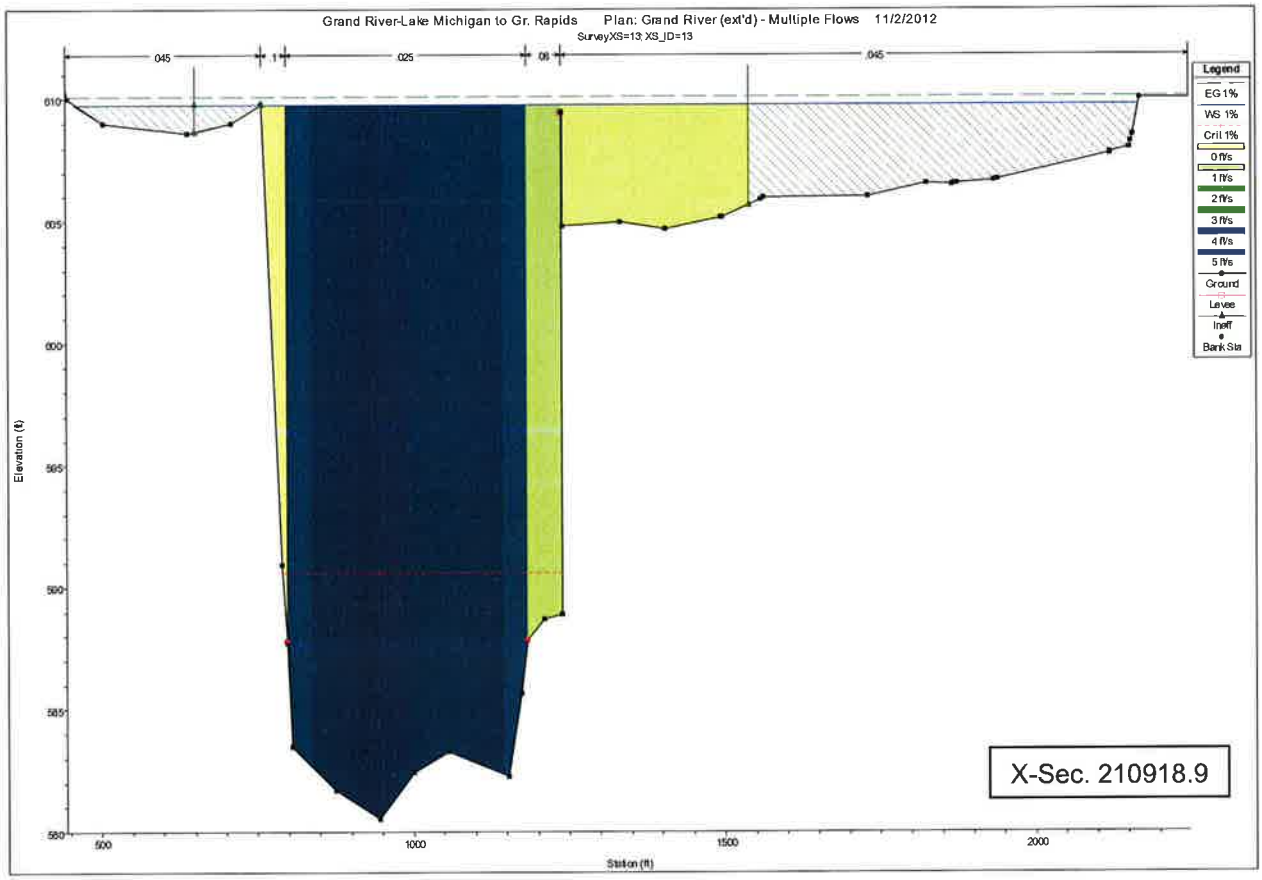
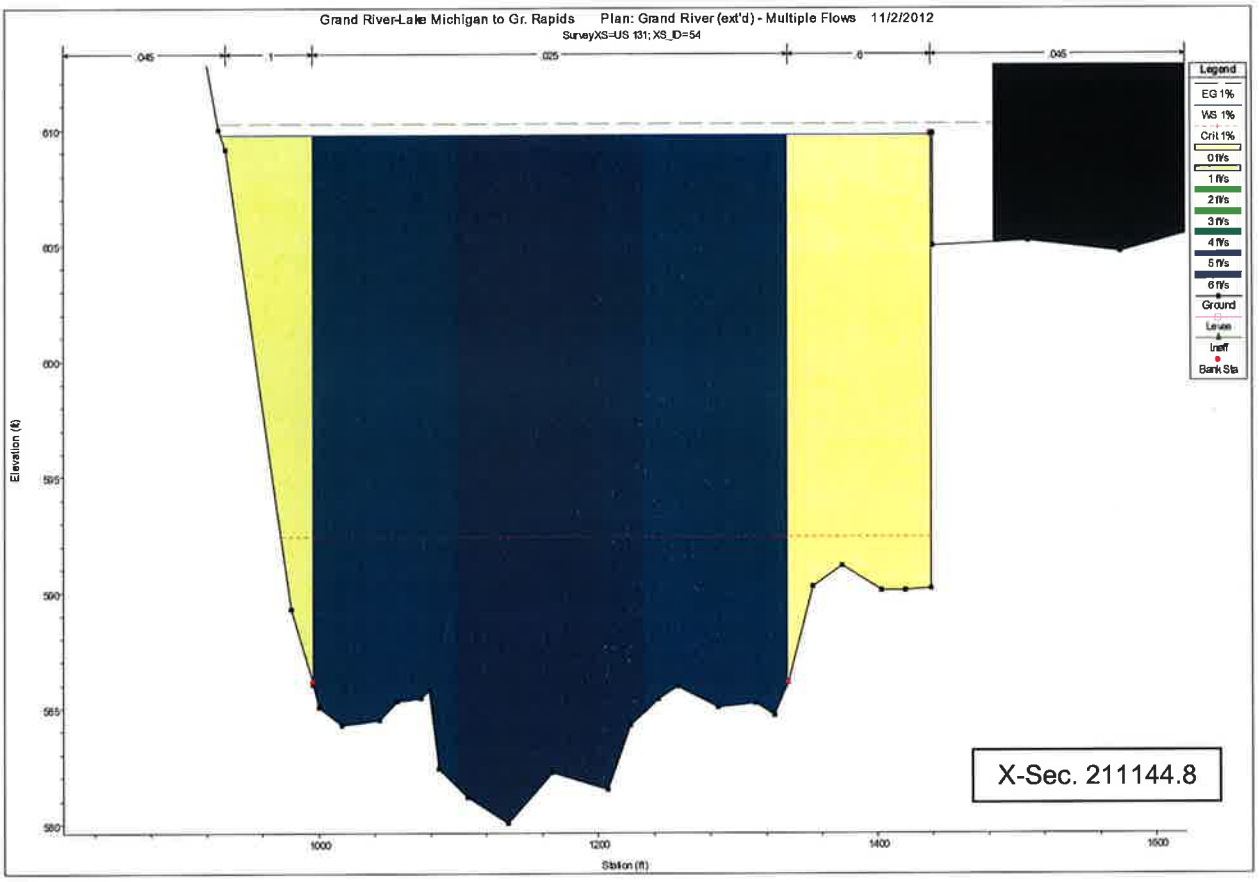
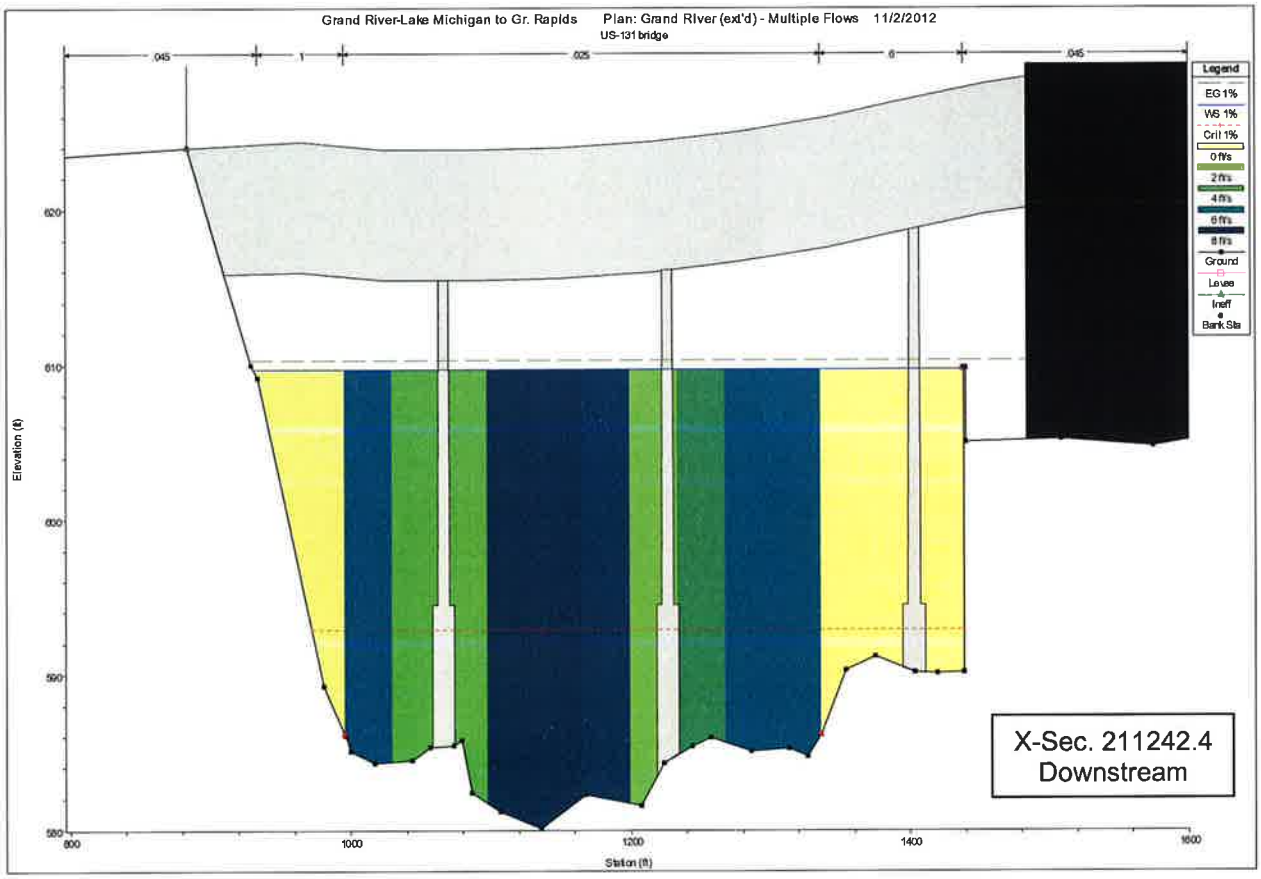
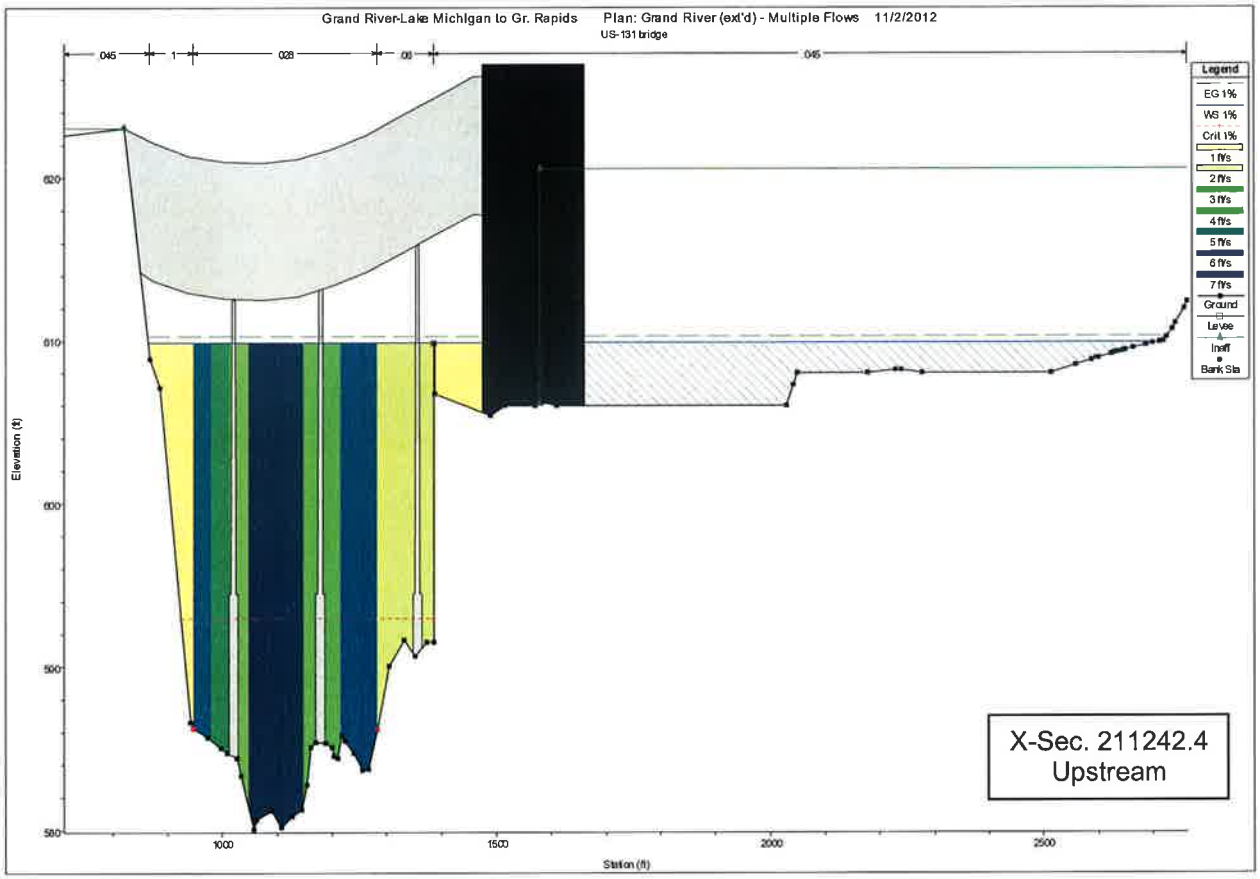
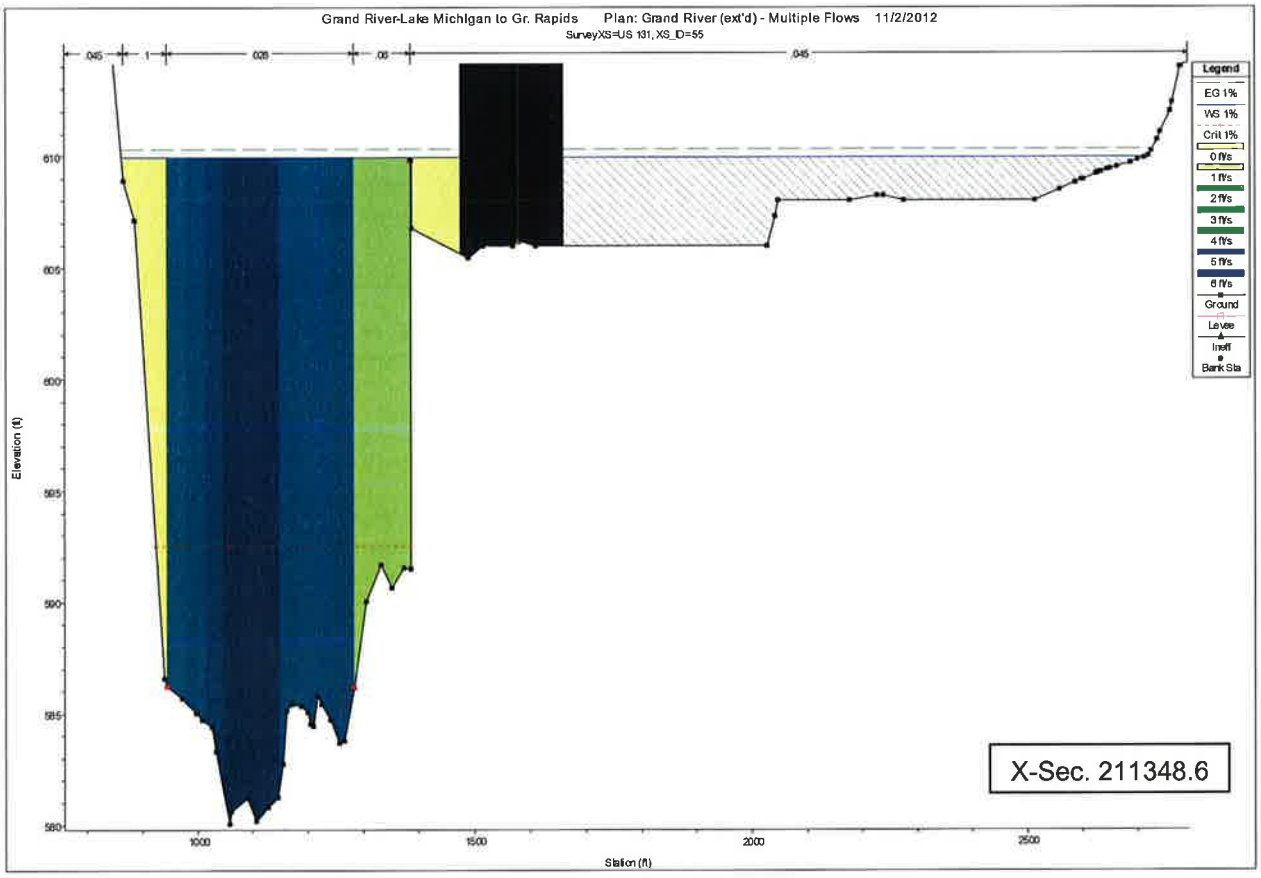
.025
.04
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 210676.0

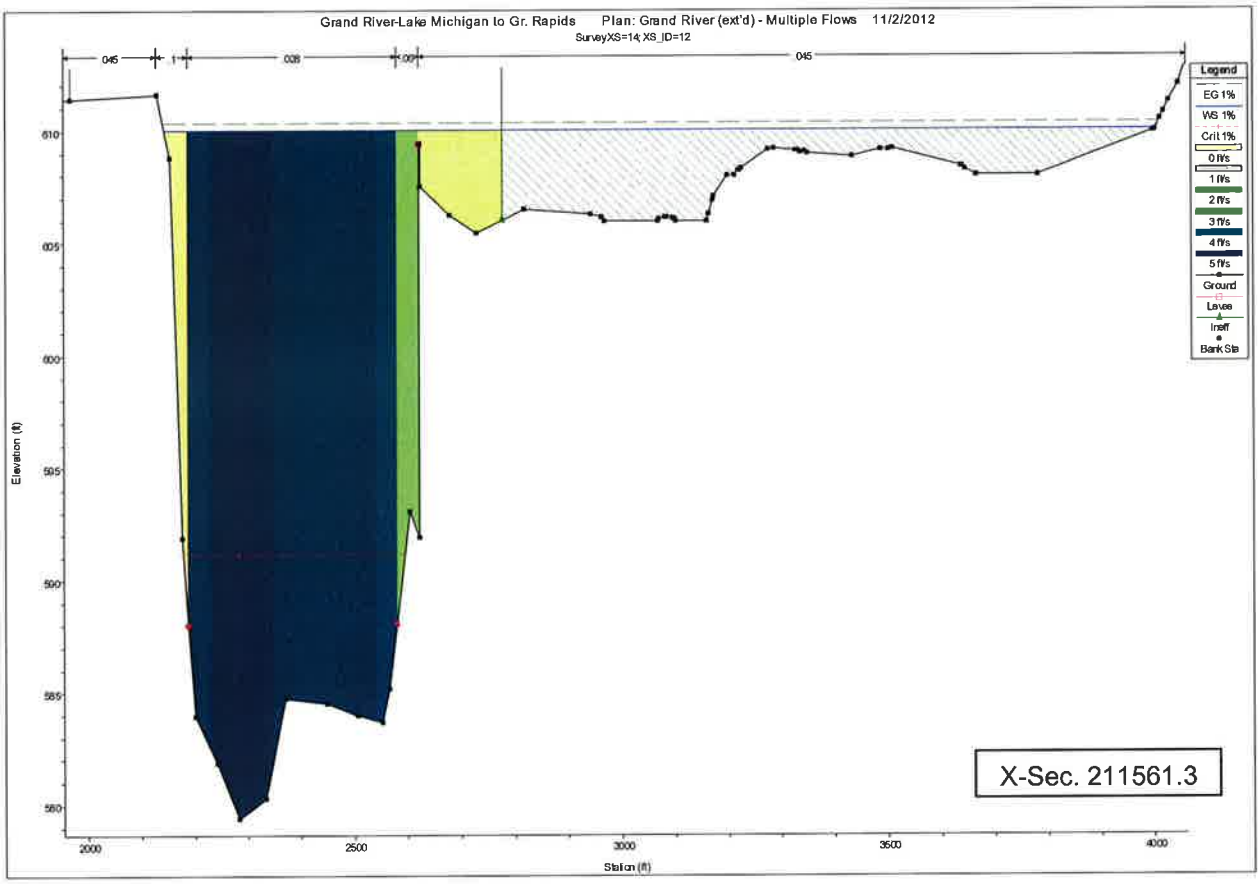

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=13; XS_ID=13
.045
.025
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 210918.9

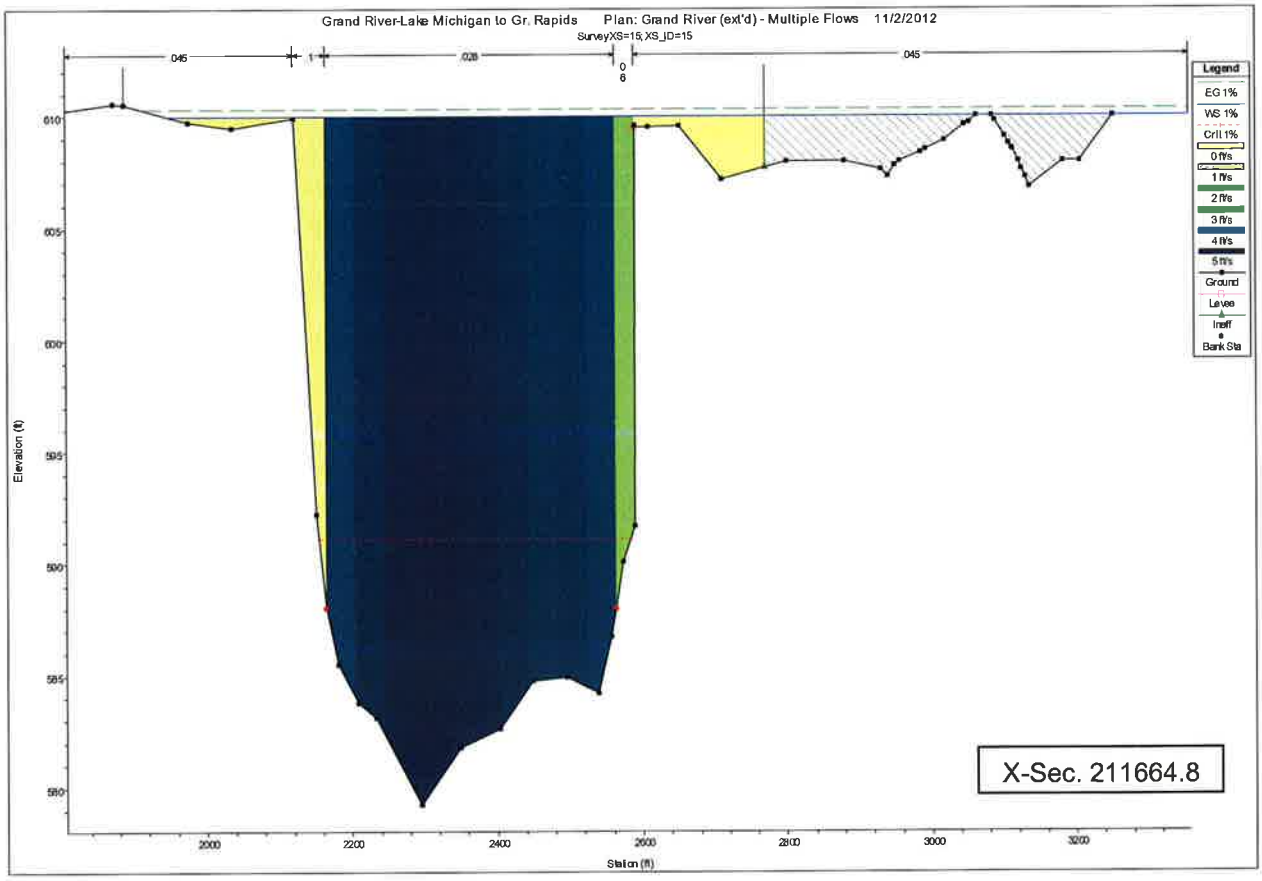

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=US 131; XS_ID=54
.045
1
.025
.6
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
1000
1200
1400
1600
Station (ft)
X-Sec. 211144.8

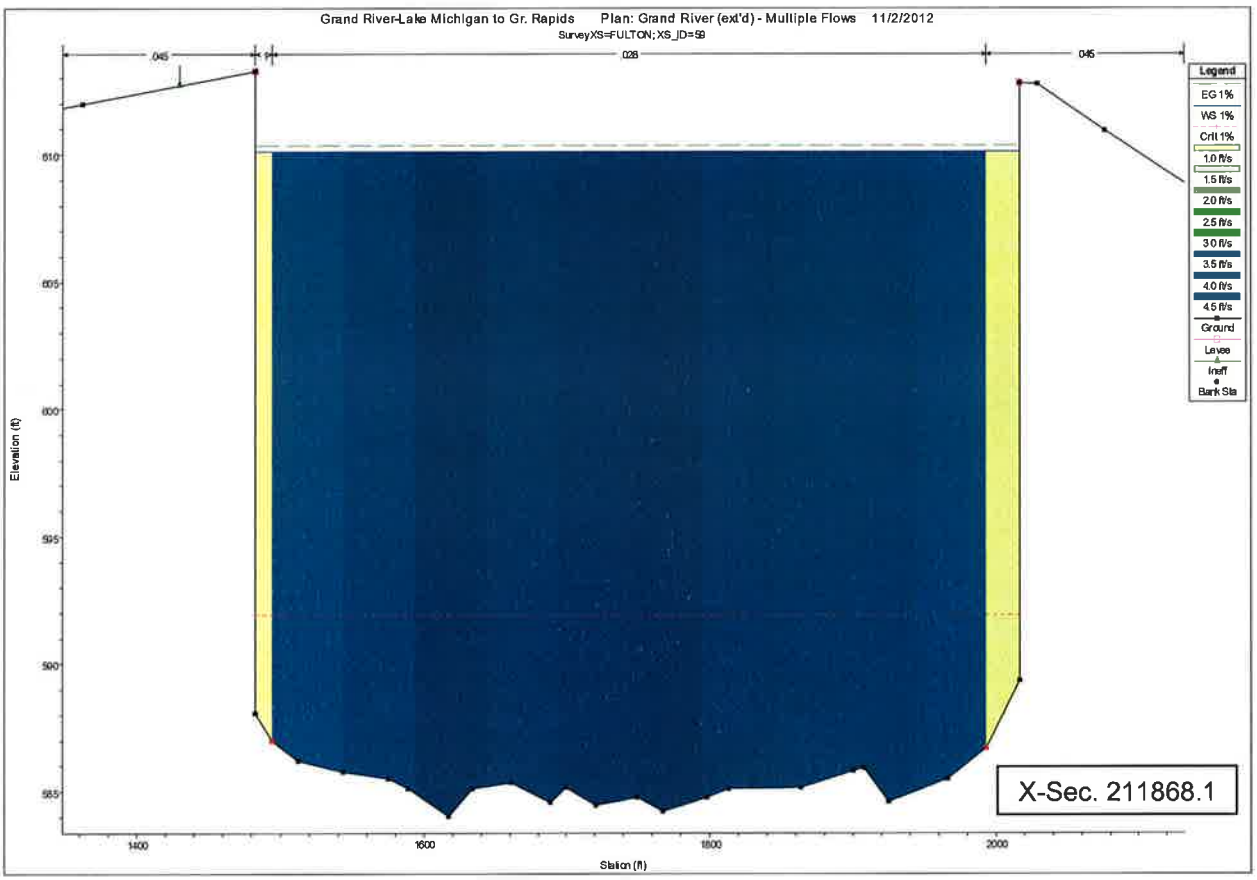

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
US-131 bridge
.045
1
.025
.6
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
580
800
1000
1200
1400
1600
Station (ft)
X-Sec. 211242.4
Downstream

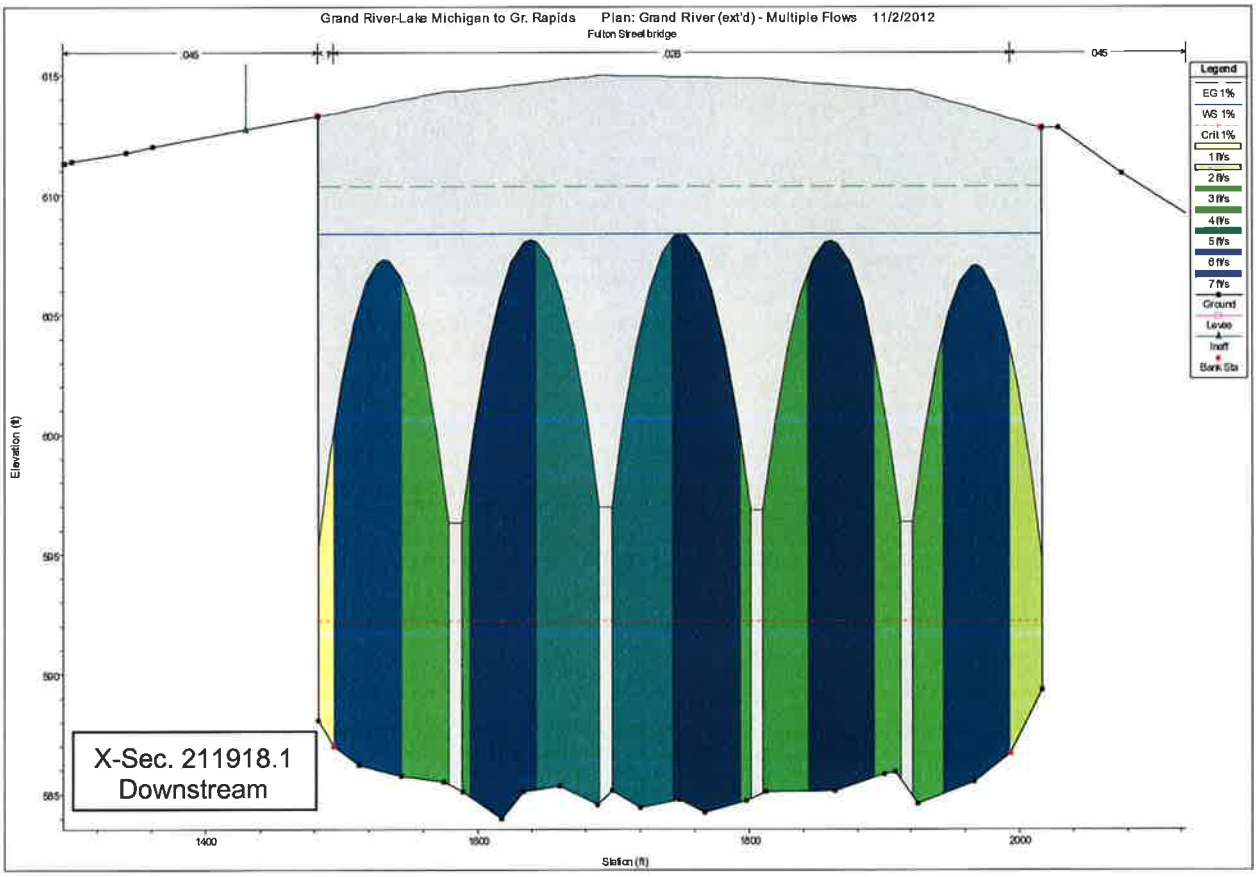

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
US-131 bridge
.045
1
.028
.08
.045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
1000
1500
2000
2500
Station (ft)
X-Sec. 211242.4
Upstream

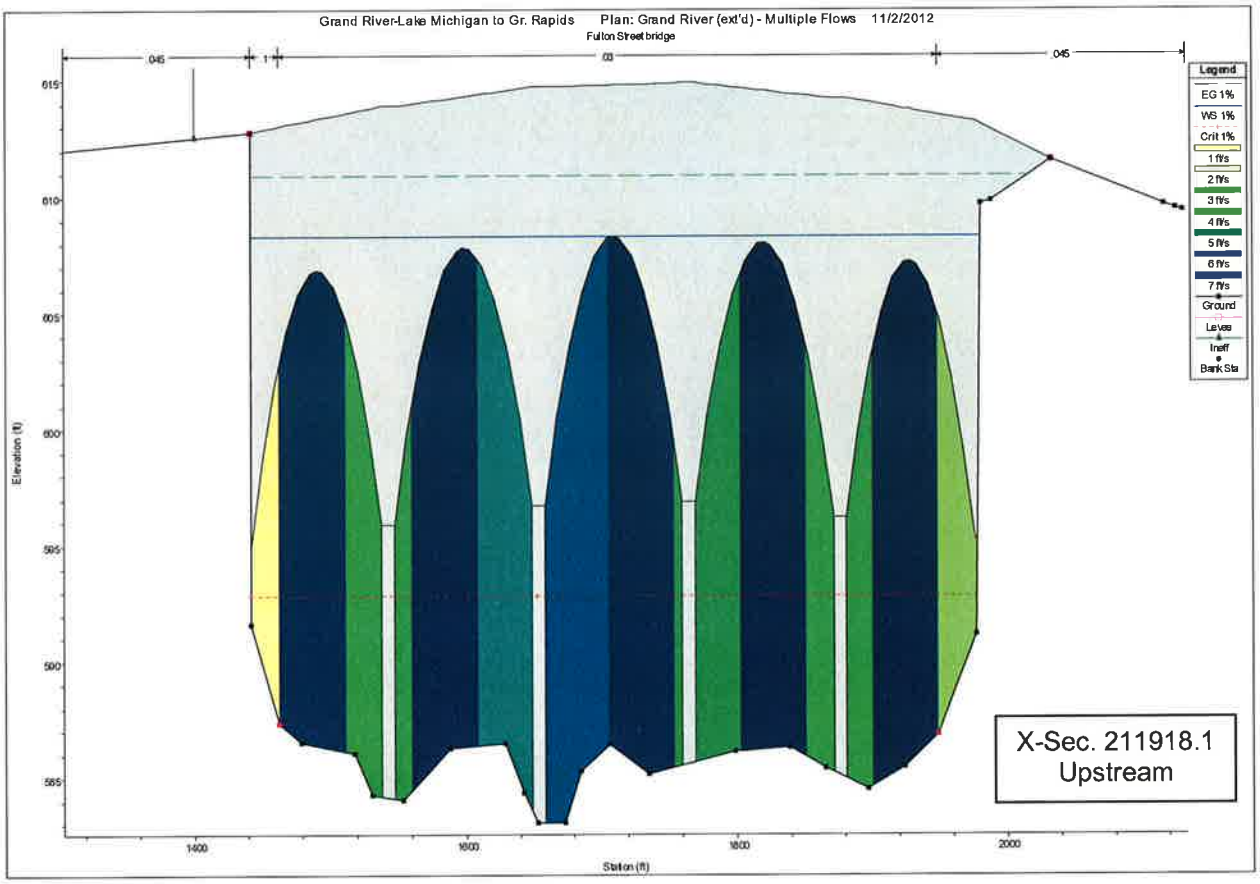

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=US 131, XS_ID=55
.045
1
.028
.08
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
1000
1500
2000
2500
Station (ft)
X-Sec. 211348.6

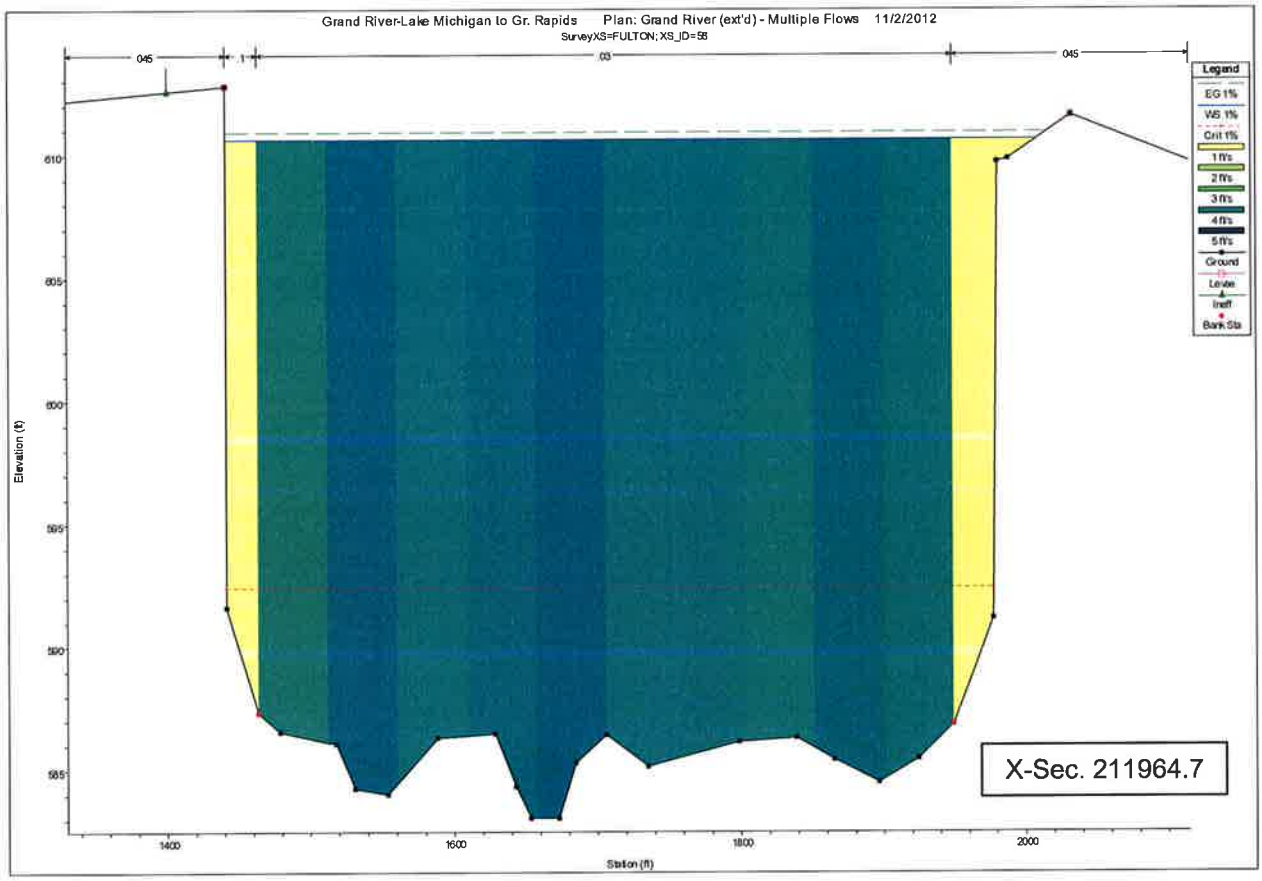

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=14, XS_ID=12
045
1
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
2000
2500
3000
3500
4000
Station (ft)
X-Sec. 211561.3

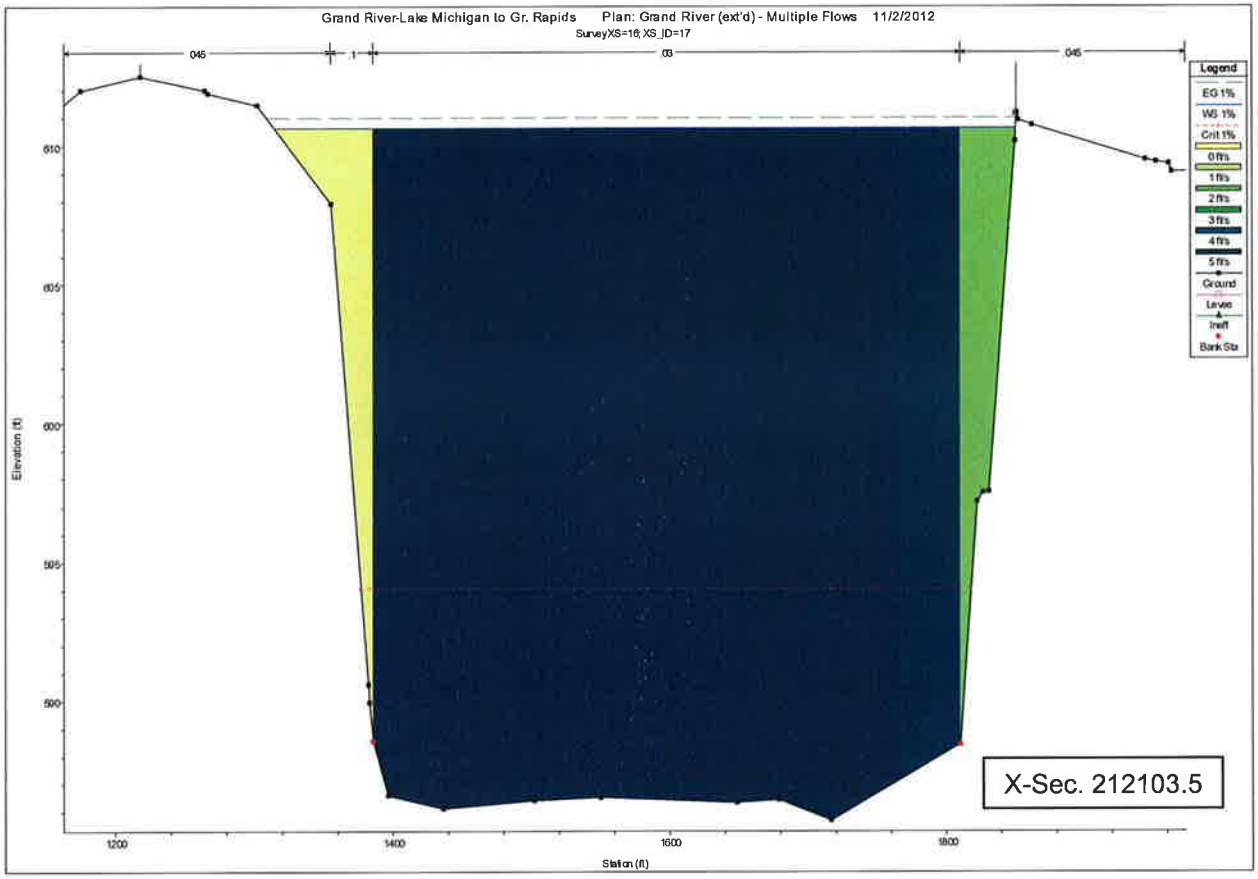

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=15, XS_ID=15
045
1
028
0
6
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
580
2000
2200
2400
2600
2800
3000
3200
Station (ft)
X-Sec. 211664.8

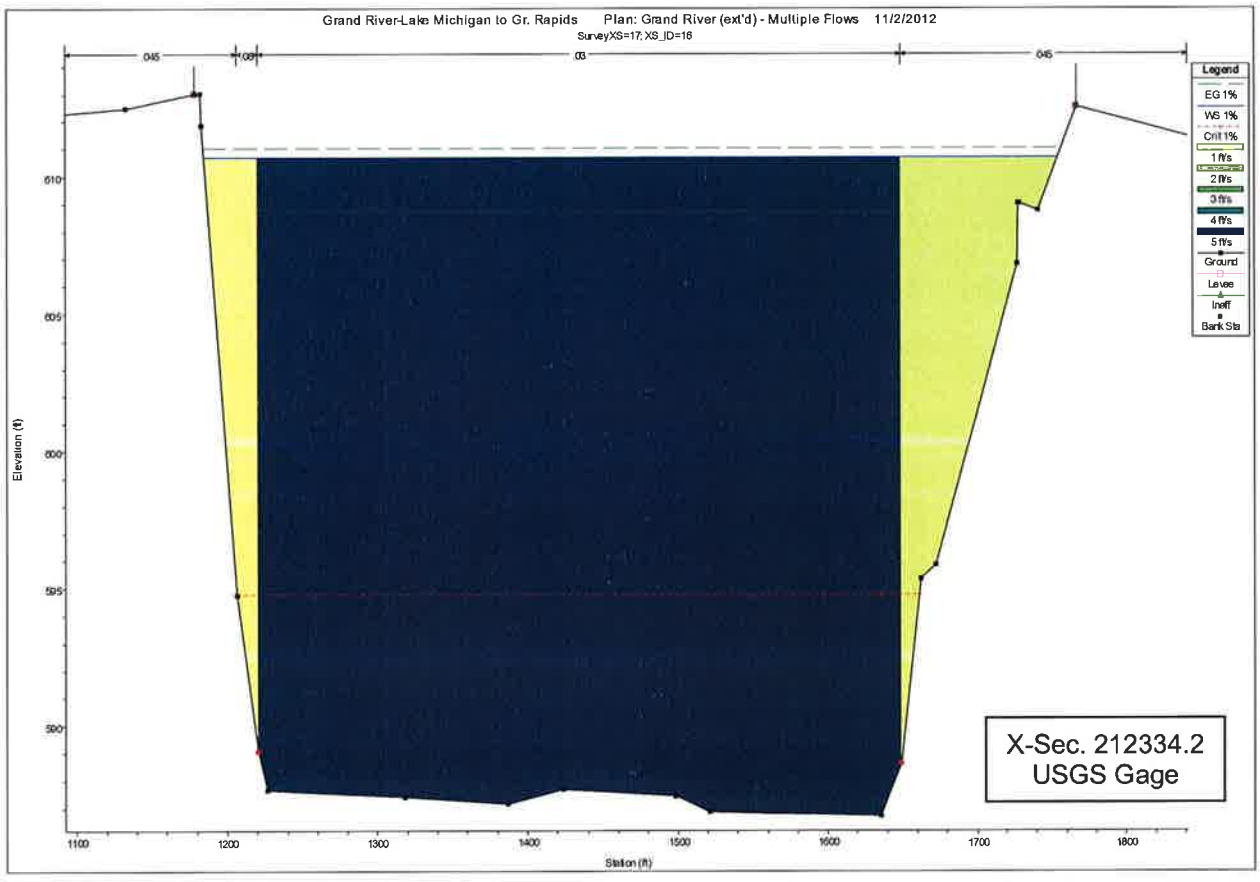

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=FULTON; XS_ID=59
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
1.0 ft/s
1.5 ft/s
2.0 ft/s
2.5 ft/s
3.0 ft/s
3.5 ft/s
4.0 ft/s
4.5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
1400
1600
1800
2000
Station (ft)
X-Sec. 211868.1

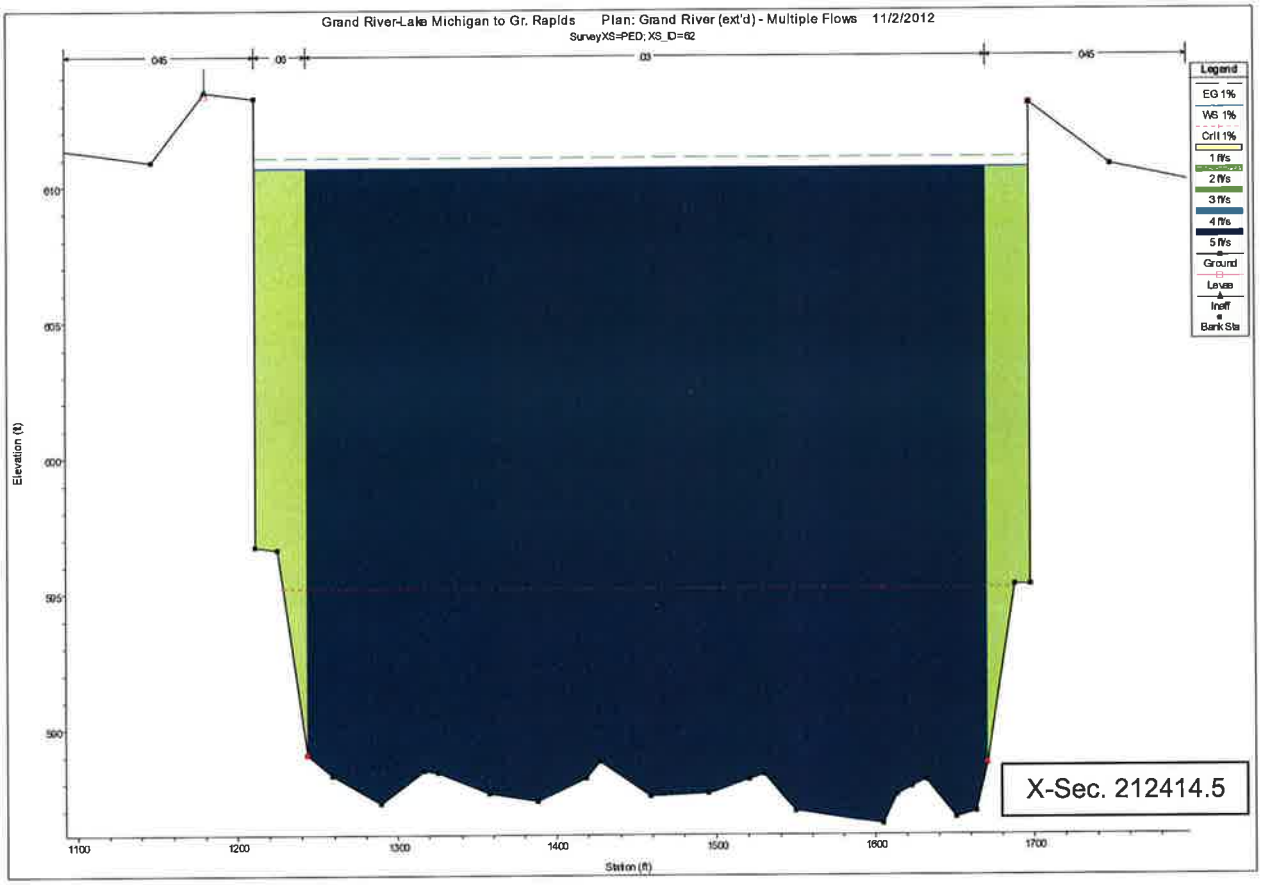

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Fulton Street bridge
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
585
1400
1600
1800
2000
Station (ft)
X-Sec. 211918.1
Downstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Fulton Street bridge
045
1
03
045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
585
1400
1600
1800
2000
Station (ft)
X-Sec. 211918.1
Upstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=FULTON; XS_ID=56
045
1
03
045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
585
1400
1600
1800
2000
Station (ft)
X-Sec. 211964.7


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=16, XS_ID=17
045
03
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1200
1400
1600
1800
Station (ft)
X-Sec. 212103.5


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=17, XS_ID=16
045
03
045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1100
1200
1300
1400
1500
1600
1700
1800
Station (ft)
X-Sec. 212334.2
USGS Gage


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=PED; XS_ID=62
045
06
03
045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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600
595
590
1100
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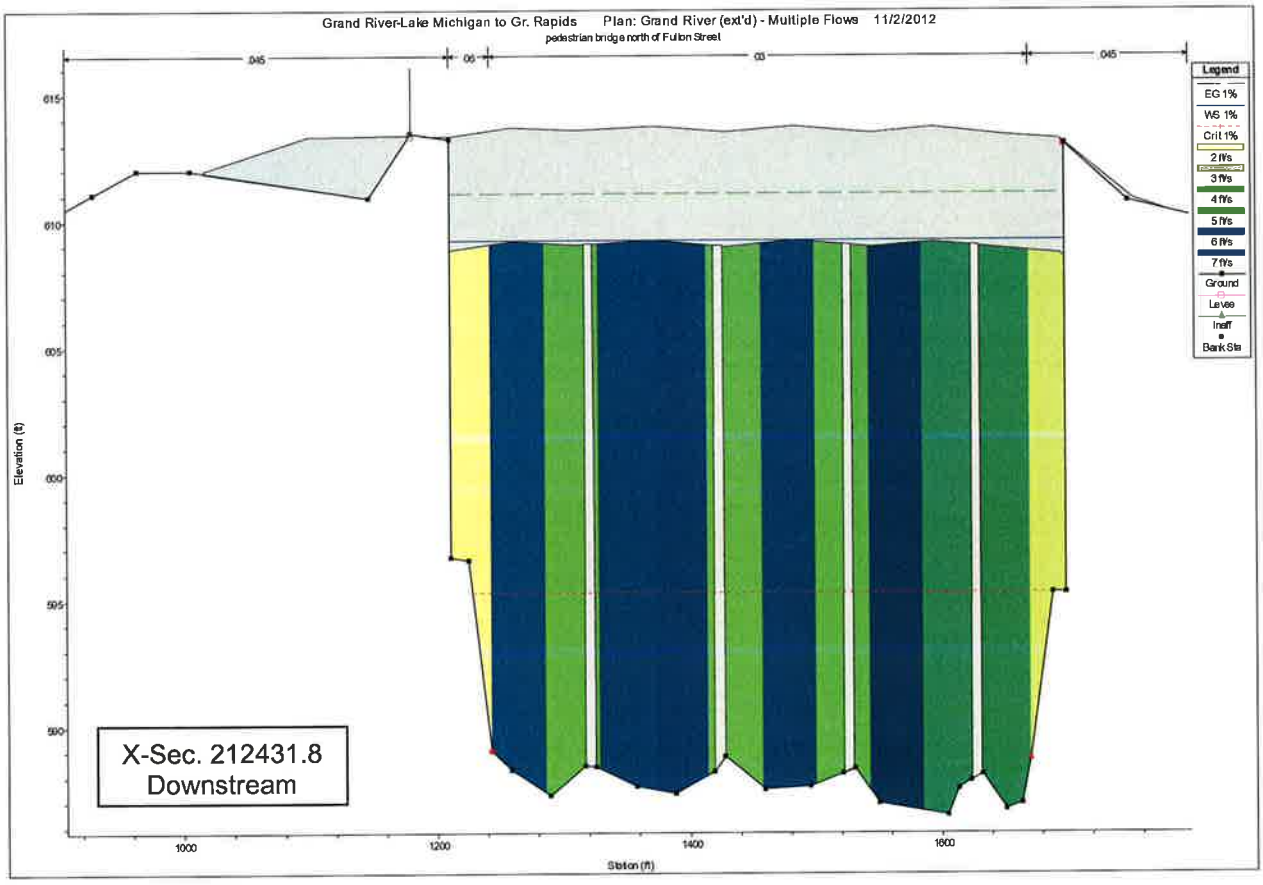
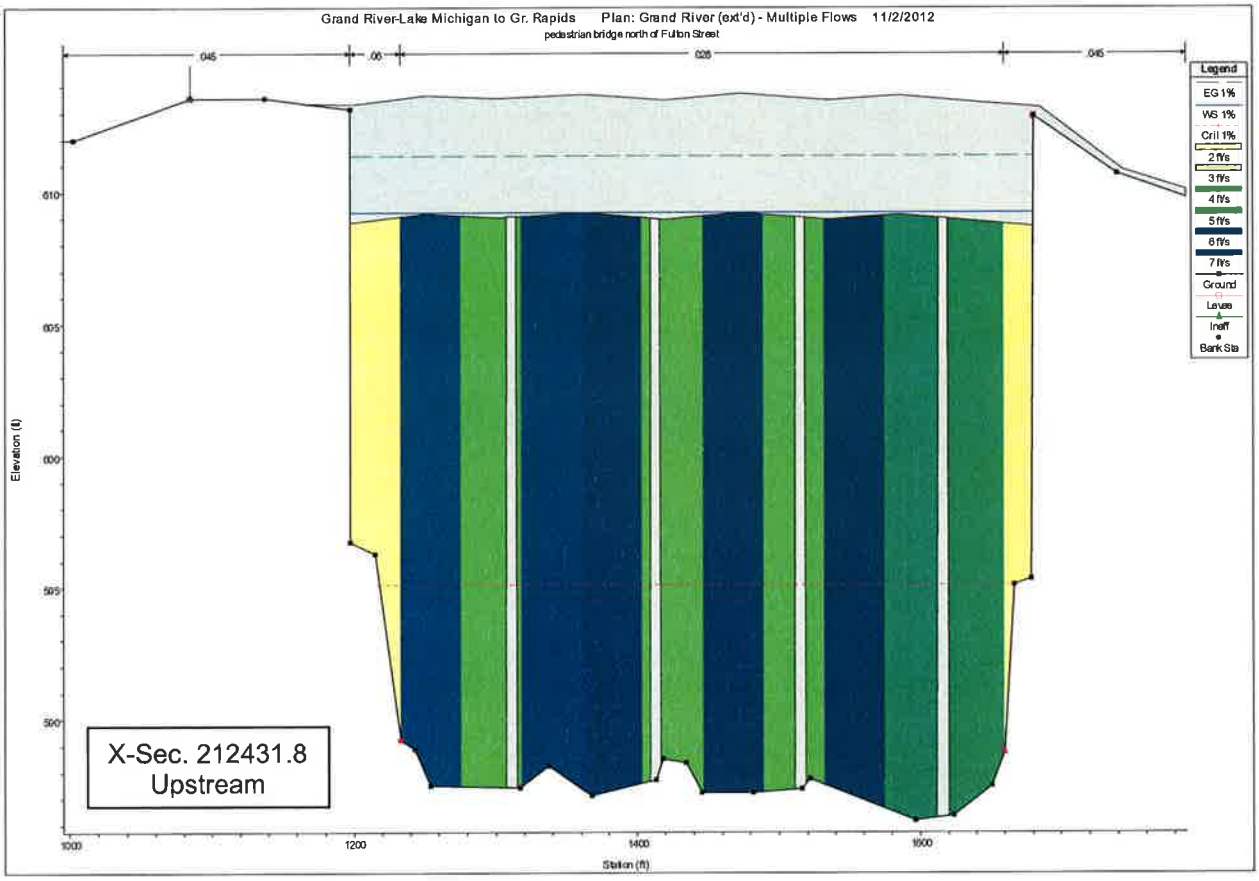
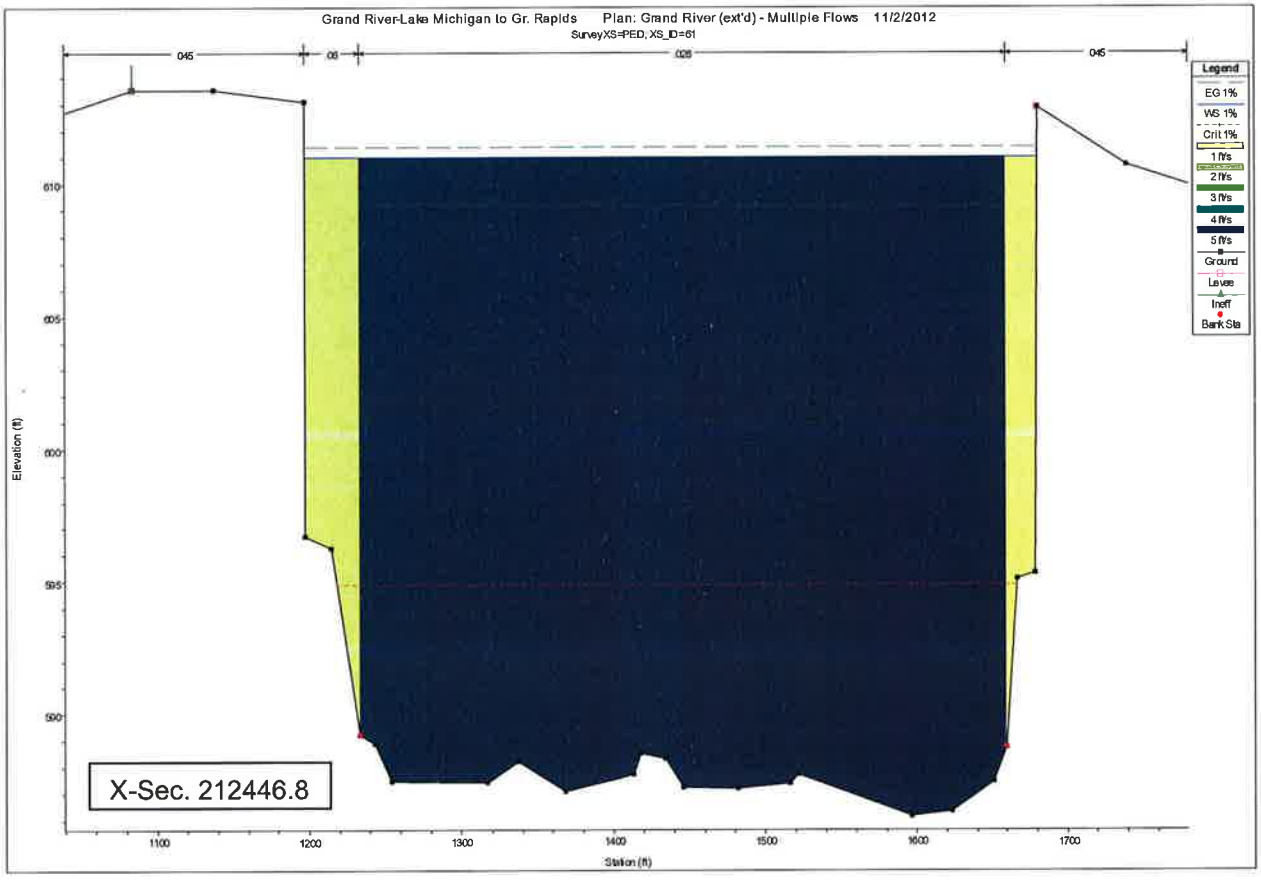
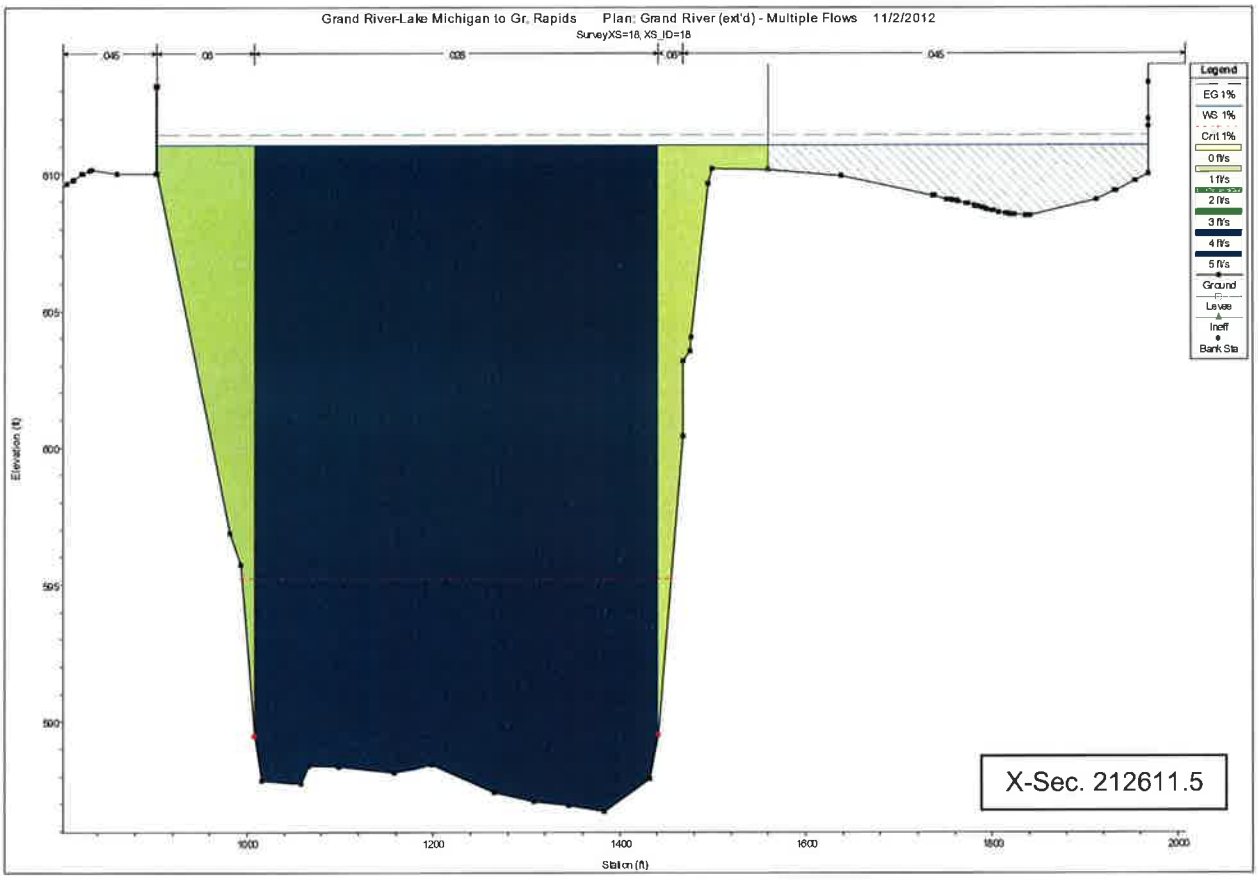
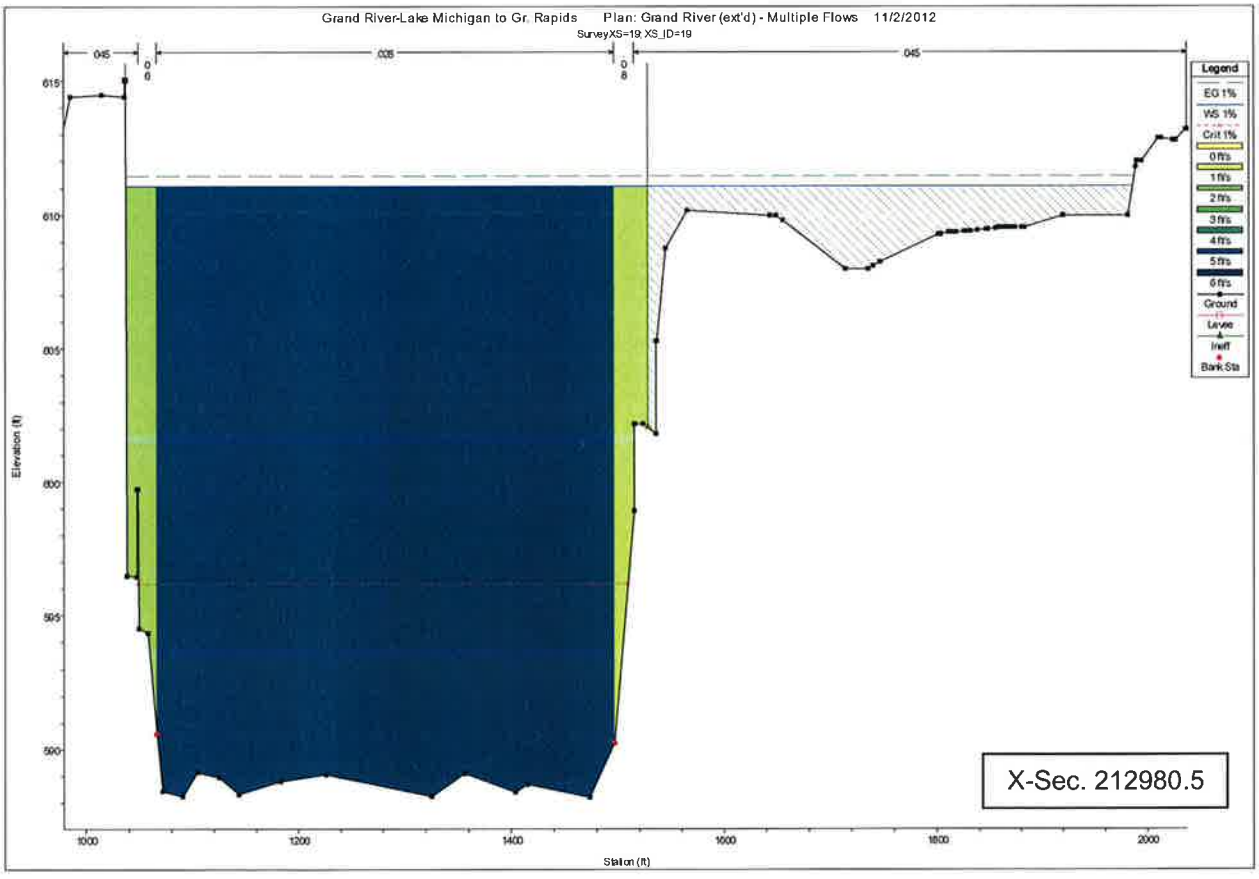
1300
1400
1500
1600
1700
Station (ft)
X-Sec. 212414.5


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
pedestrian bridge north of Fulton Street
045
06
03
045
Legend
EG 1%
WS 1%
Crit 1%
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
1000
1200
1400
1600
Station (ft)
X-Sec. 212431.8
Downstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
pedestrian bridge north of Fulton Street
.045
.06
.026
.045
Legend
EG 1%
WS 1%
Crit 1%
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
X-Sec. 212431.8
Upstream
1000
1200
1400
1600
Station (ft)


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=PED; XS_ID=61
.045
.06
.026
.045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
X-Sec. 212446.8
1100
1200
1300
1400
1500
1600
1700
Station (ft)


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=18, XS_ID=18
.045
.08
.028
.08
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1200
1400
1600
1800
2000
Station (ft)
X-Sec. 212611.5


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=19, XS_ID=19
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
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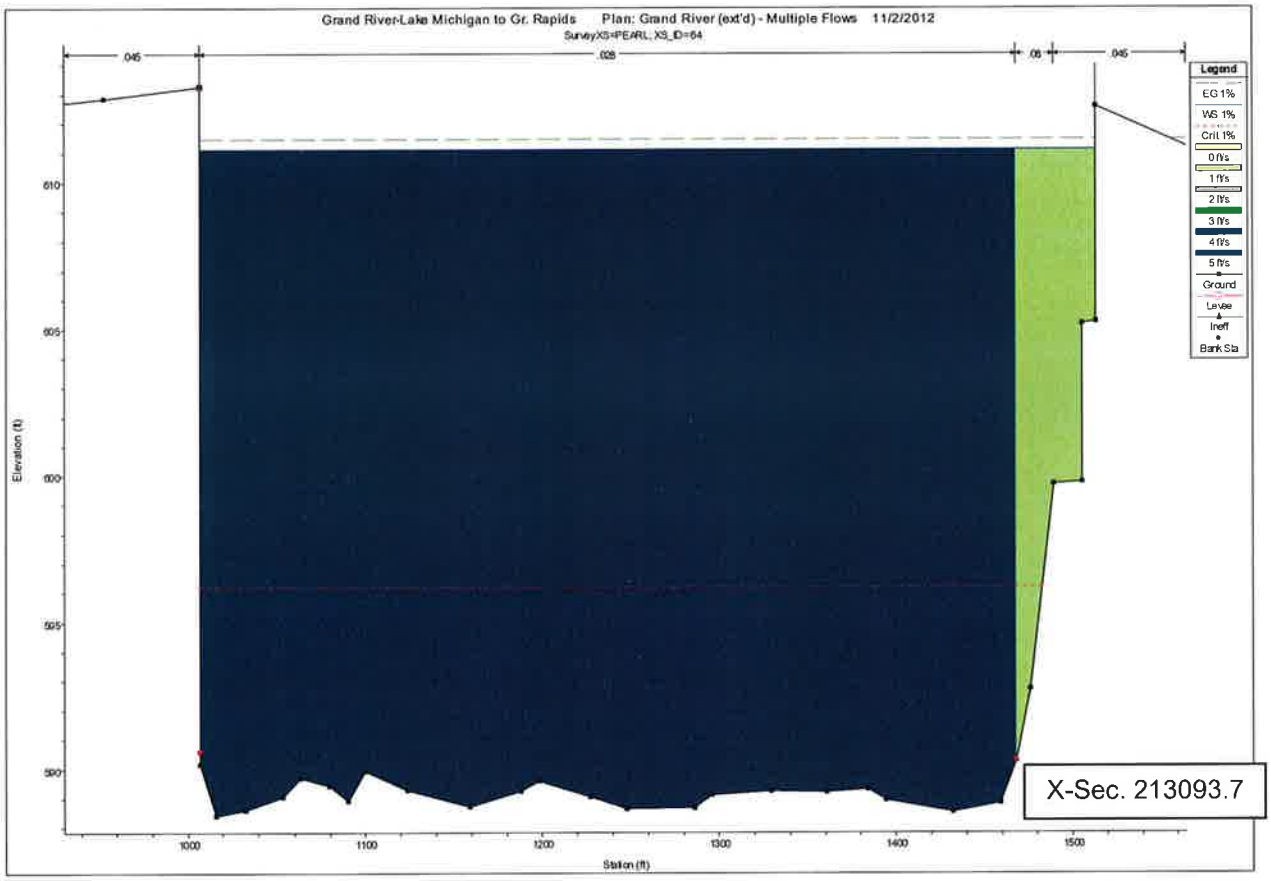
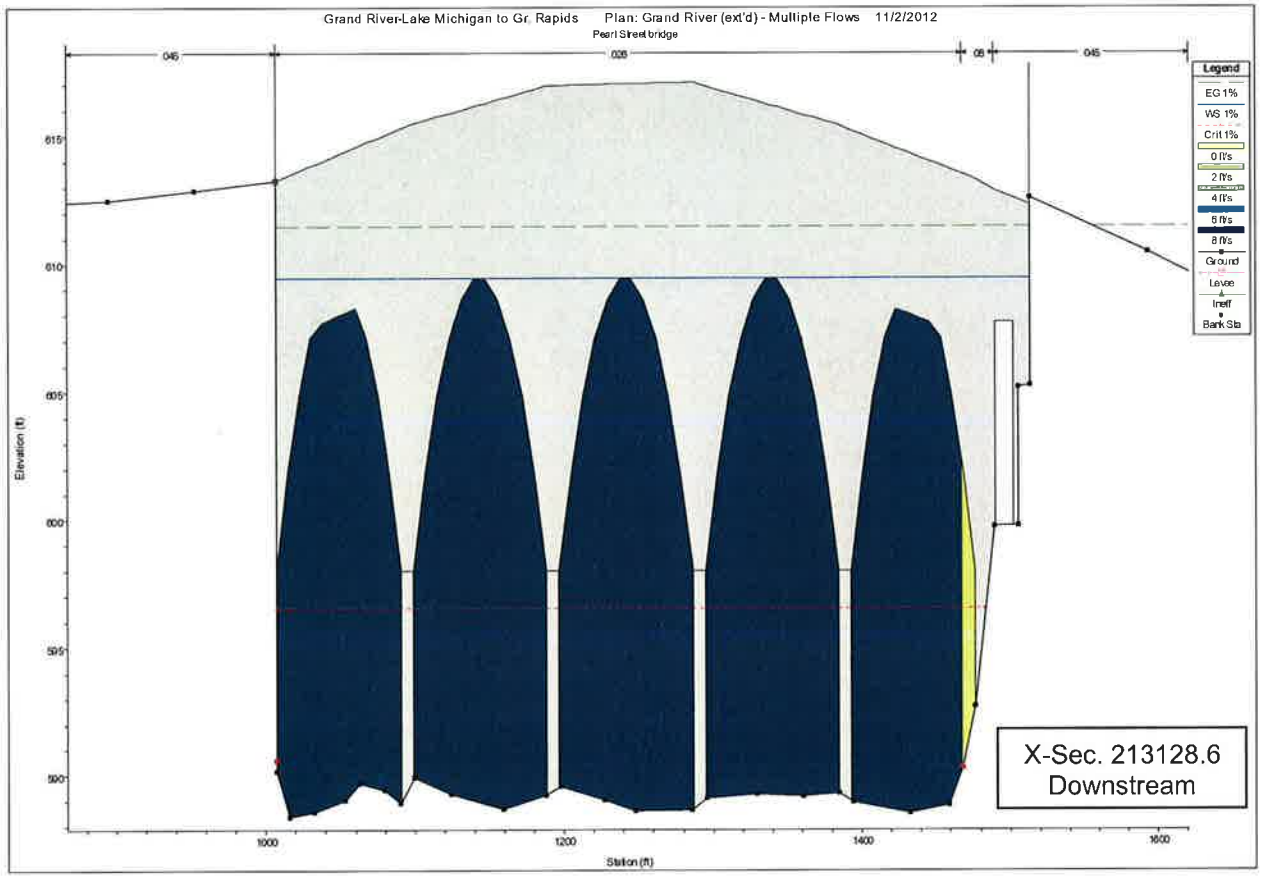
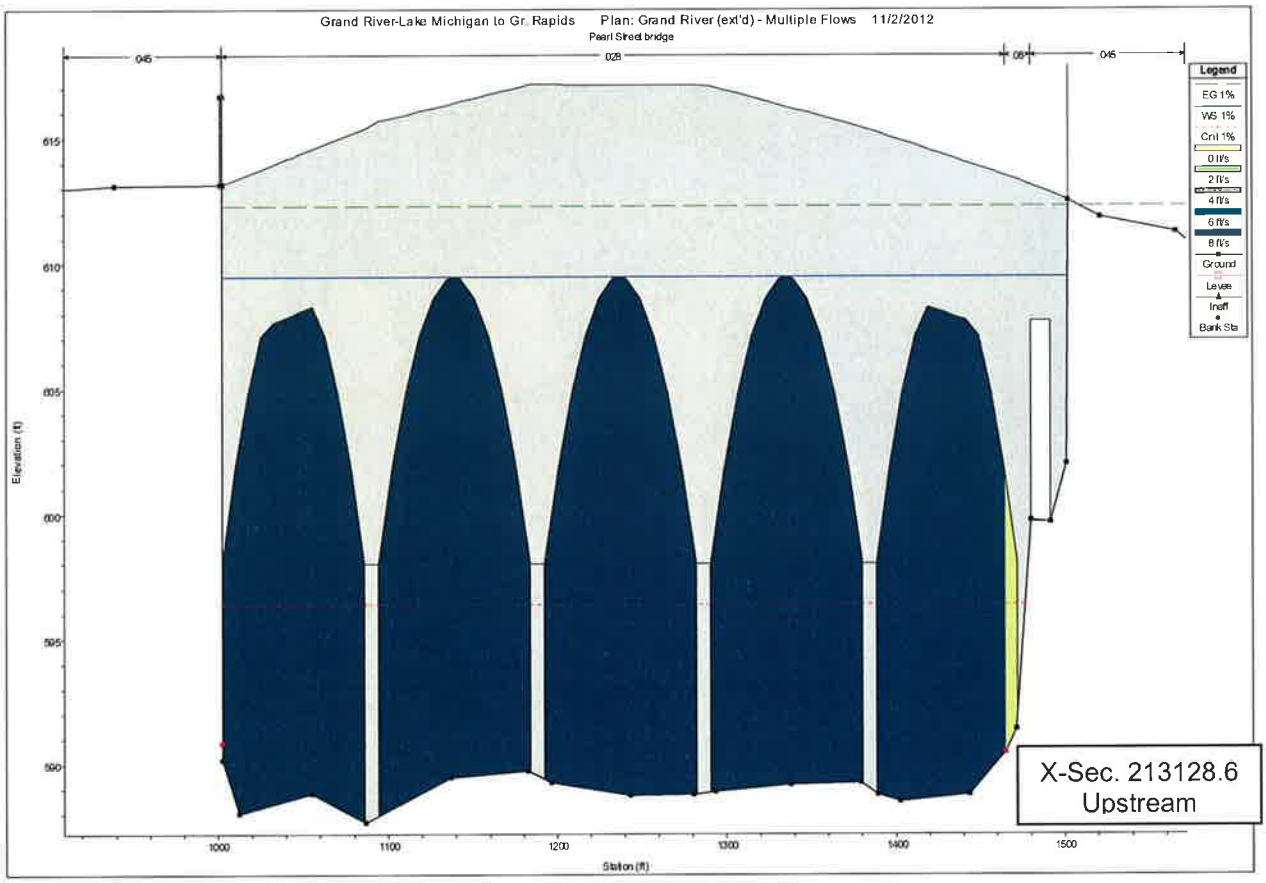
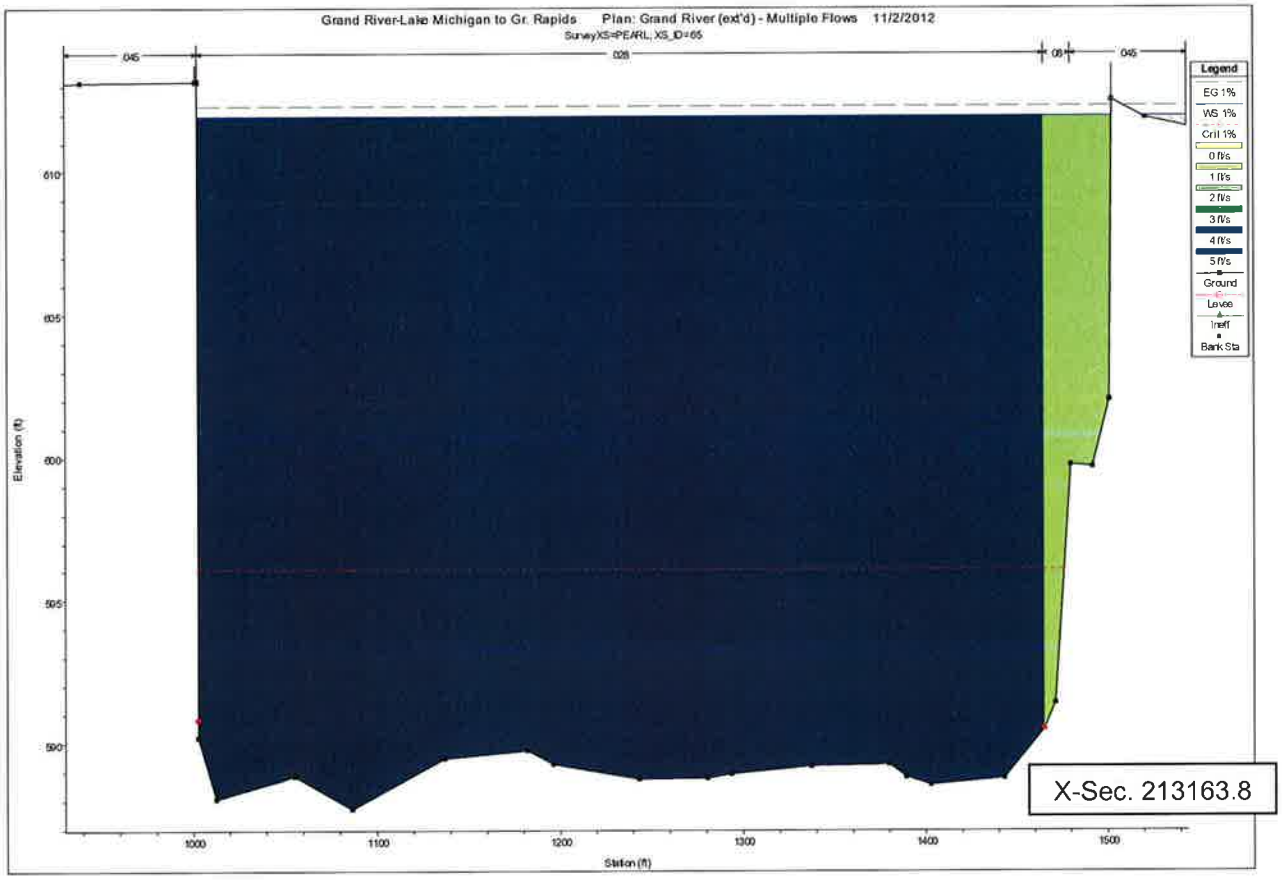
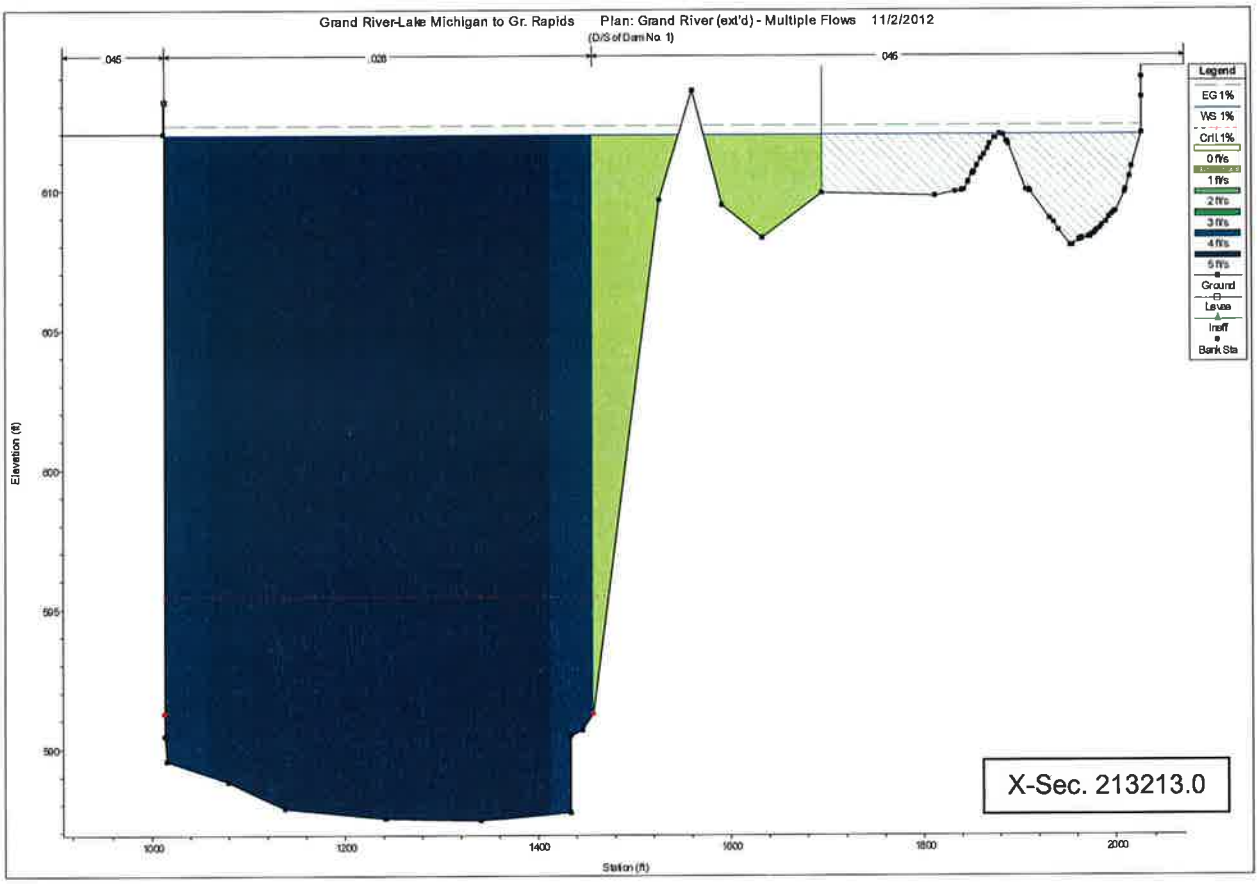
605
600
595
590
1000
1200
1400
1600
1800
2000
Station (ft)
X-Sec. 212980.5

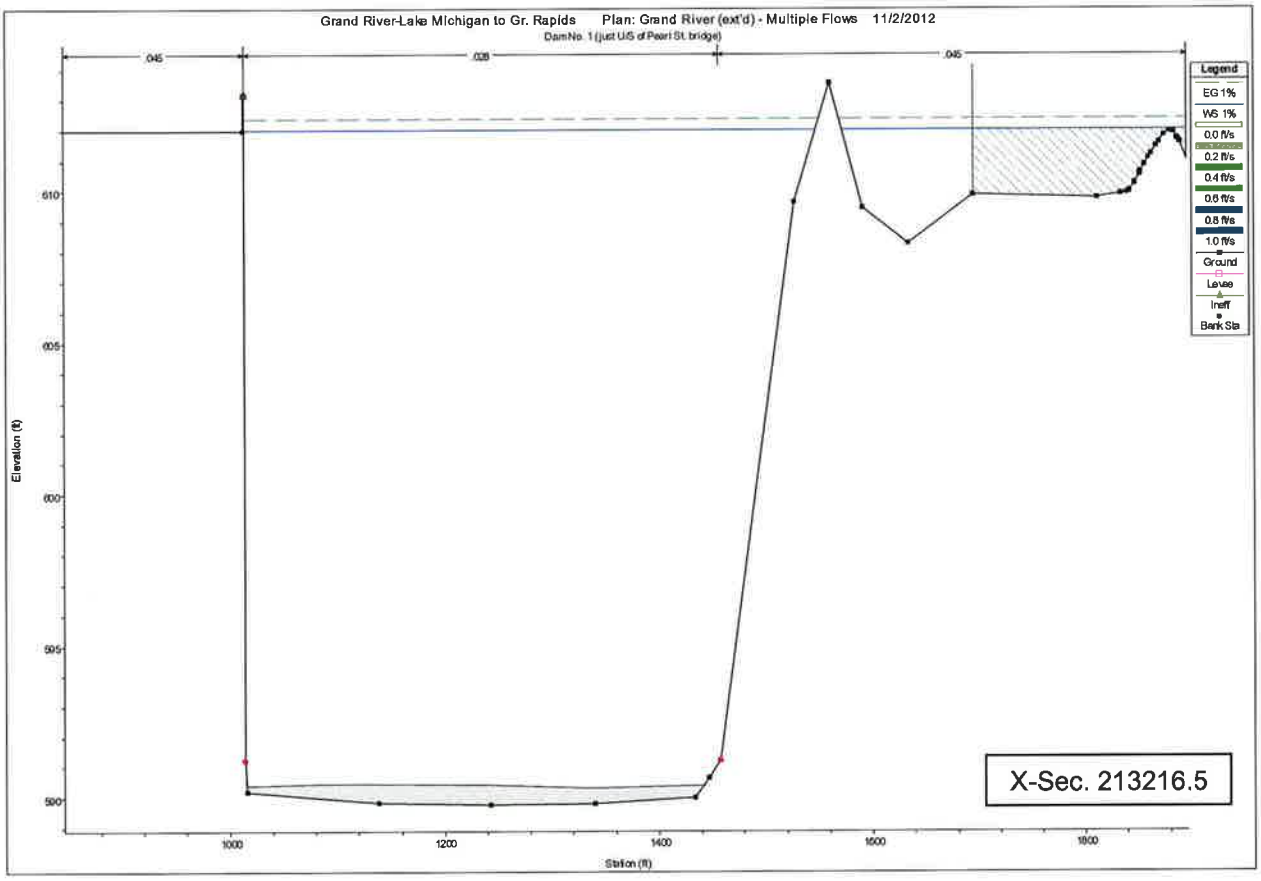

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=PEARL XS_ID=64
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1100
1200
1300
1400
1500
Station (ft)
X-Sec. 213093.7

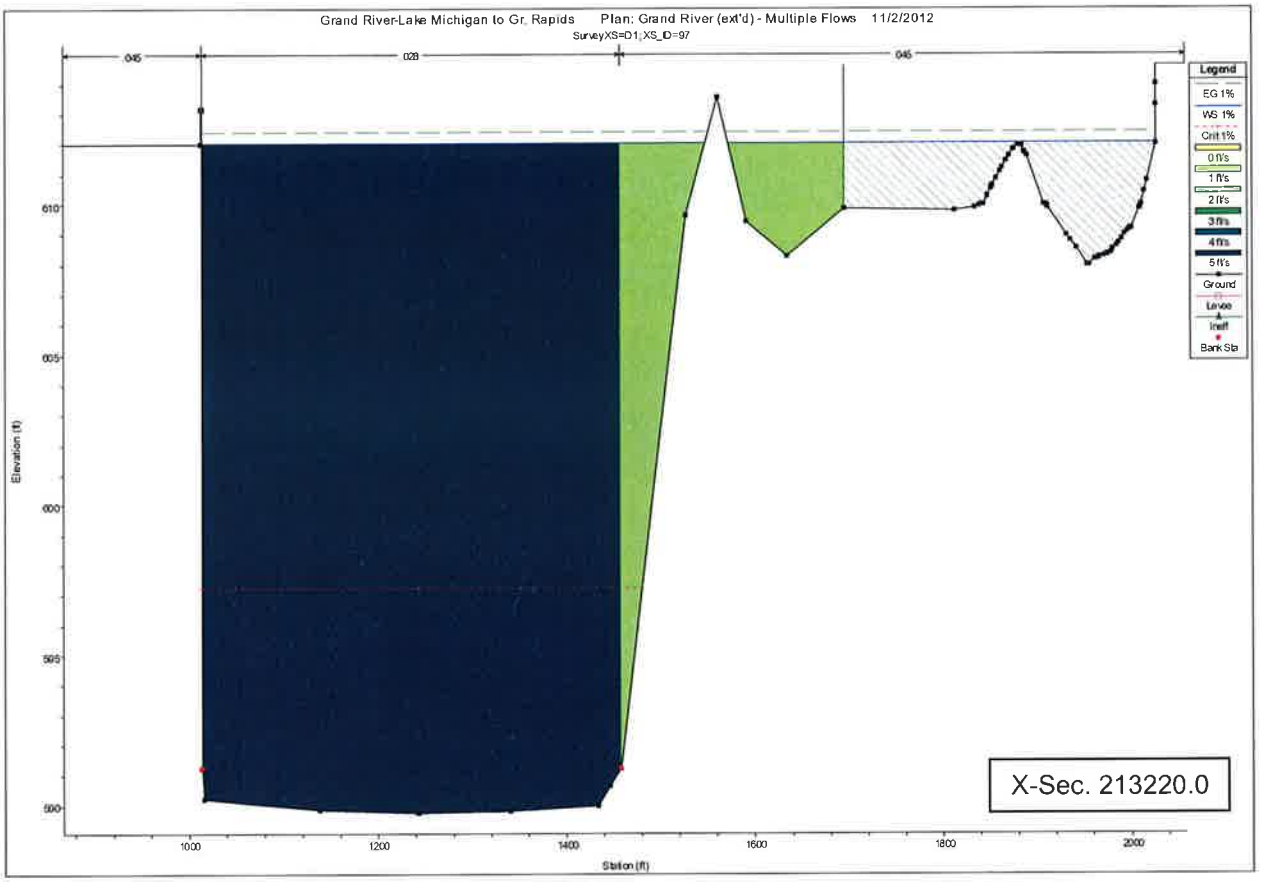

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Pearl Street bridge
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
1000
1200
1400
1600
Station (ft)
X-Sec. 213128.6
Downstream

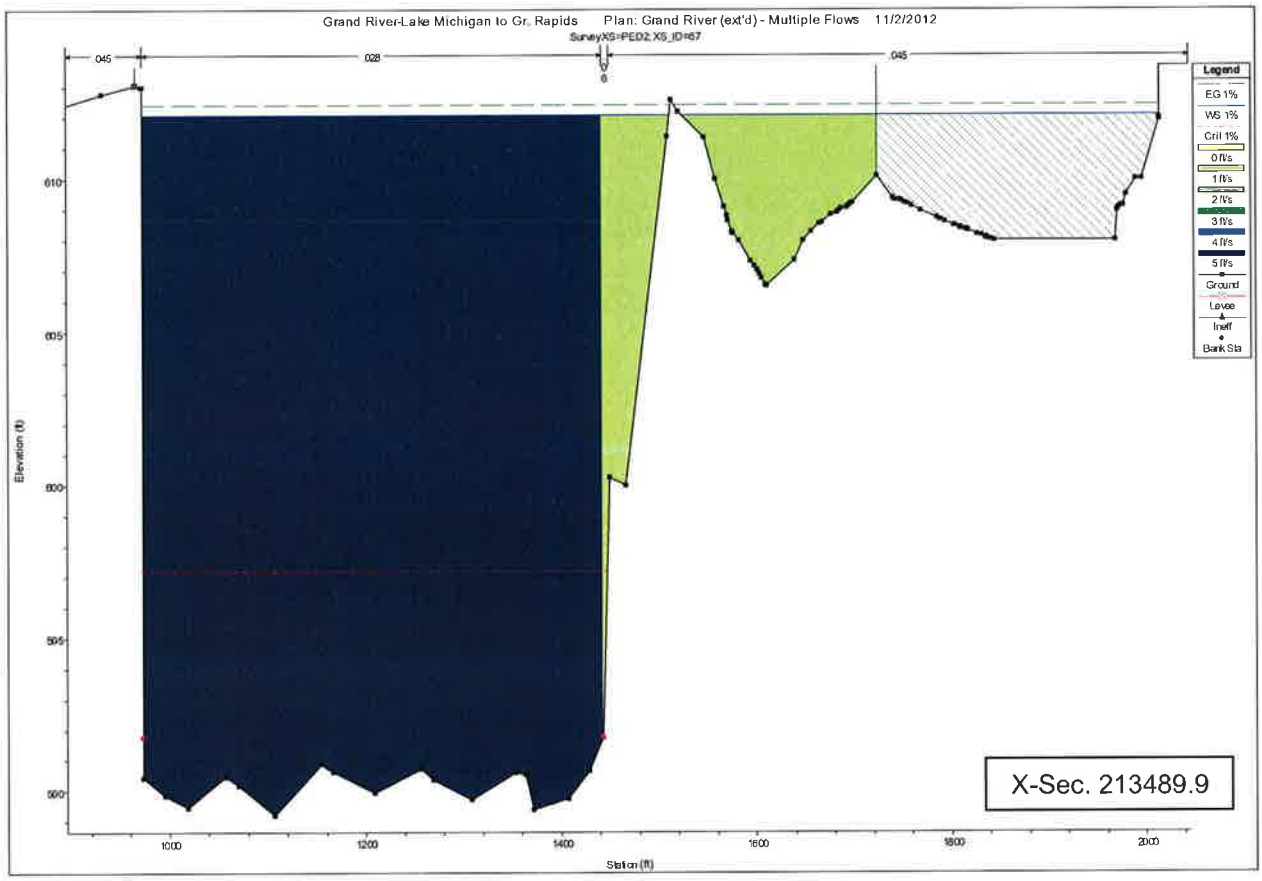

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Pearl Street bridge
045
028
05
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
1000
1100
1200
1300
1400
1500
Station (ft)
X-Sec. 213128.6
Upstream

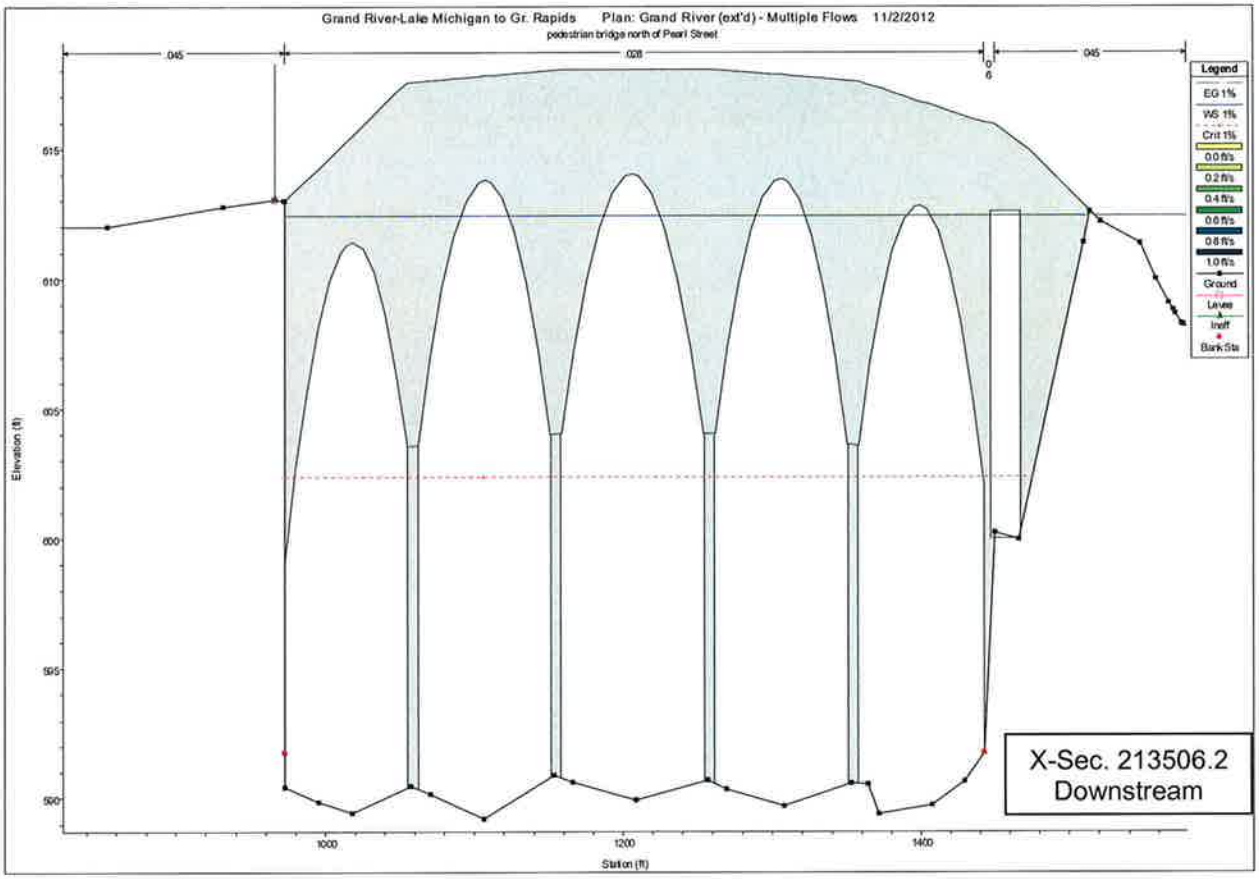

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=PEARL, XS_ID=65
045
028
05
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1100
1200
1300
1400
1500
Station (ft)
X-Sec. 213163.8

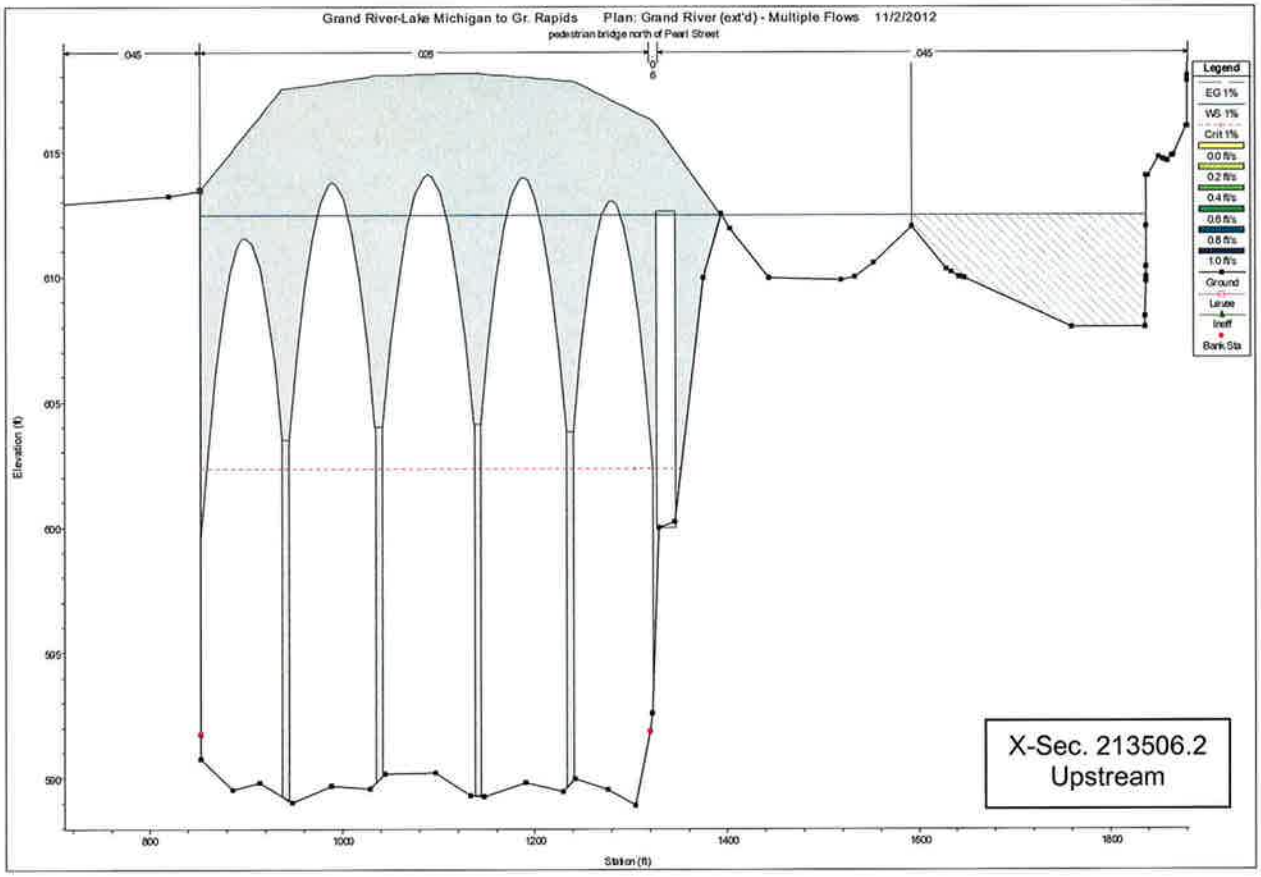

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(D/S of Dam No. 1)
.045
.028
.046
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1200
1400
1600
1800
2000
Station (ft)
X-Sec. 213213.0

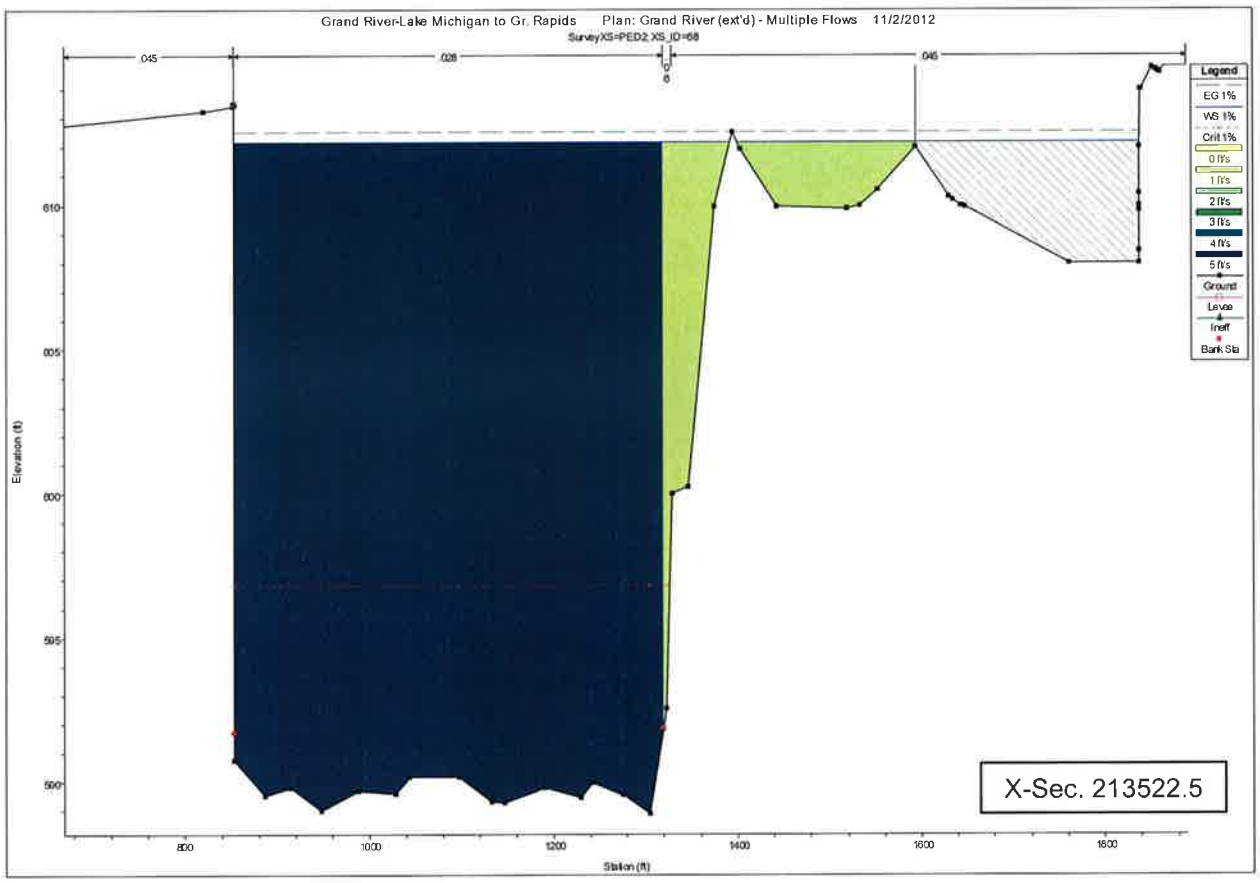

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Dam No. 1 (just U/S of Pearl St. bridge)
.045
.028
.045
Legend
EG 1%
WS 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 213216.5

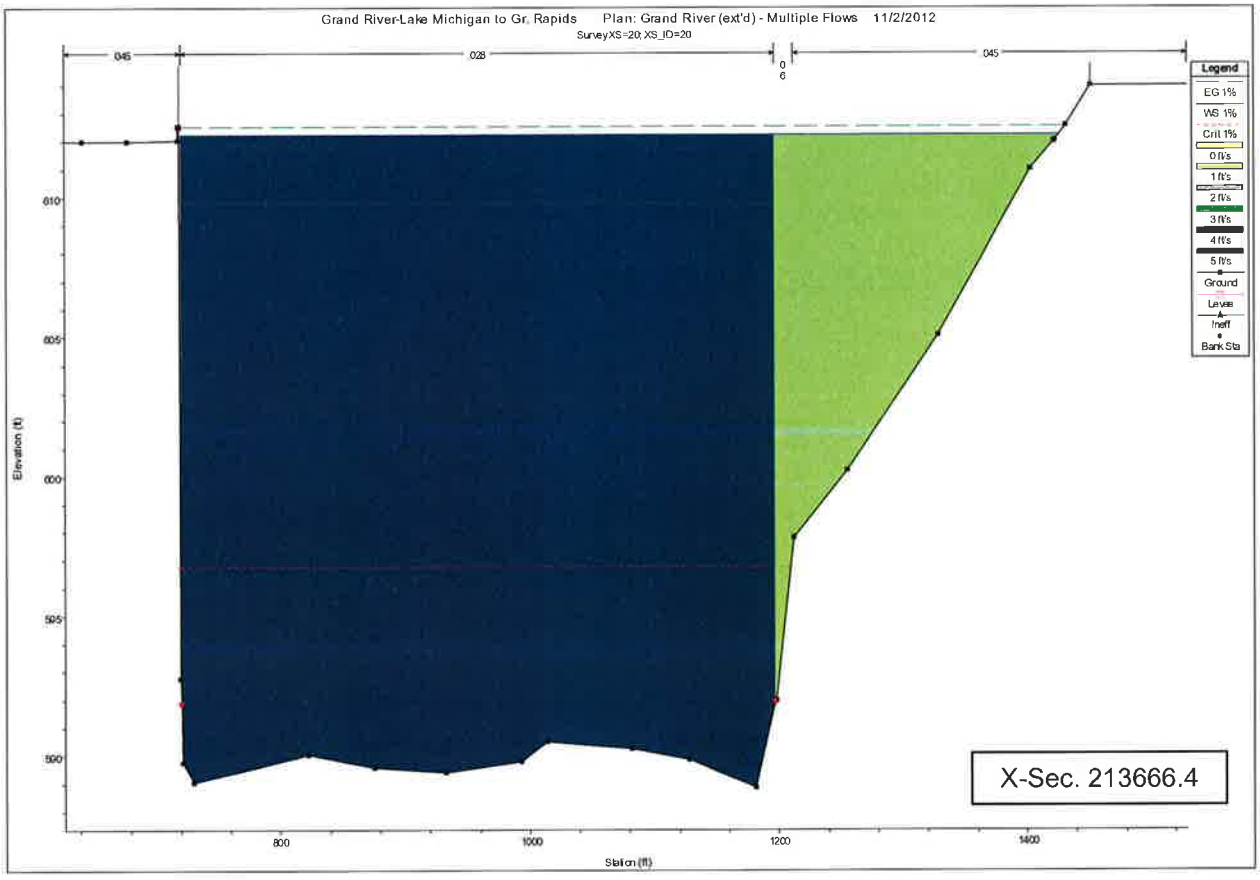

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=D1,XS_ID=97
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1200
1400
1600
1800
2000
Station (ft)
X-Sec. 213220.0

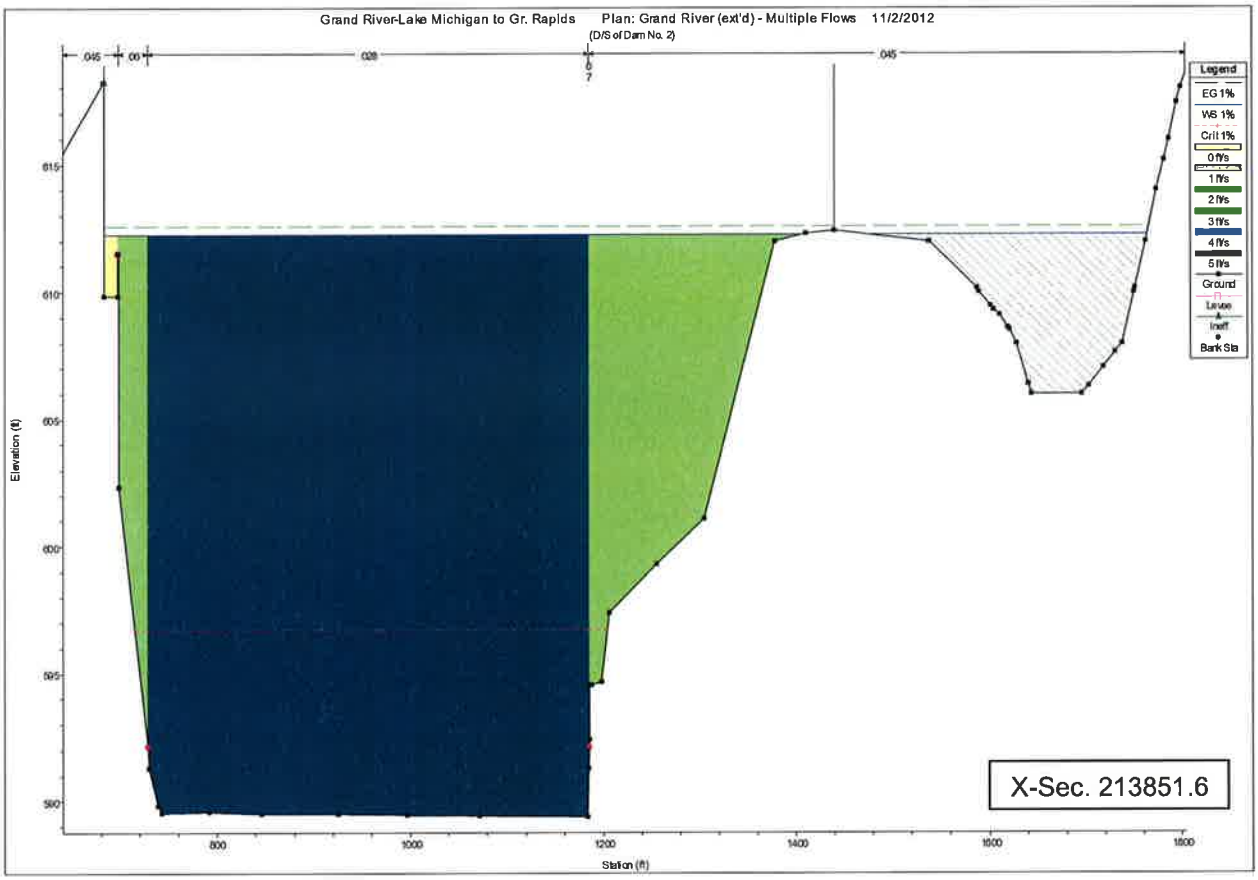

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=PED2,XS_ID=67
045
028
0
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
1000
1200
1400
1600
1800
2000
Station (ft)
X-Sec. 213489.9

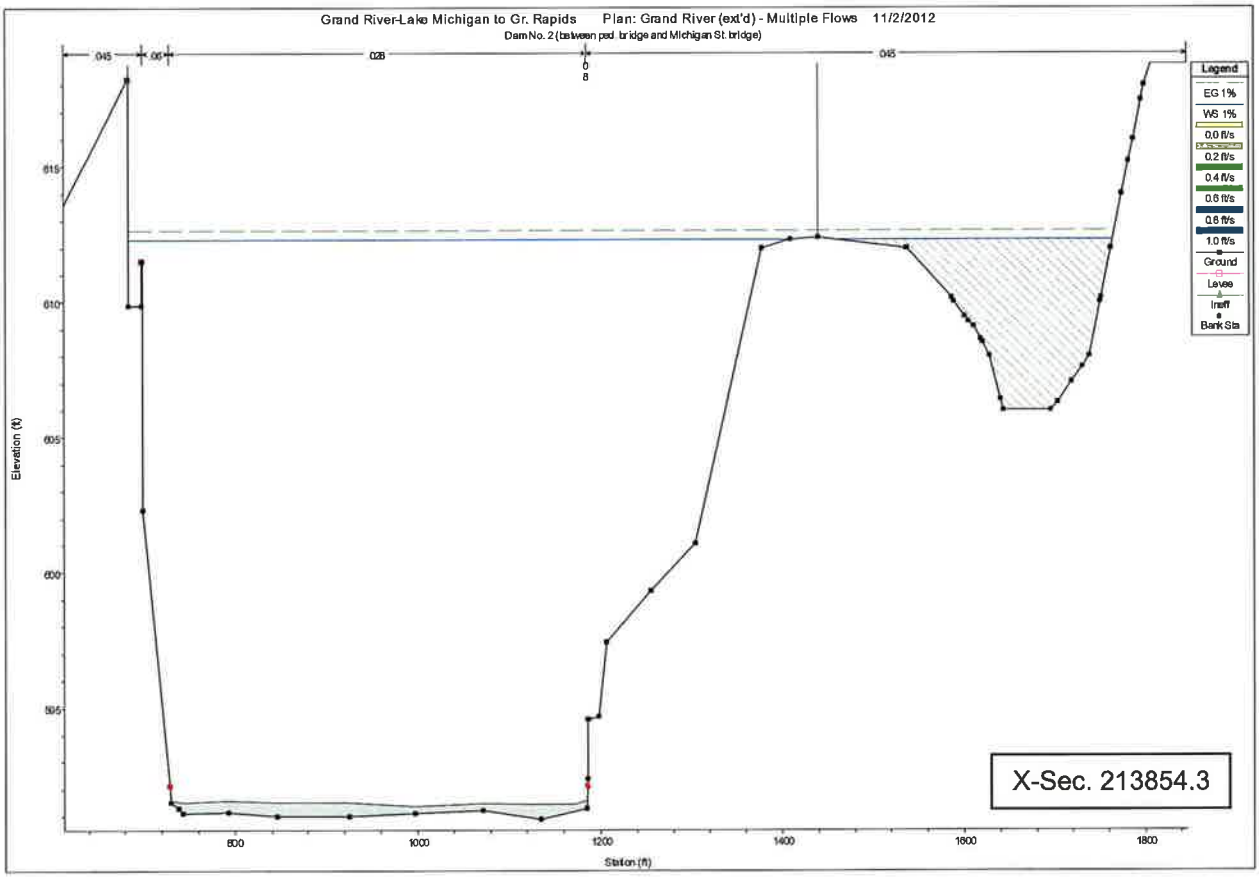

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
pedestrian bridge north of Pearl Street
045
028
0
6
045
Legend
EG 1%
WS 1%
Crit 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
1000
1200
1400
Station (ft)
X-Sec. 213506.2
Downstream

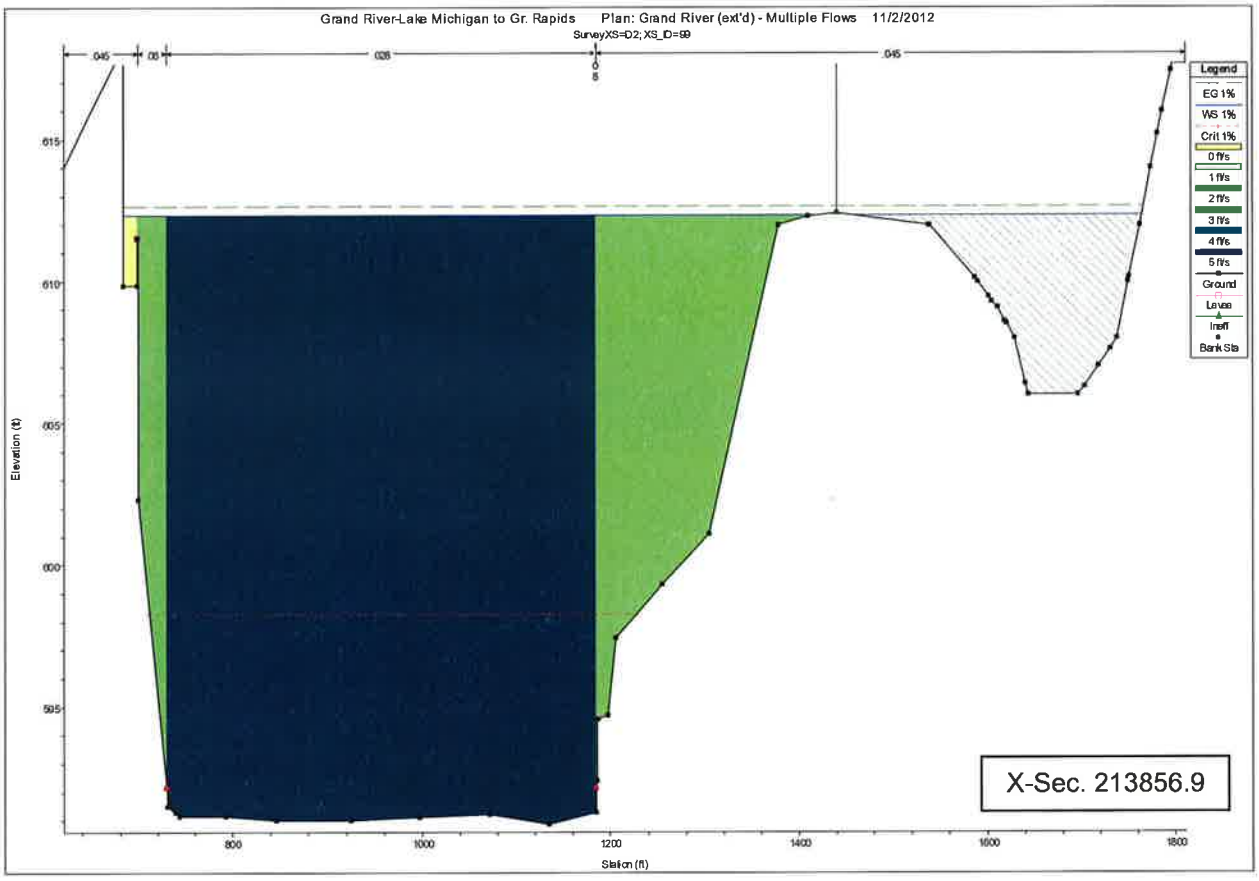

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
pedestrian bridge north of Pearl Street
045
028
0
6
045
Legend
EG 1%
WS 1%
Crit 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 213506.2
Upstream

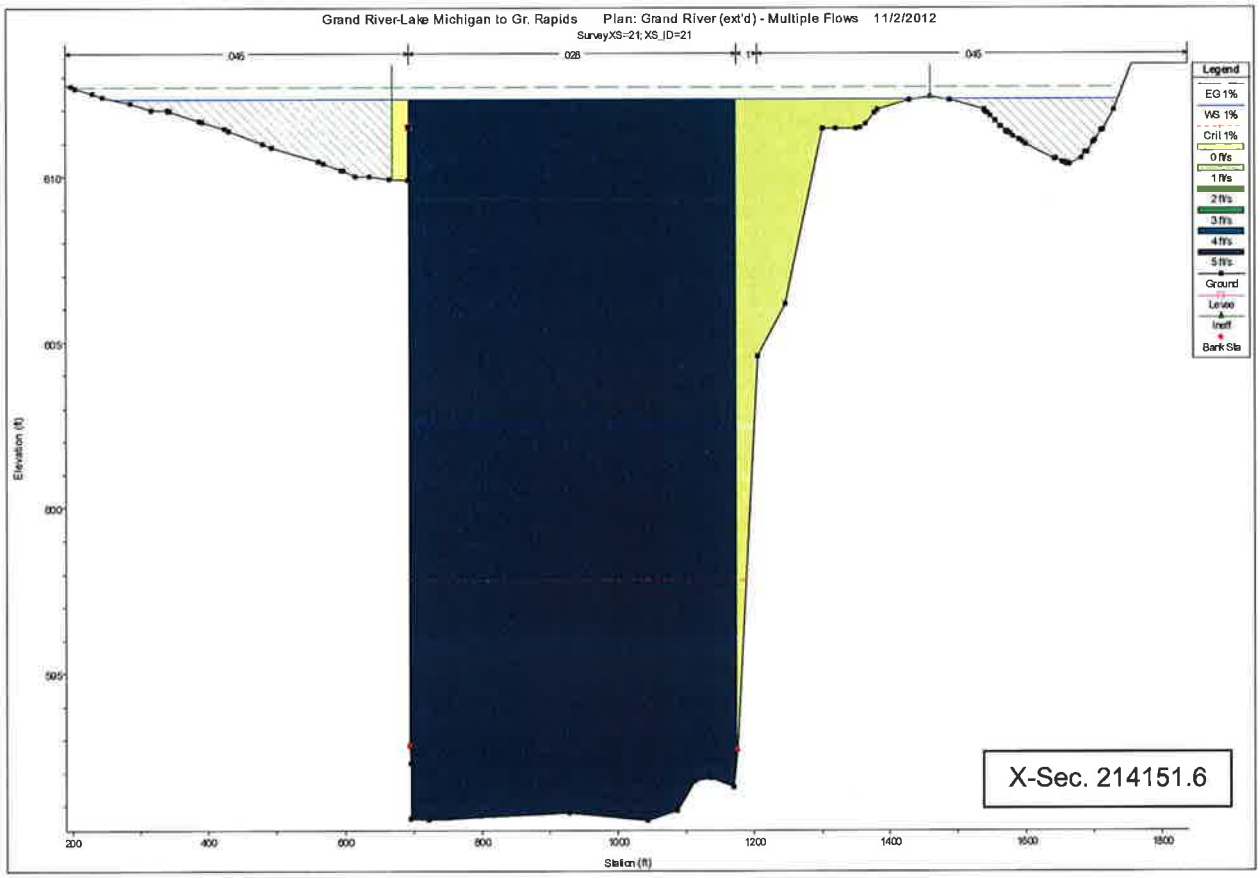

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=PED2 XS_ID=68
.045
.028
.045
0
0
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 213522.5

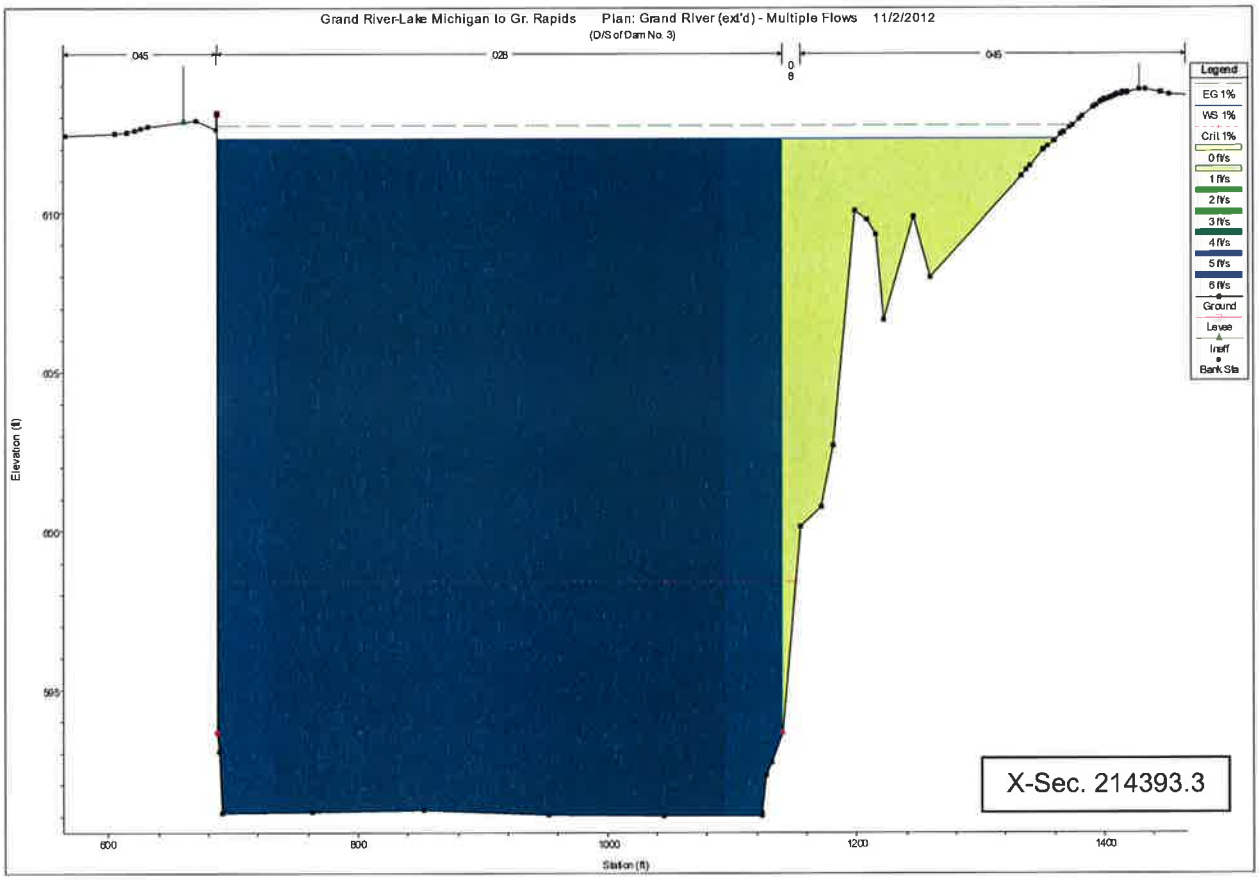

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Survey XS=20 XS_ID=20
.045
.028
.045
0
0
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
590
800
1000
1200
1400
Station (ft)
X-Sec. 213666.4

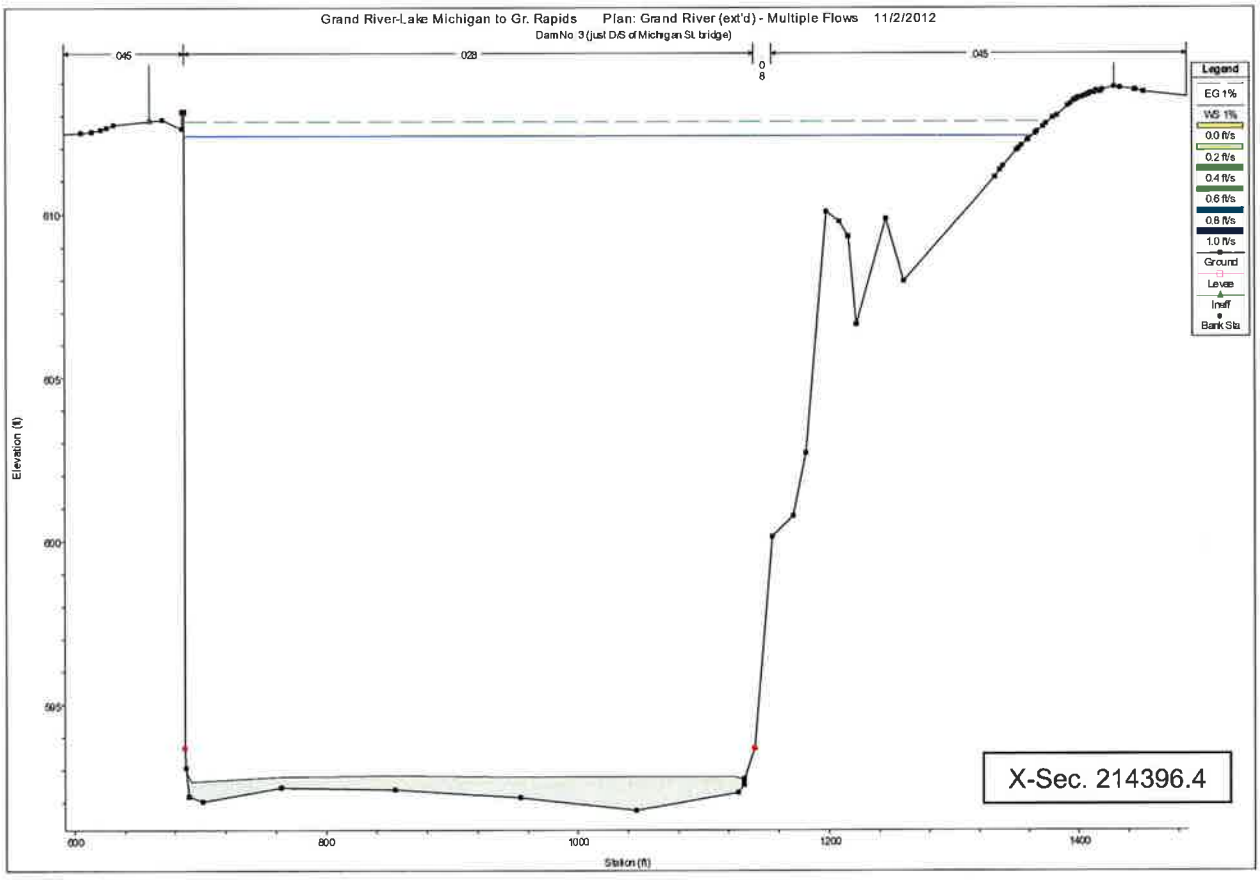

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(D/S of Dam No. 2)
045
.00
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 213851.6

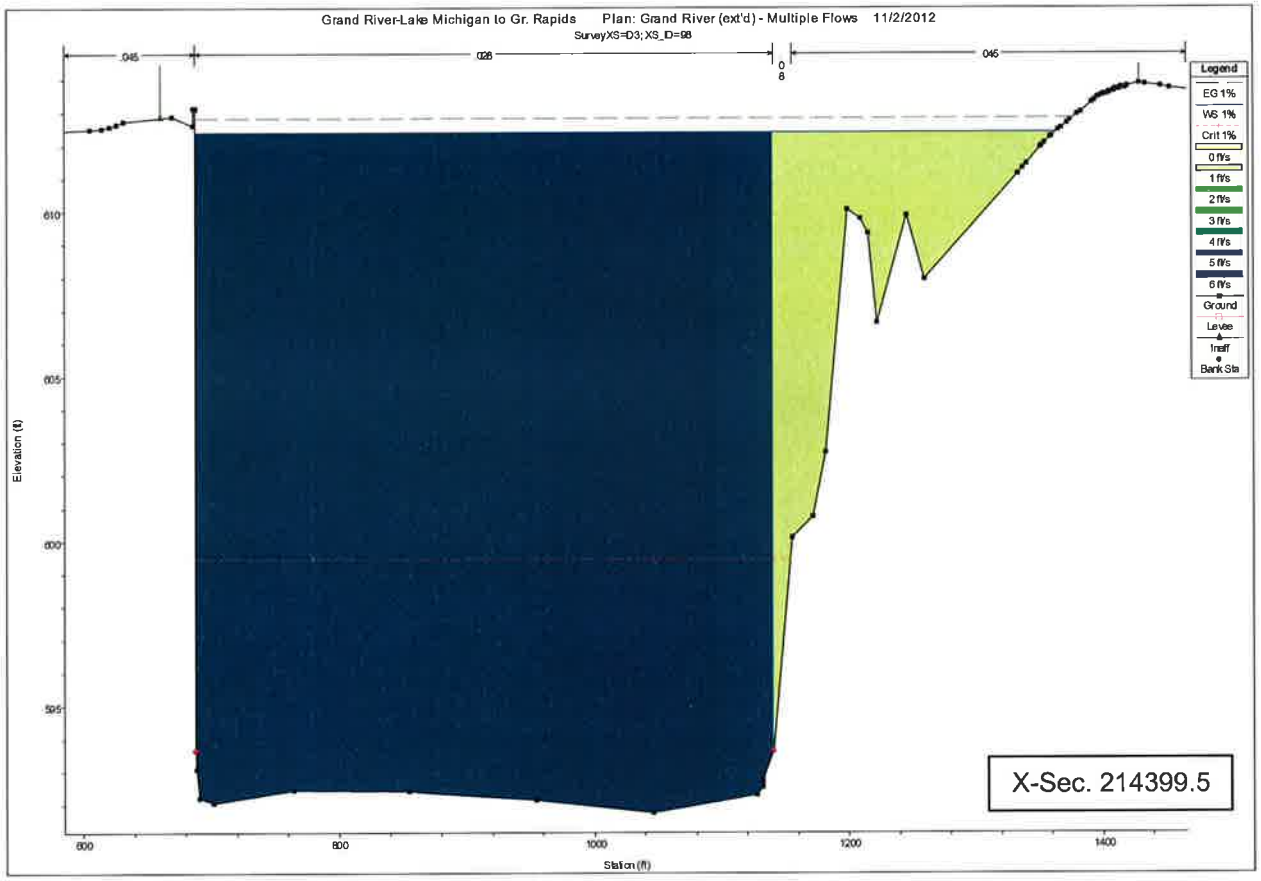

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Dam No. 2 (between ped. bridge and Michigan St. bridge)
045
.05
028
045
Legend
EG 1%
WS 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 213854.3

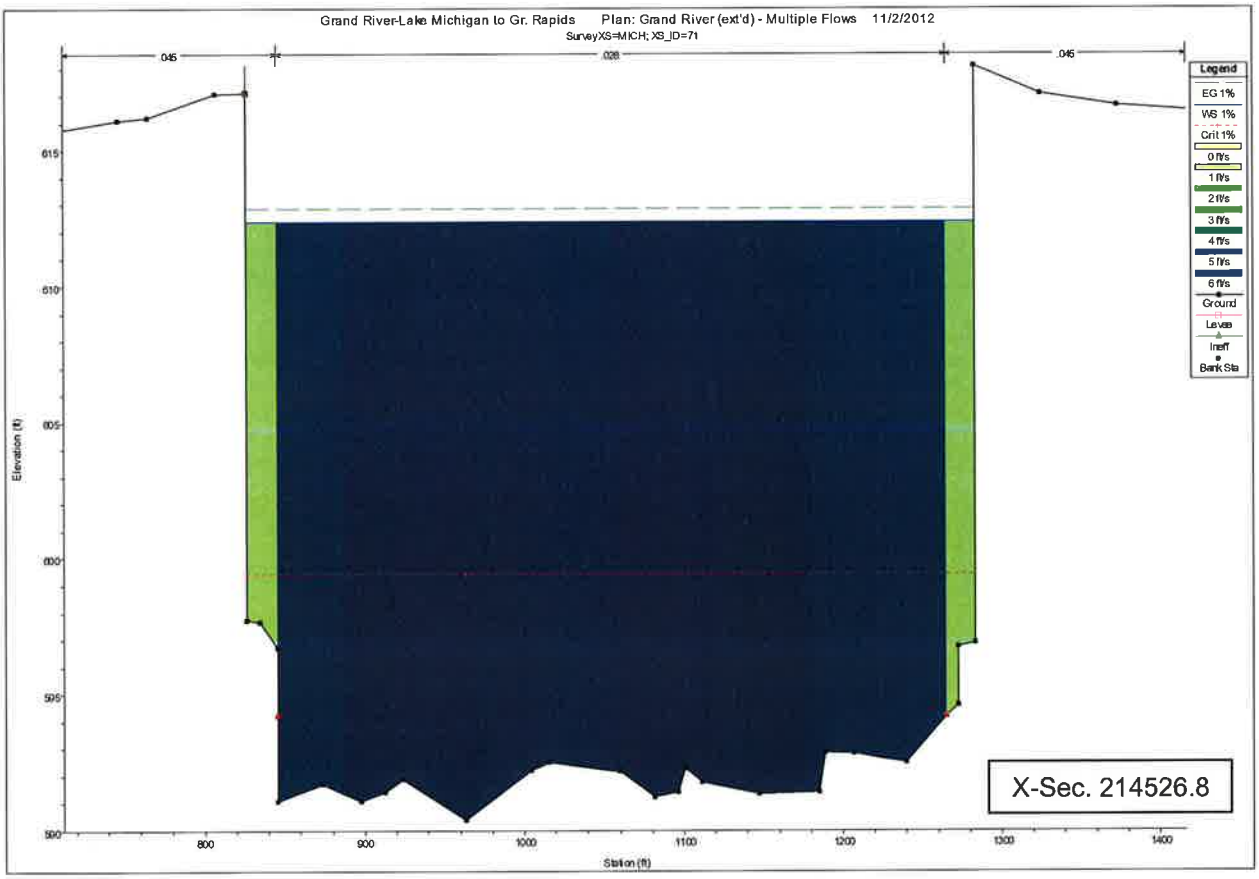

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=D2; XS_ID=89
.045
.08
.026
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 213856.9

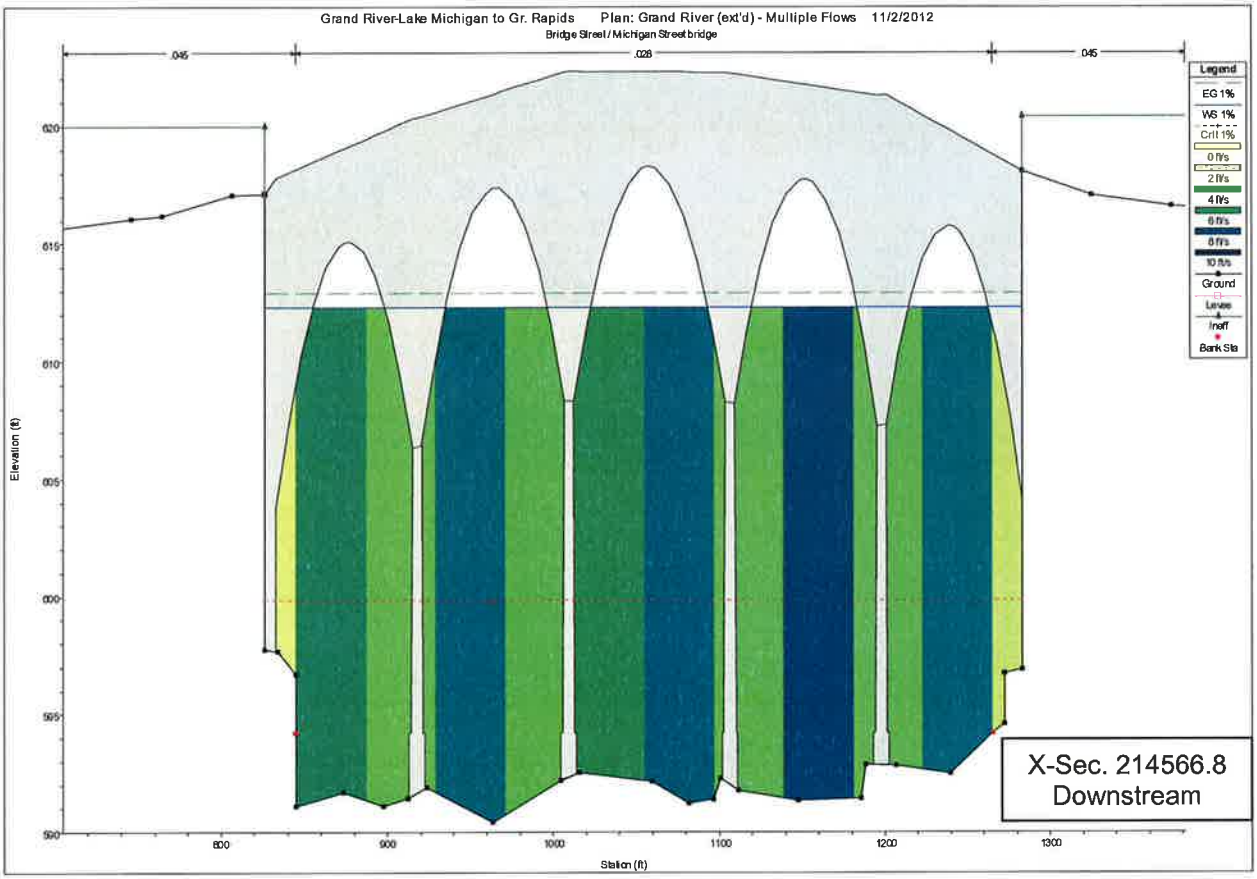

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=21; XS_ID=21
.045
.026
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 214151.6

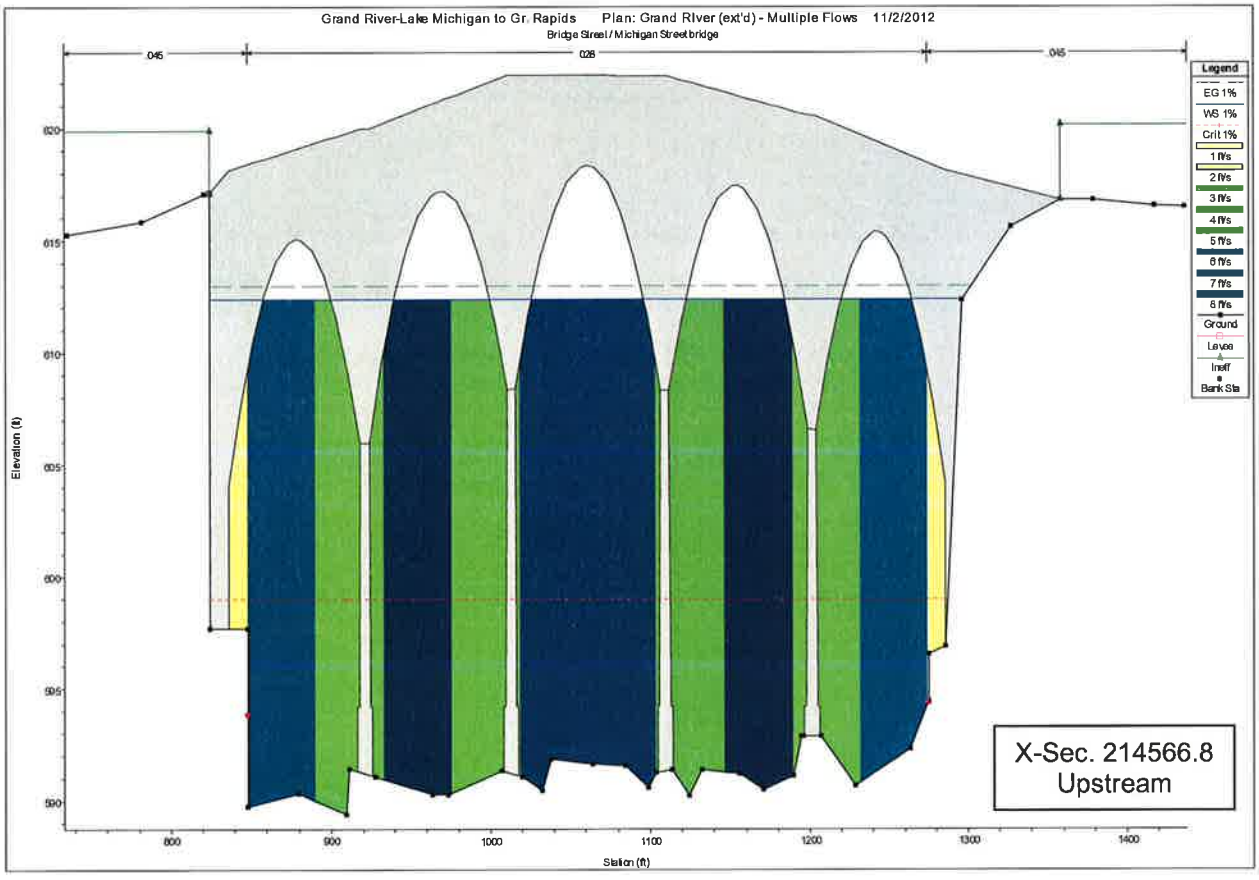

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(D/S of Dam No. 3)
045
028
0
8
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
600
800
1000
1200
1400
Station (ft)
X-Sec. 214393.3

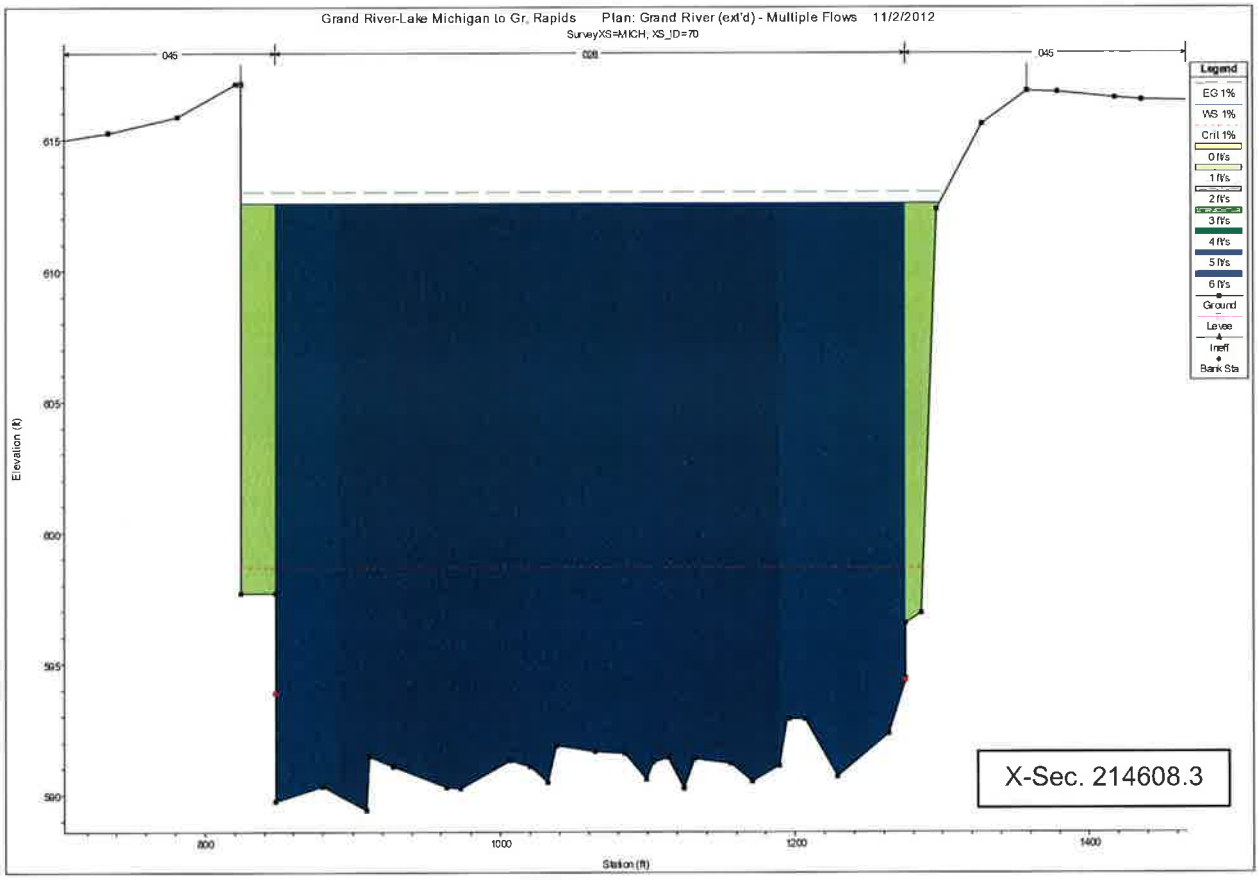

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Dam No. 3 (just D/S of Michigan St. bridge)
045
028
0
8
045
Legend
EG 1%
WS 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
600
800
1000
1200
1400
Station (ft)
X-Sec. 214396.4

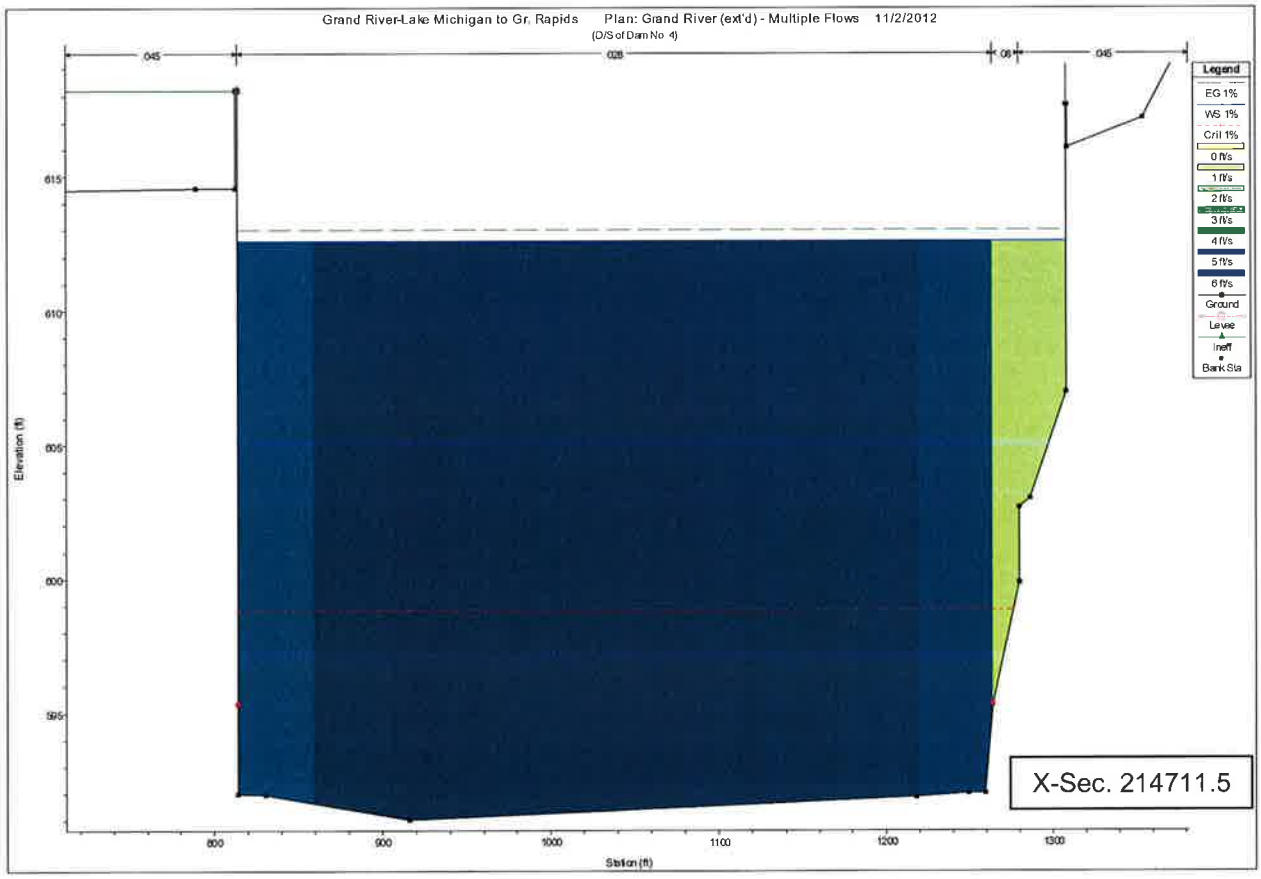

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=D3; XS_ID=98
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
610
605
600
595
600
800
1000
1200
1400
Station (ft)
X-Sec. 214399.5

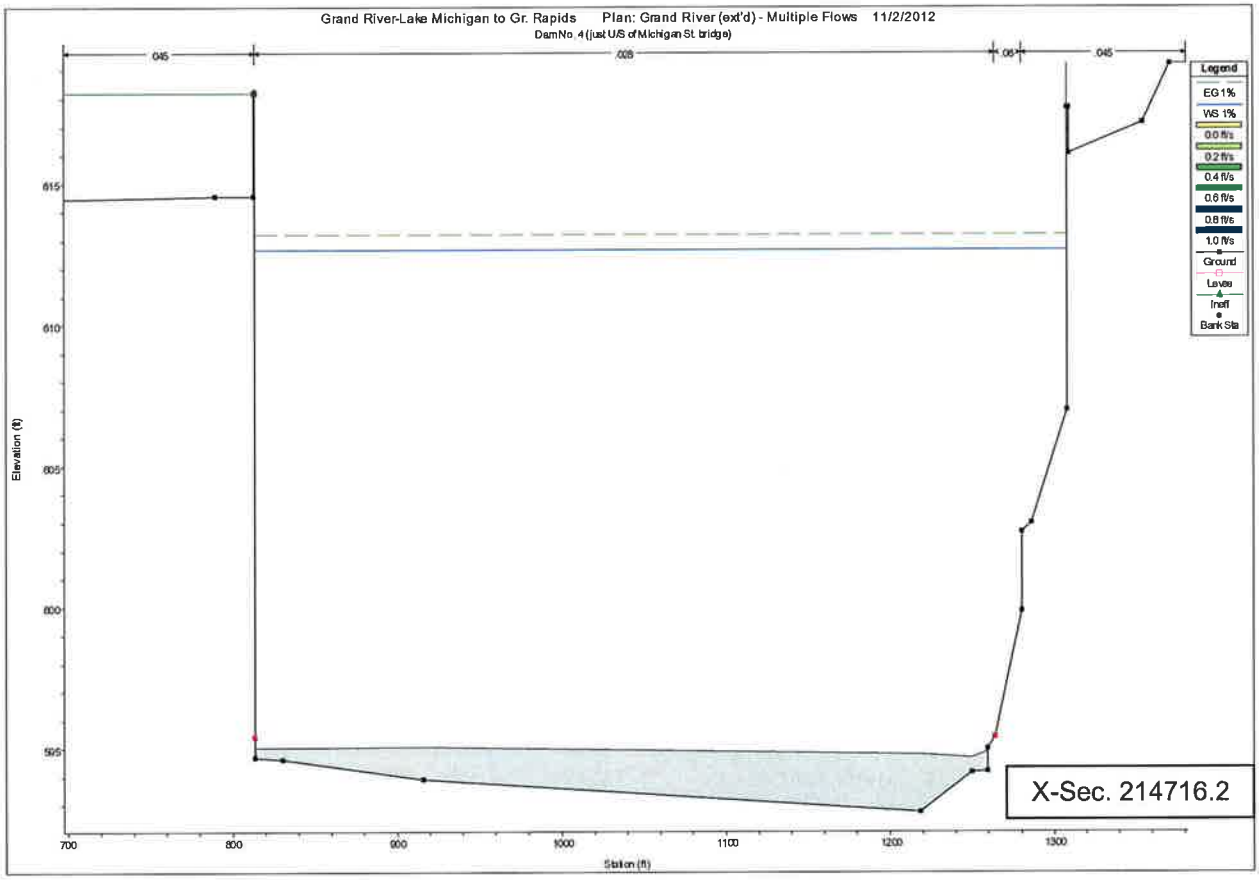

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=MICH; XS_ID=71
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
800
900
1000
1100
1200
1300
1400
Station (ft)
X-Sec. 214526.8

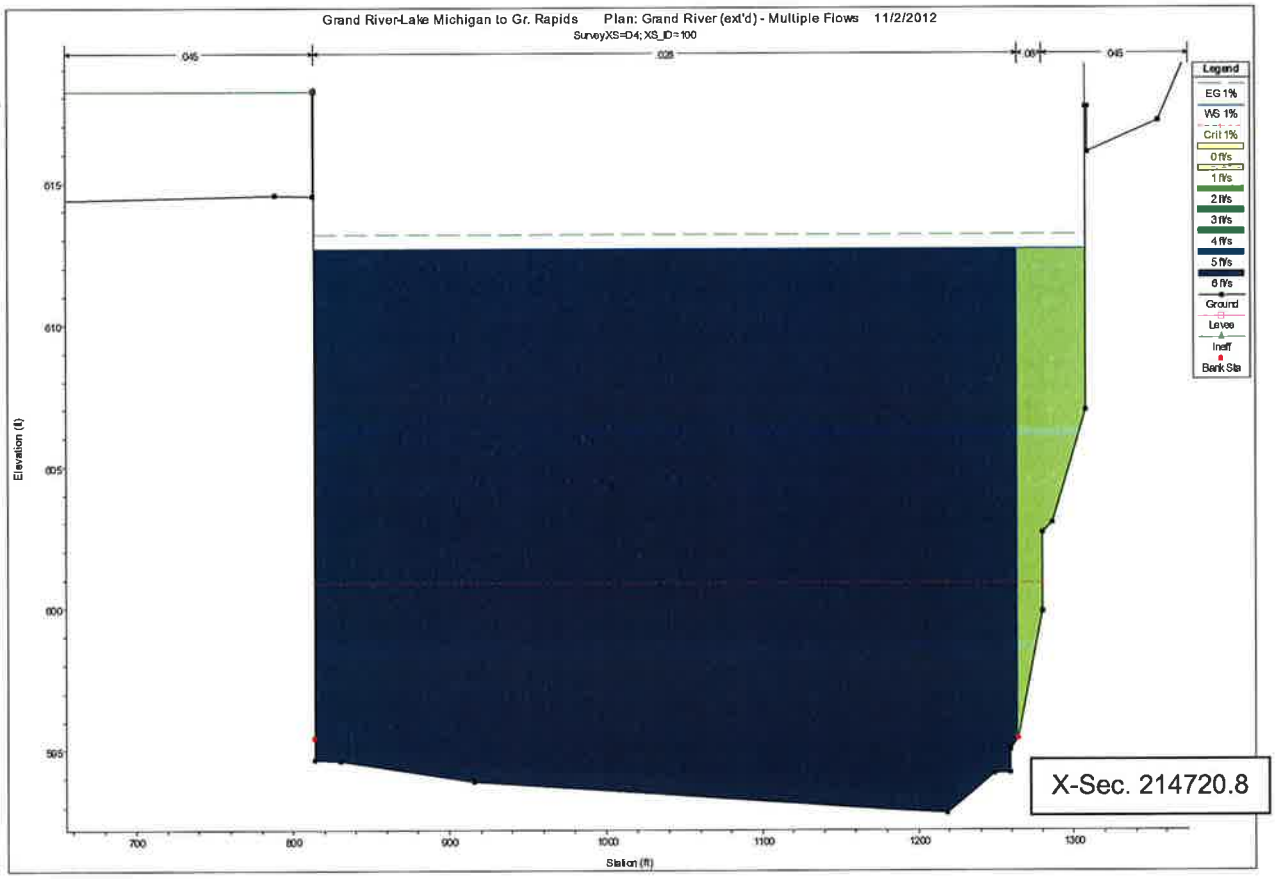

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Bridge Street / Michigan Street bridge
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
595
590
800
900
1000
1100
1200
1300
Station (ft)
X-Sec. 214566.8
Downstream

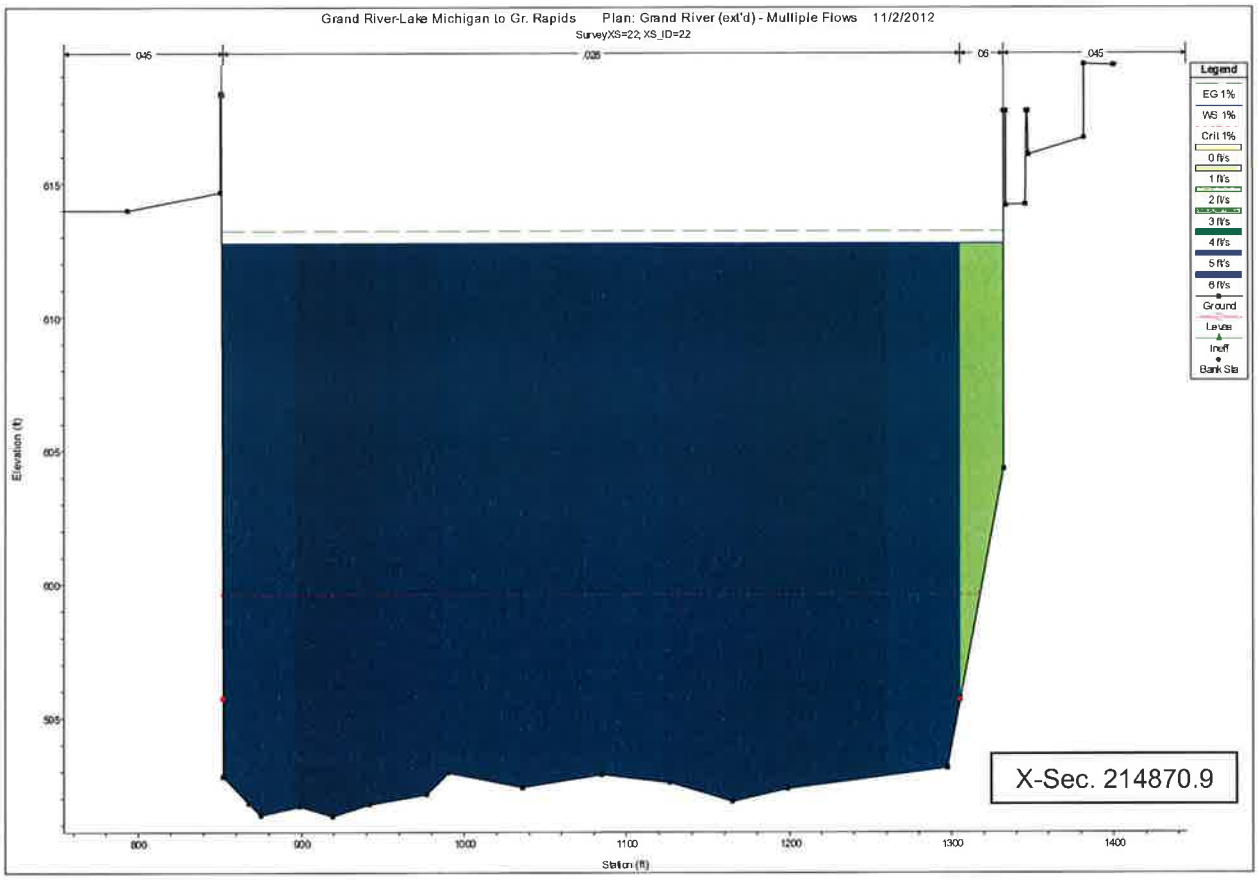

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Bridge Street / Michigan Street bridge
.045
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
595
590
800
900
1000
1100
1200
1300
1400
Station (ft)
X-Sec. 214566.8
Upstream

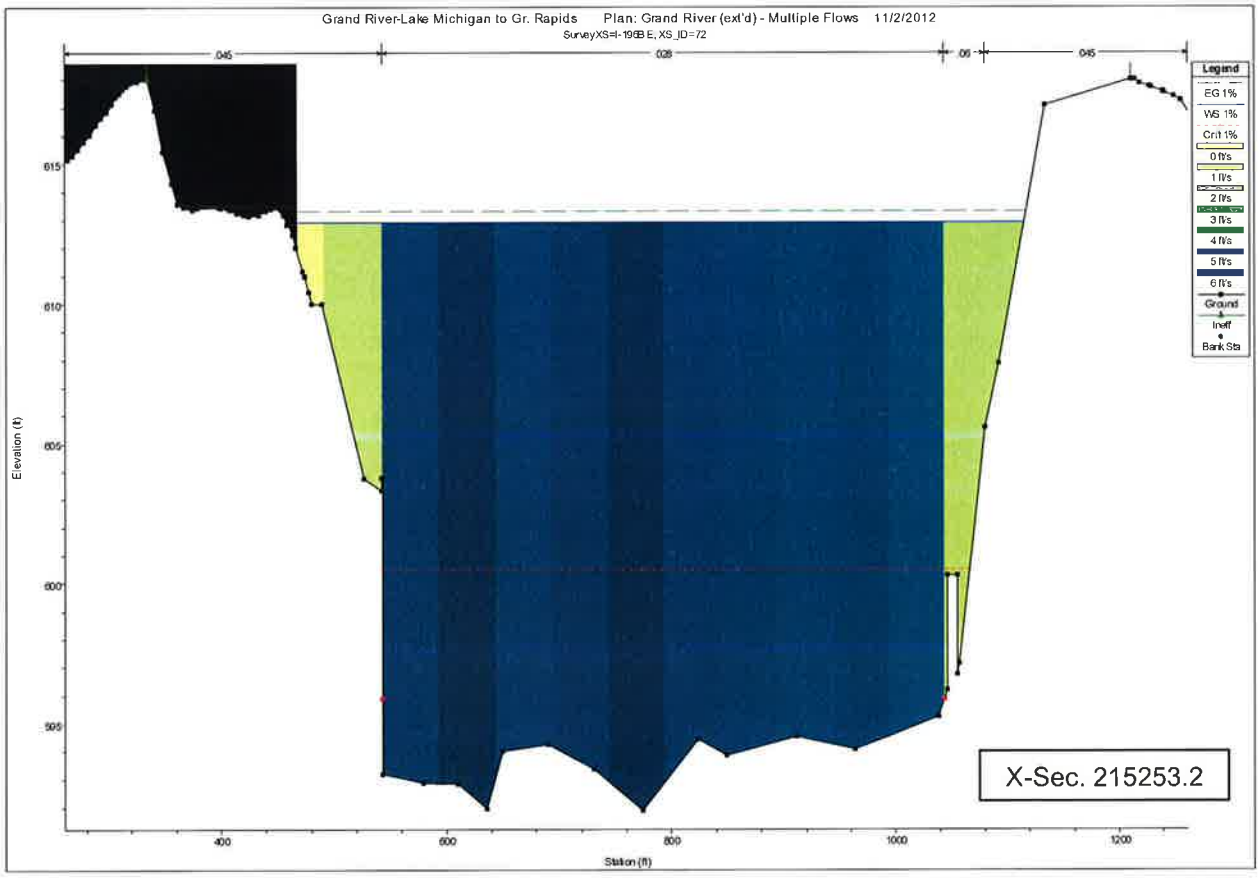

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=MICH, XS_ID=70
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
590
800
1000
1200
1400
Station (ft)
X-Sec. 214608.3

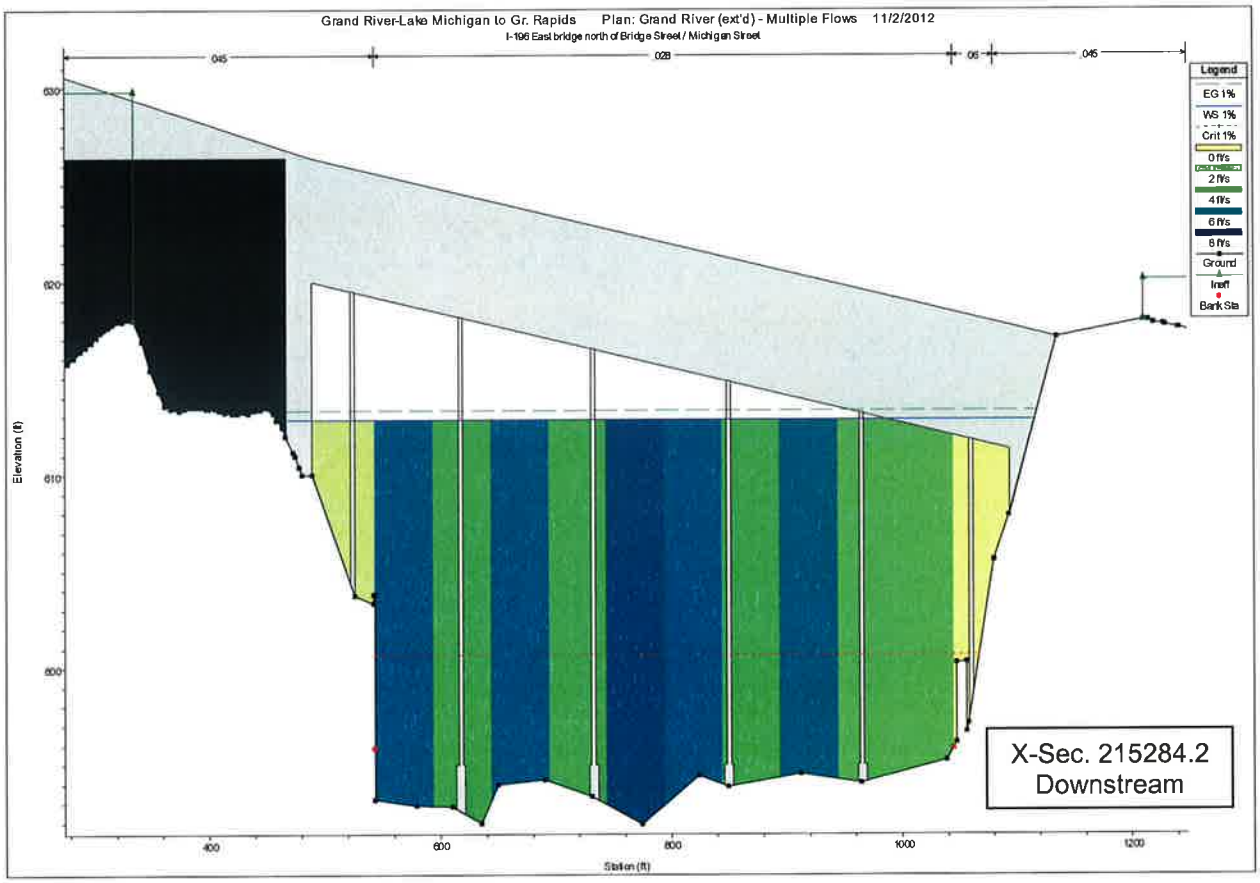

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(D/S of Dam No. 4)
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
900
1000
1100
1200
1300
Station (ft)
X-Sec. 214711.5

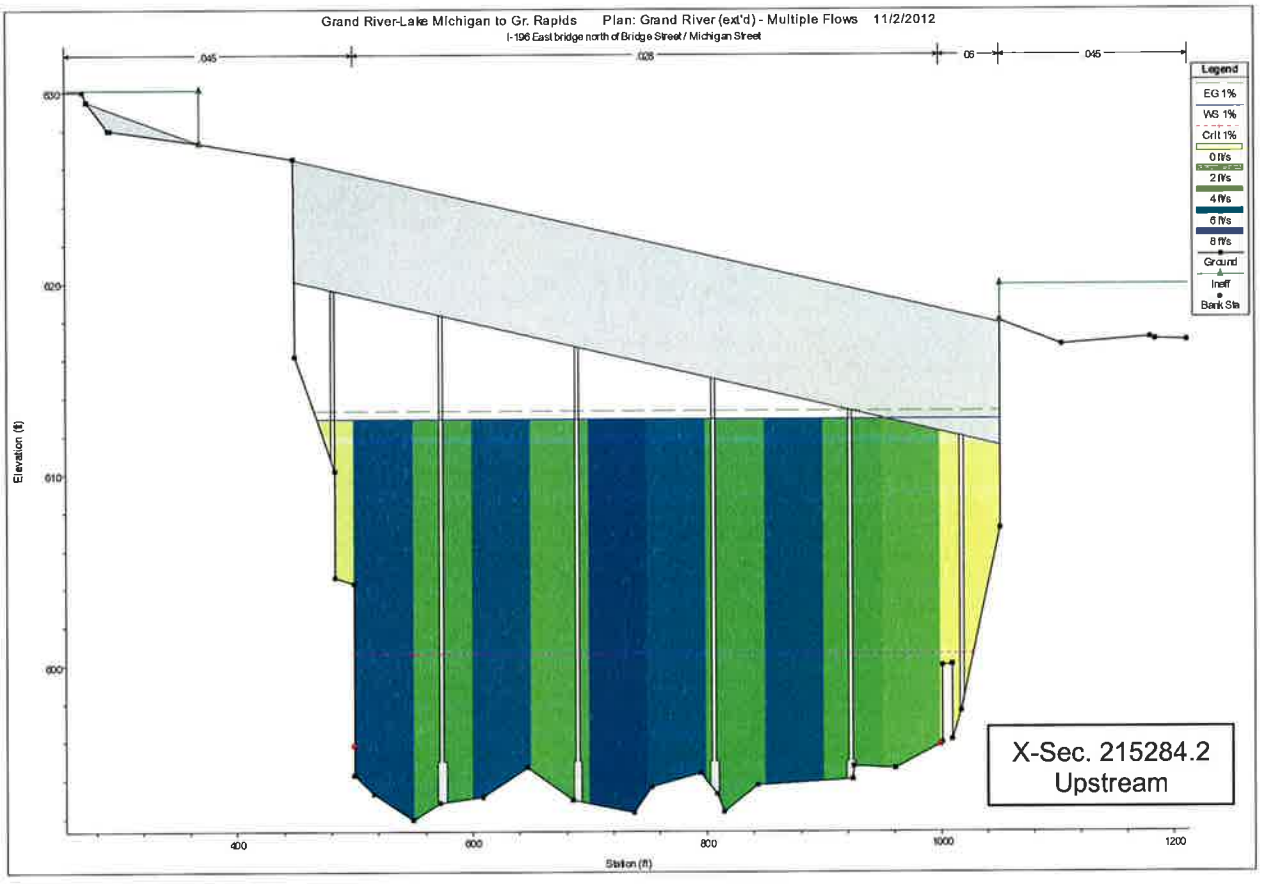

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
DamNo_4 (just U/S of Michigan St. bridge)
.045
.028
.06
.045
Legend
EG 1%
WS 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
700
800
900
1000
1100
1200
1300
Station (ft)
X-Sec. 214716.2

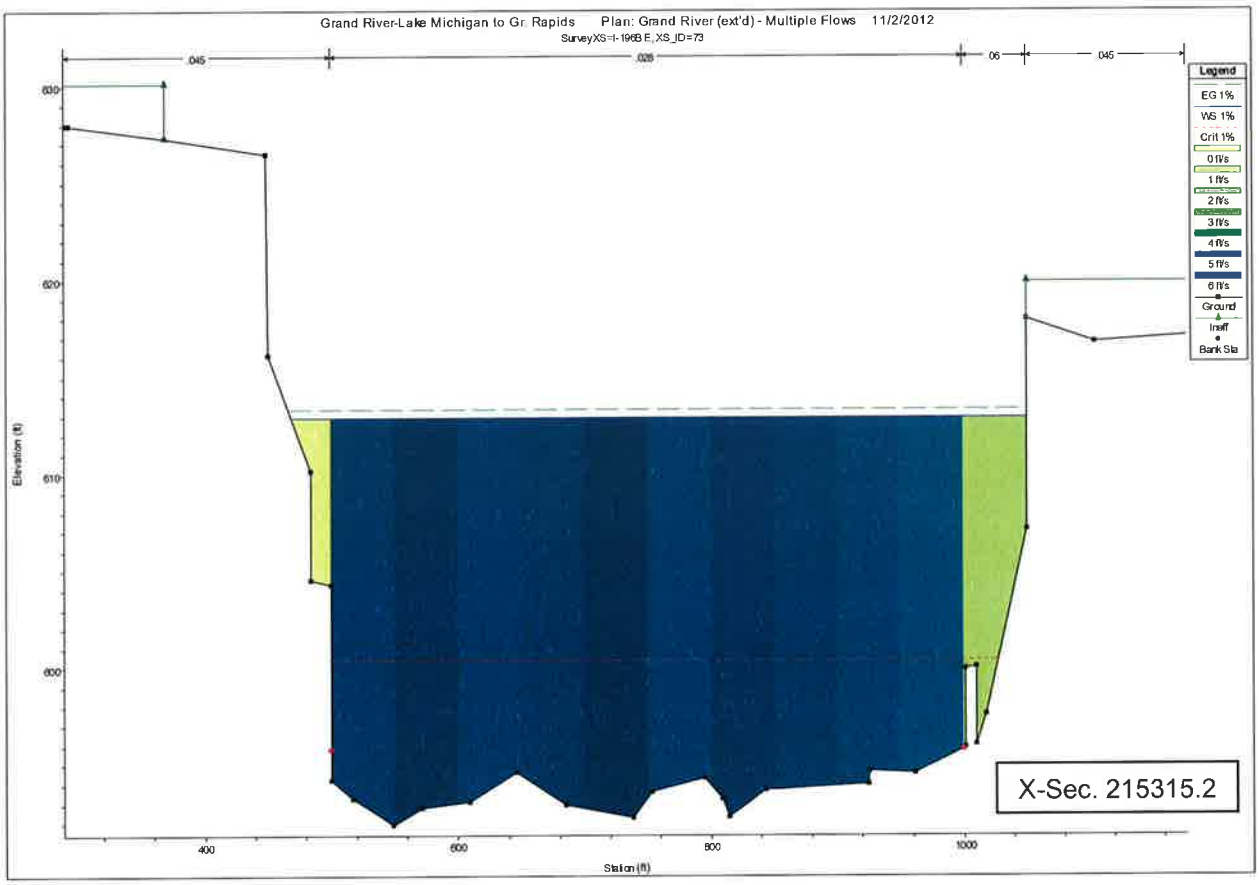

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=04; XS_ID=100
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
700
800
900
1000
1100
1200
1300
Station (ft)
X-Sec. 214720.8

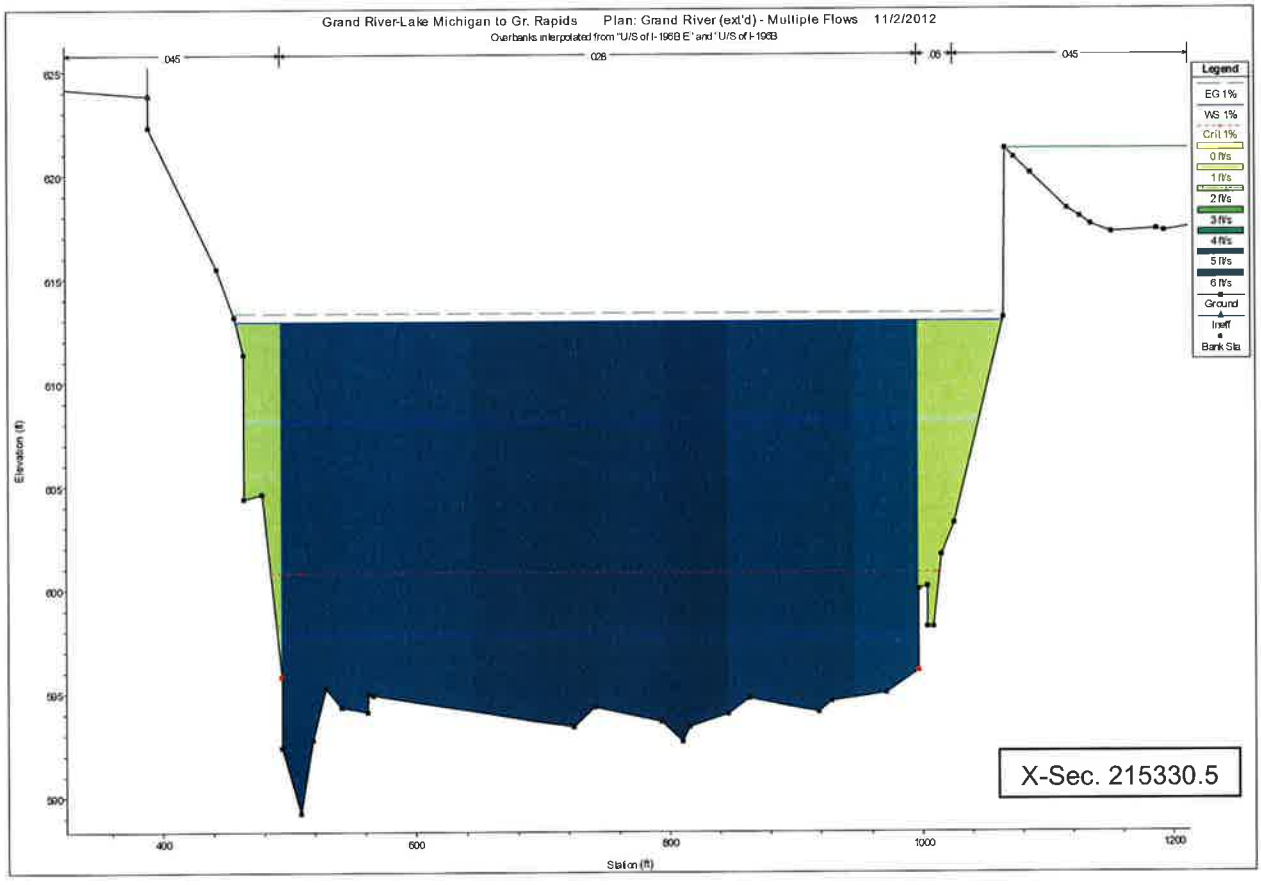

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=22, XS_ID=22
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
900
1000
1100
1200
1300
1400
Station (ft)
X-Sec. 214870.9

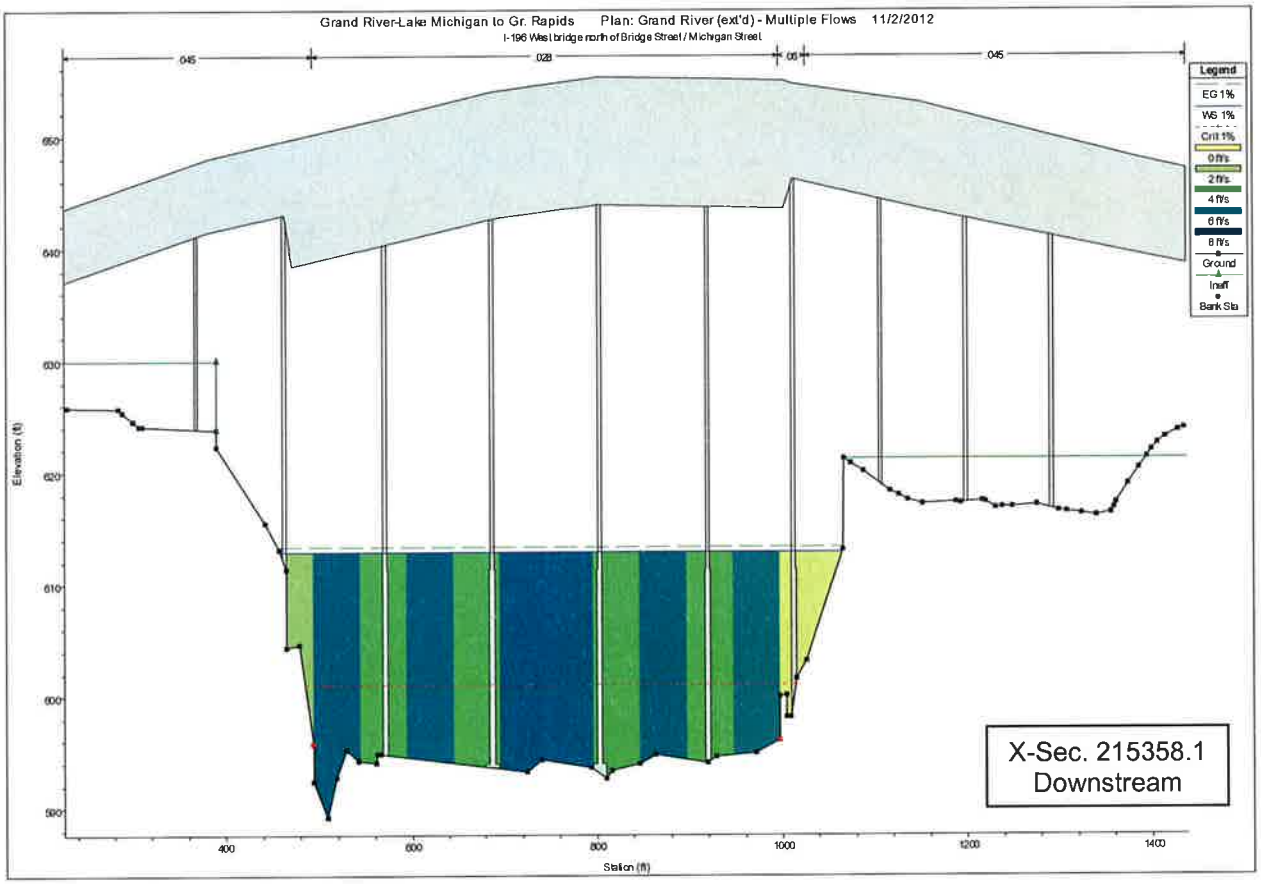

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=I-196B E, XS_ID=72
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
400
600
800
1000
1200
Station (ft)
X-Sec. 215253.2

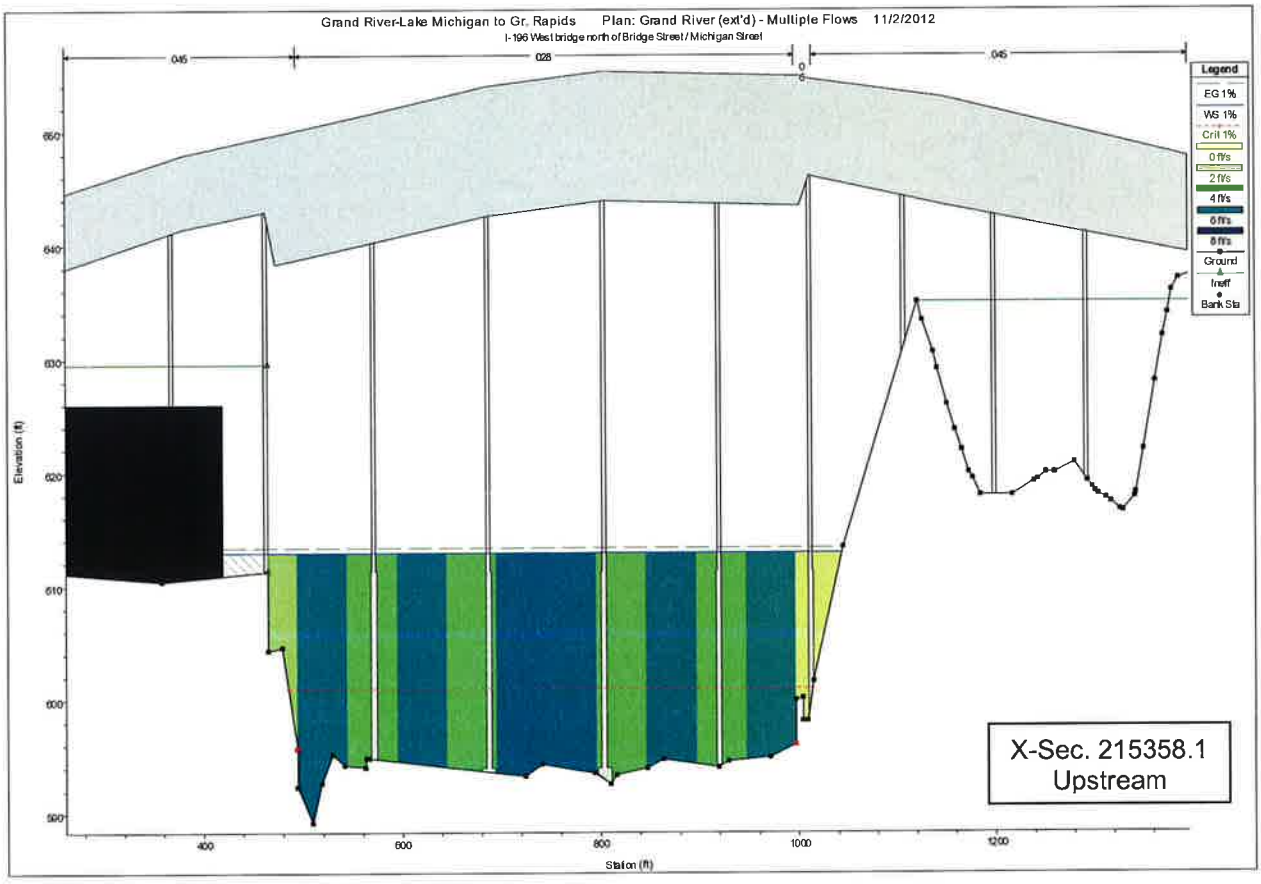

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-196 East bridge north of Bridge Street / Michigan Street
045
028
06
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
1200
Station (ft)
X-Sec. 215284.2
Downstream

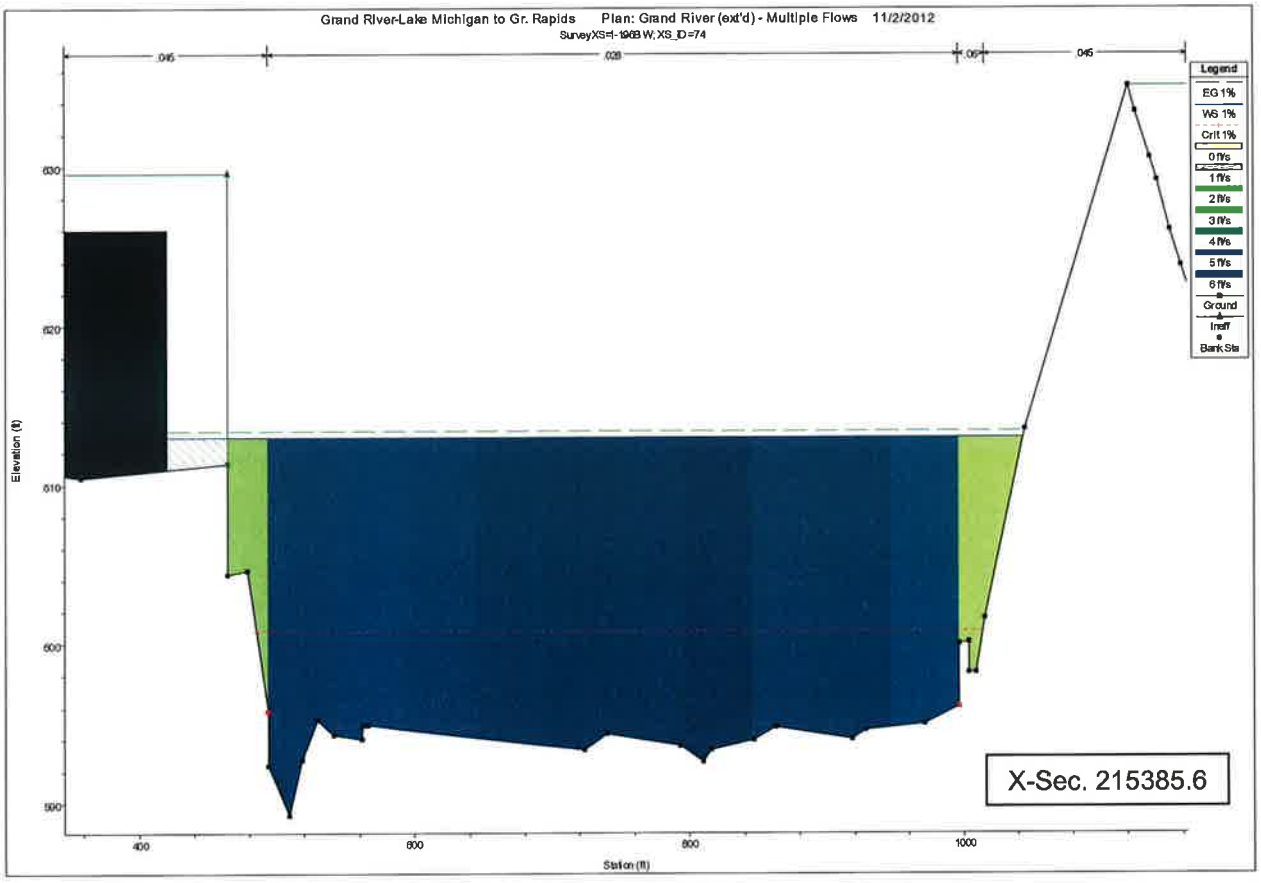

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-196 East bridge north of Bridge Street / Michigan Street
045
028
06
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
1200
Station (ft)
X-Sec. 215284.2
Upstream

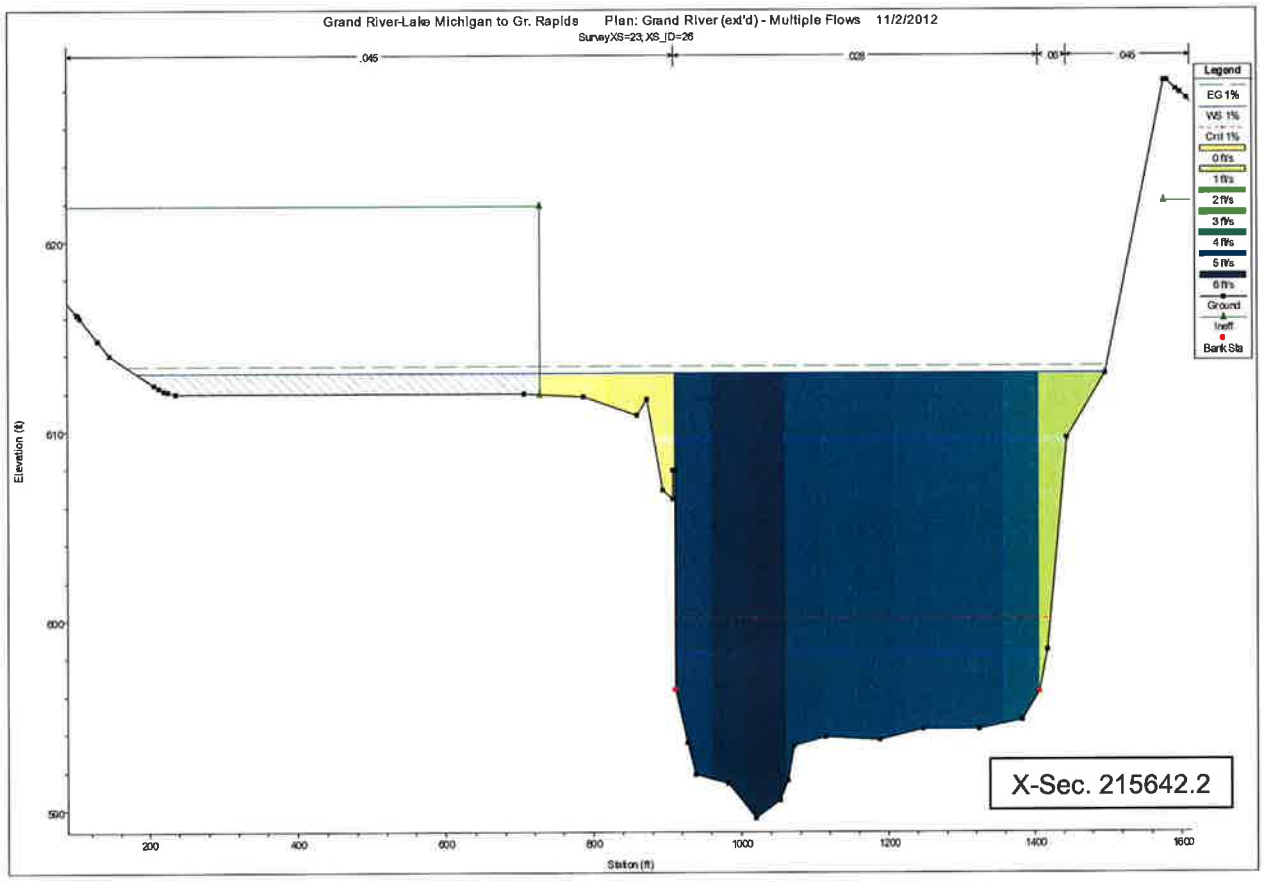

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=I-196B E, XS_ID=73
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
Station (ft)
X-Sec. 215315.2

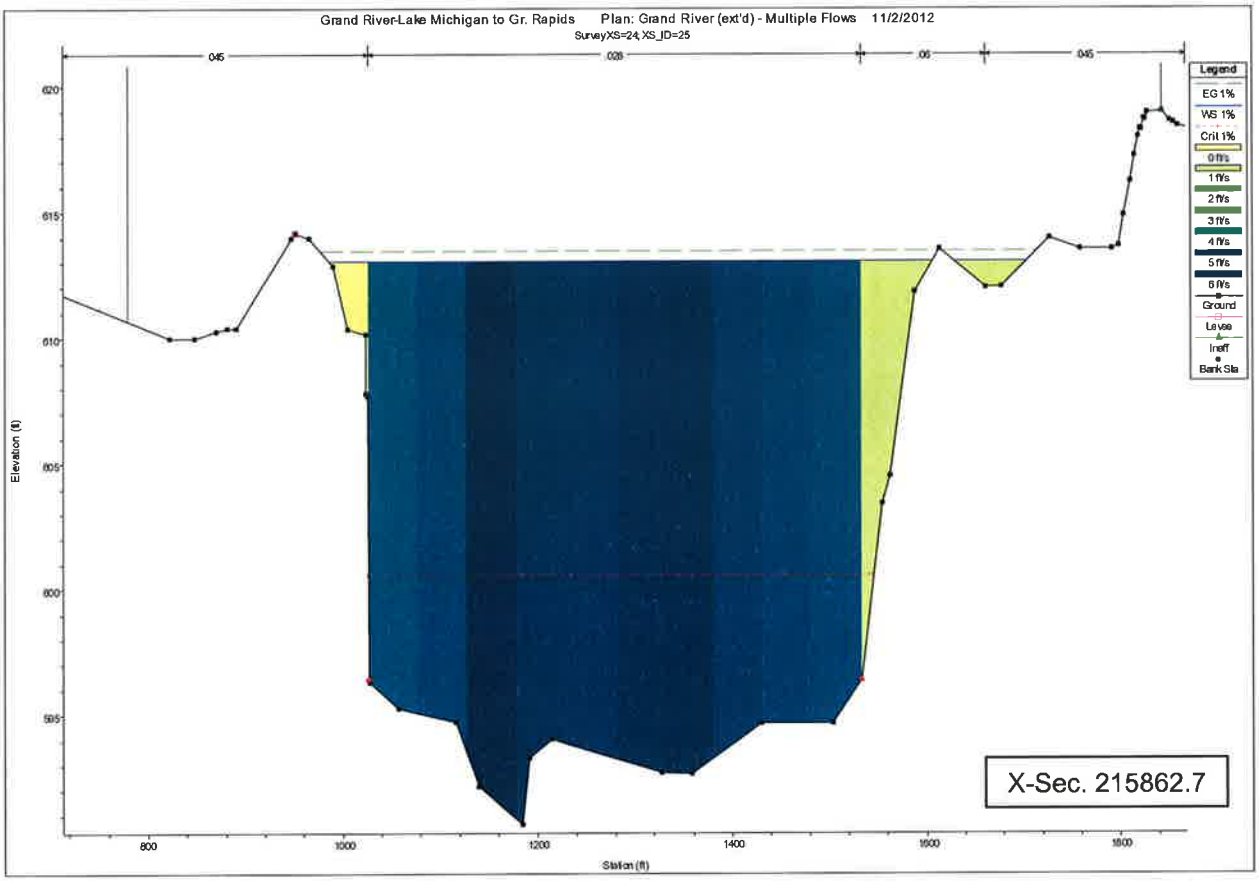

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Overbanks interpolated from "U/S of I-196B E" and "U/S of I-196B
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
595
590
400
600
800
1000
1200
Station (ft)
X-Sec. 215330.5

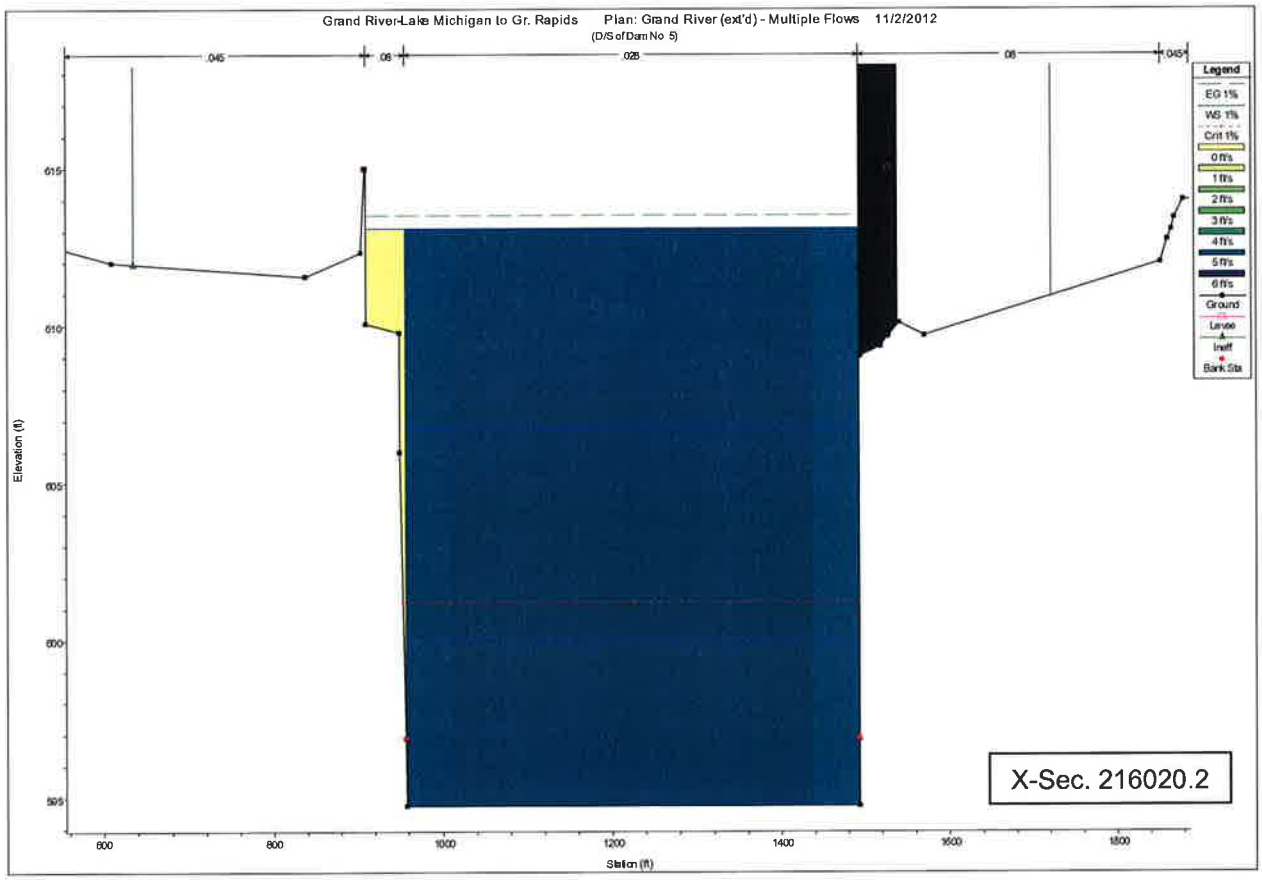

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-196 West bridge north of Bridge Street / Michigan Street
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
650
640
630
620
610
600
590
400
600
800
1000
1200
1400
Station (ft)
X-Sec. 215358.1
Downstream

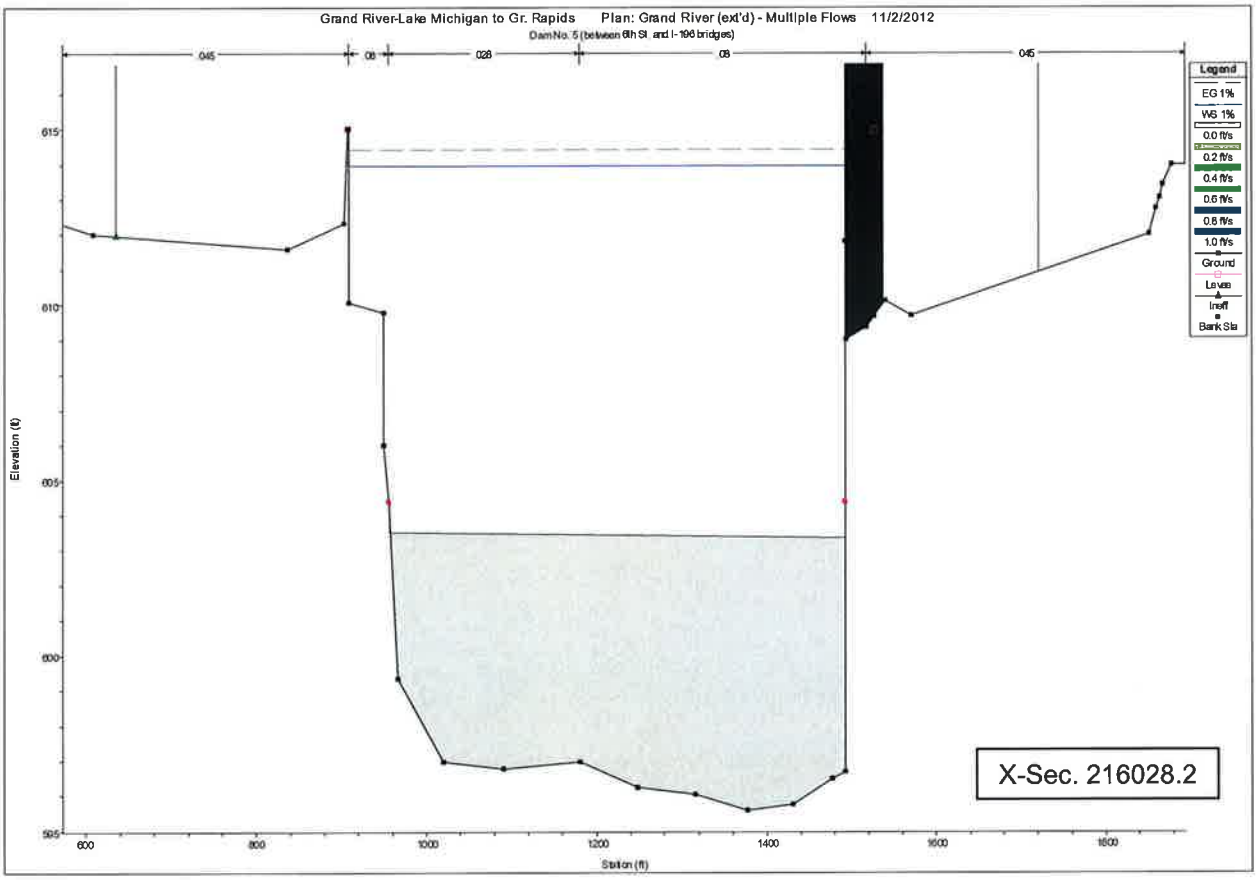

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-196 West bridge north of Bridge Street / Michigan Street
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
650
640
630
620
610
600
590
400
600
800
1000
1200
Station (ft)
X-Sec. 215358.1
Upstream

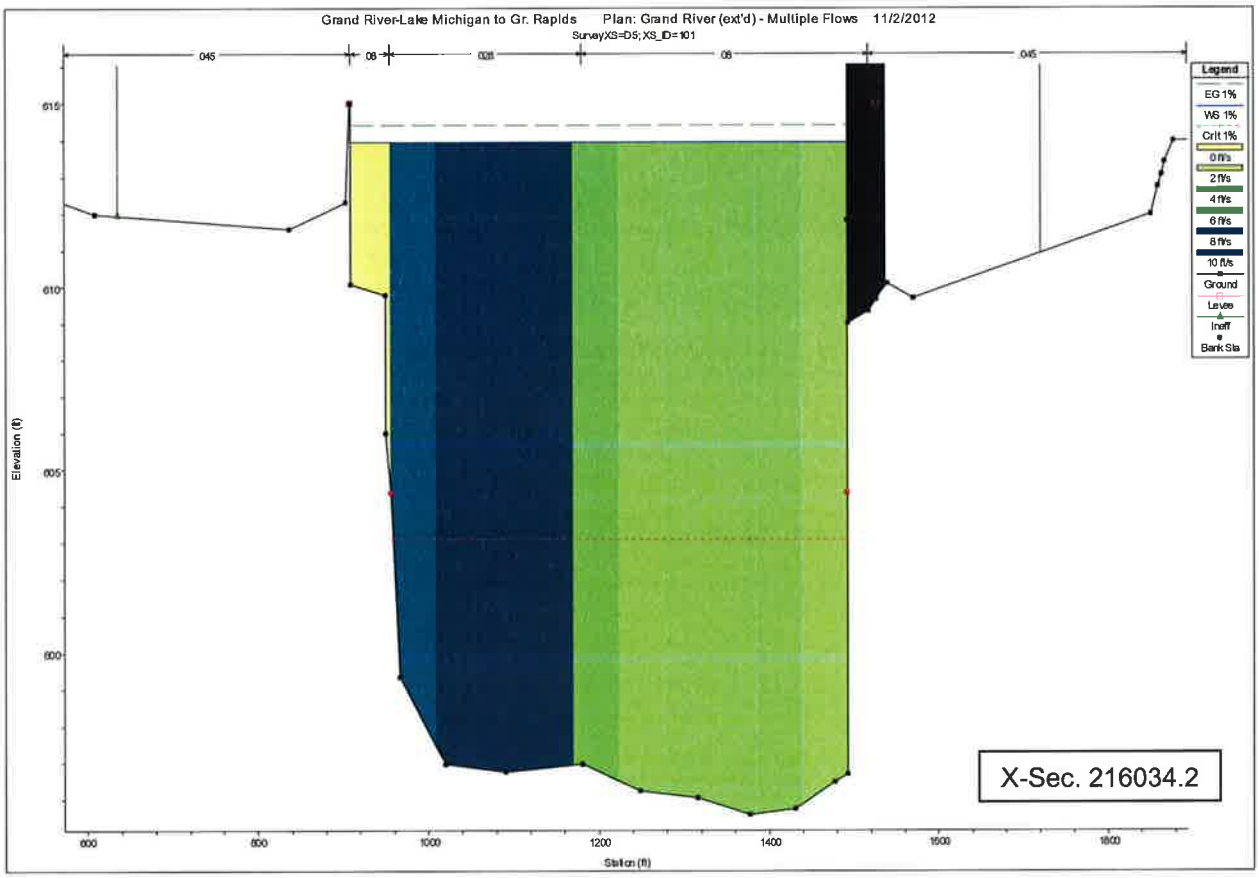

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=I-196B W; XS_ID=74
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
590
400
600
800
1000
Station (ft)
X-Sec. 215385.6

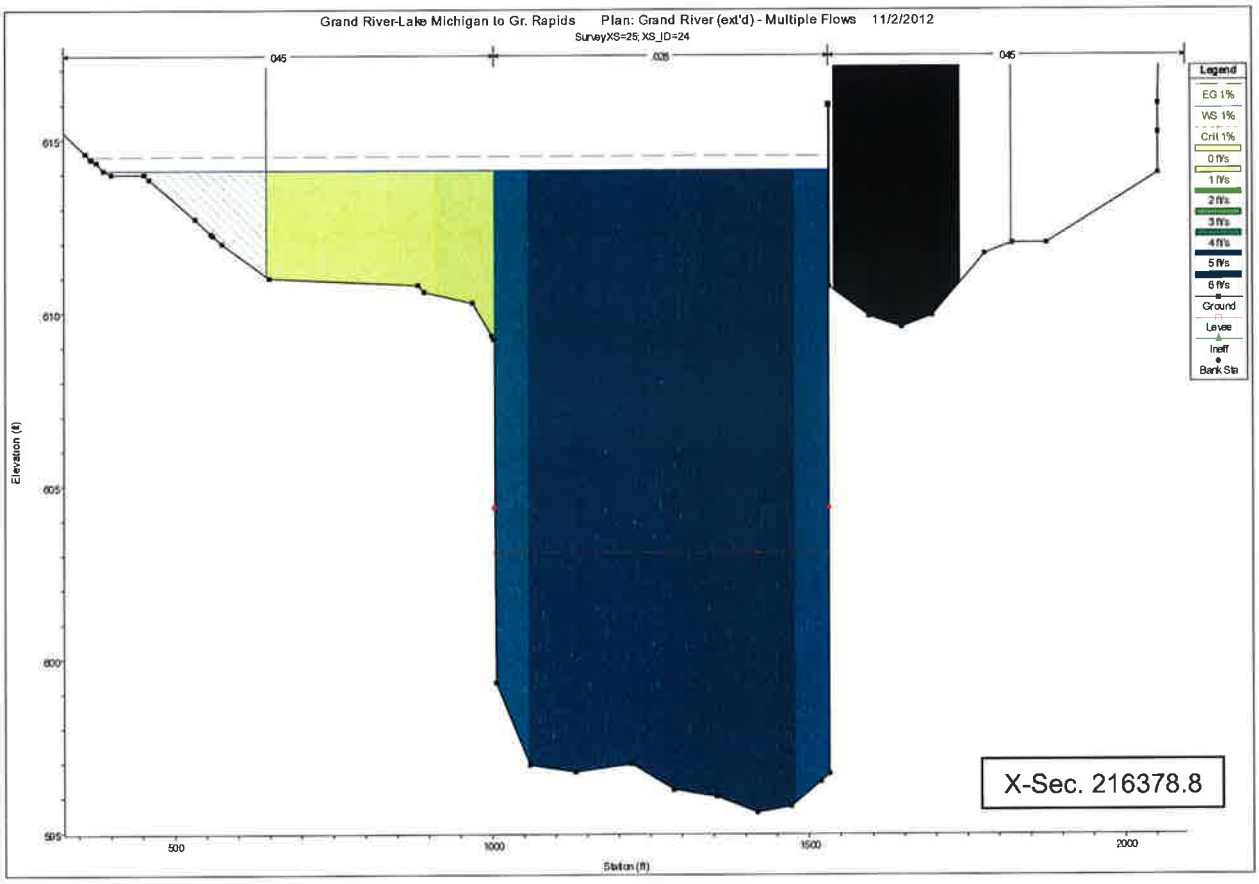

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=23; XS_ID=26
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
610
600
590
200
400
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 215642.2

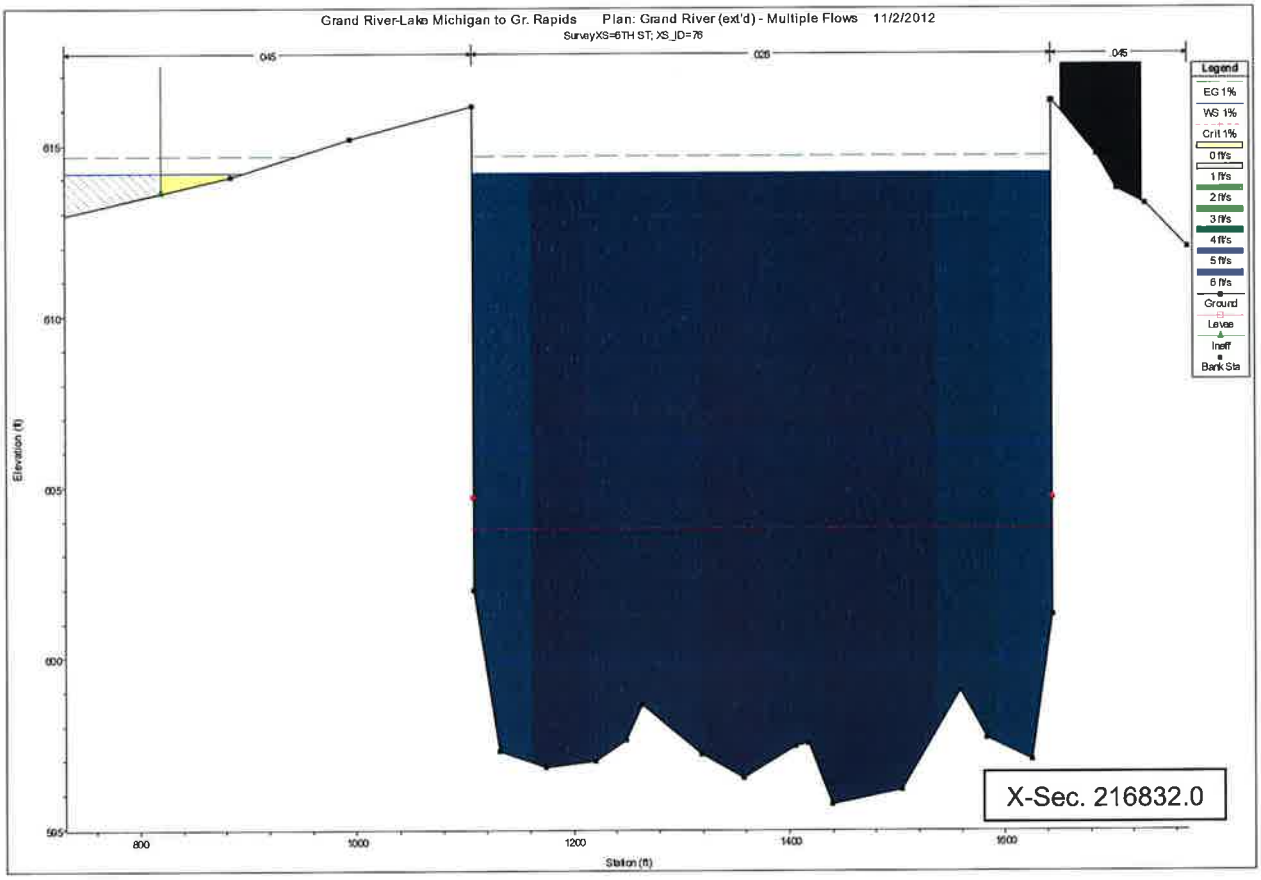

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=24, XS_ID=25
.045
.028
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
595
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 215862.7

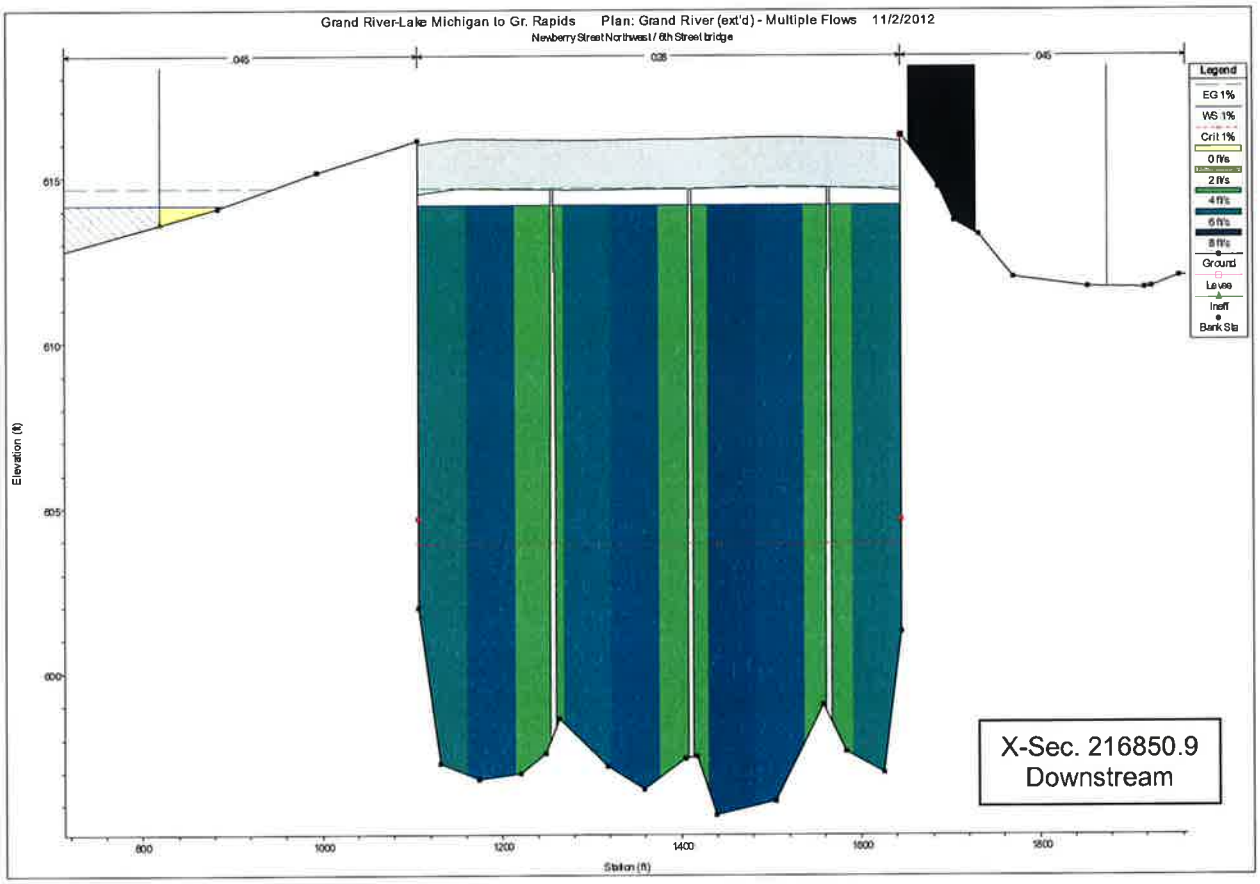

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(D/S of Dam No 5)
.045
.06
.025
.06
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
600
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 216020.2

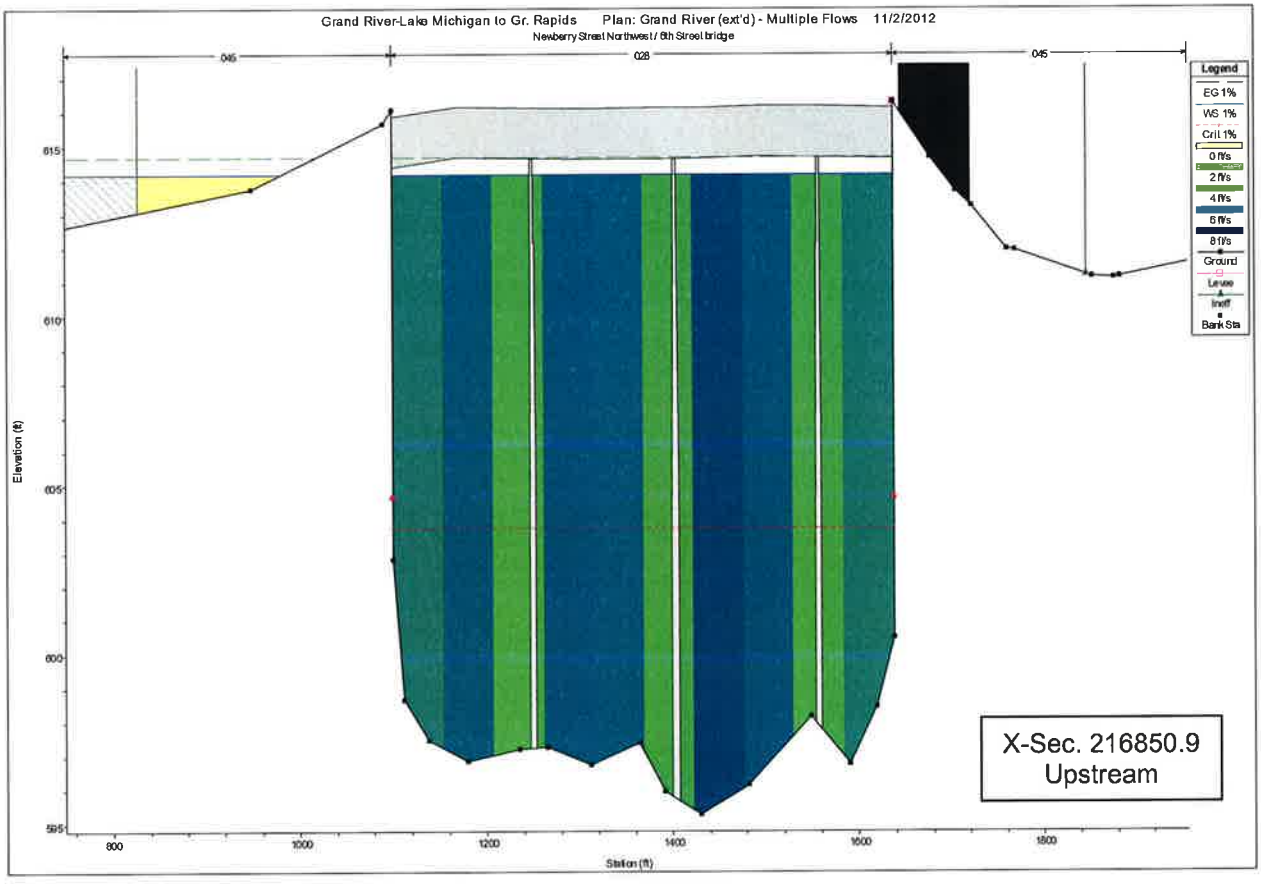

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Dam No. 5 (between 6th St. and I-196 bridges)
045
08
028
08
045
Legend
EG 1%
WS 1%
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
600
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 216028.2

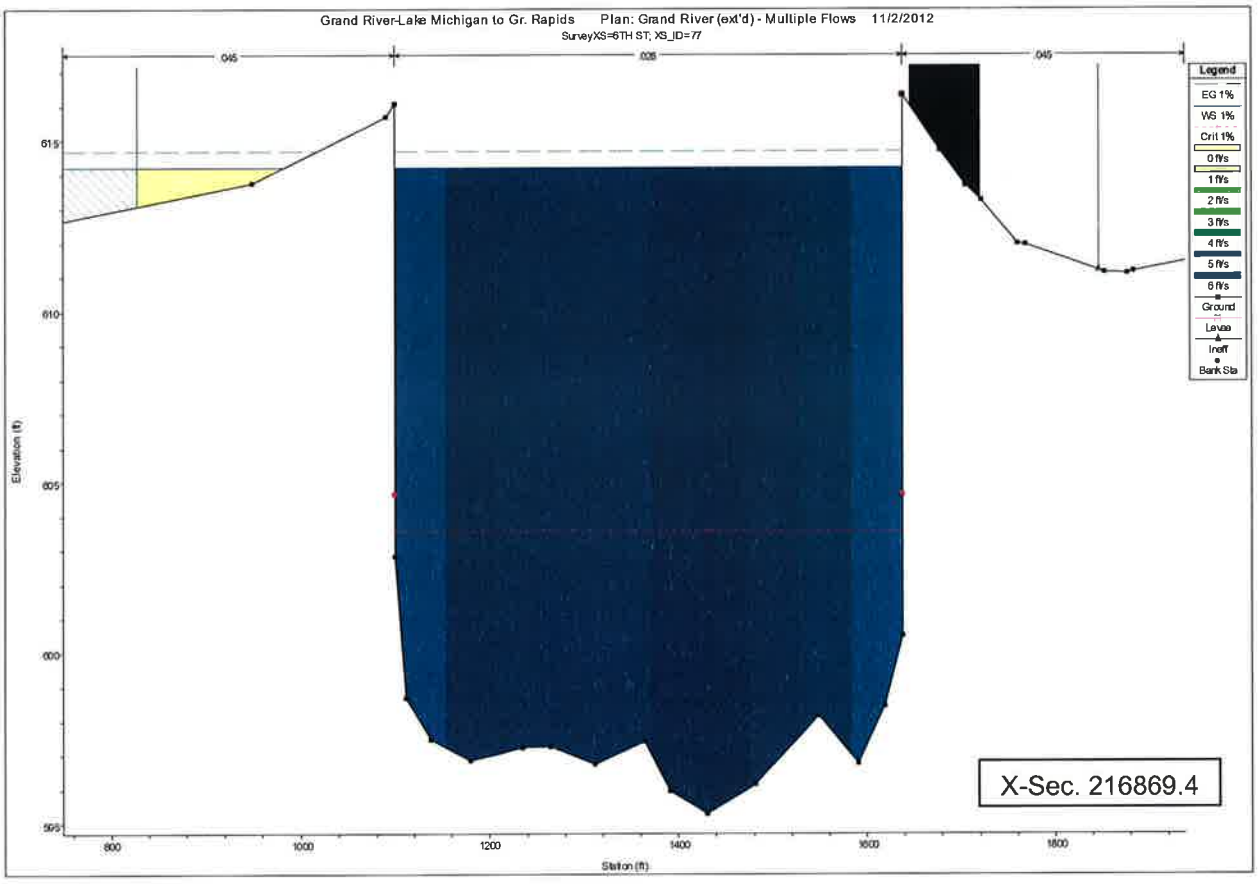

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=D5;XS_ID=101
045
08
028
08
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
600
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 216034.2

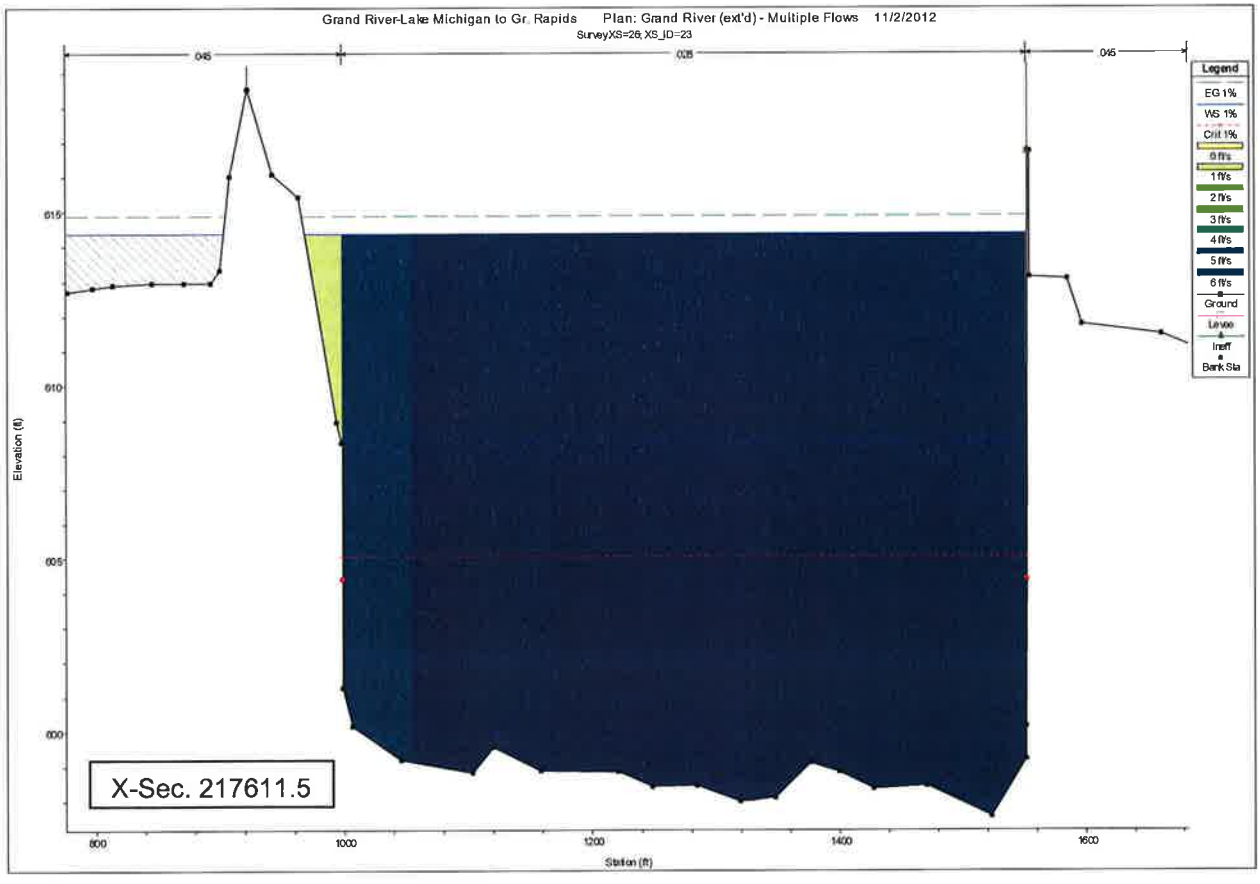

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=25; XS_ID=24
045
026
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
500
1000
1500
2000
Station (ft)
X-Sec. 216378.8

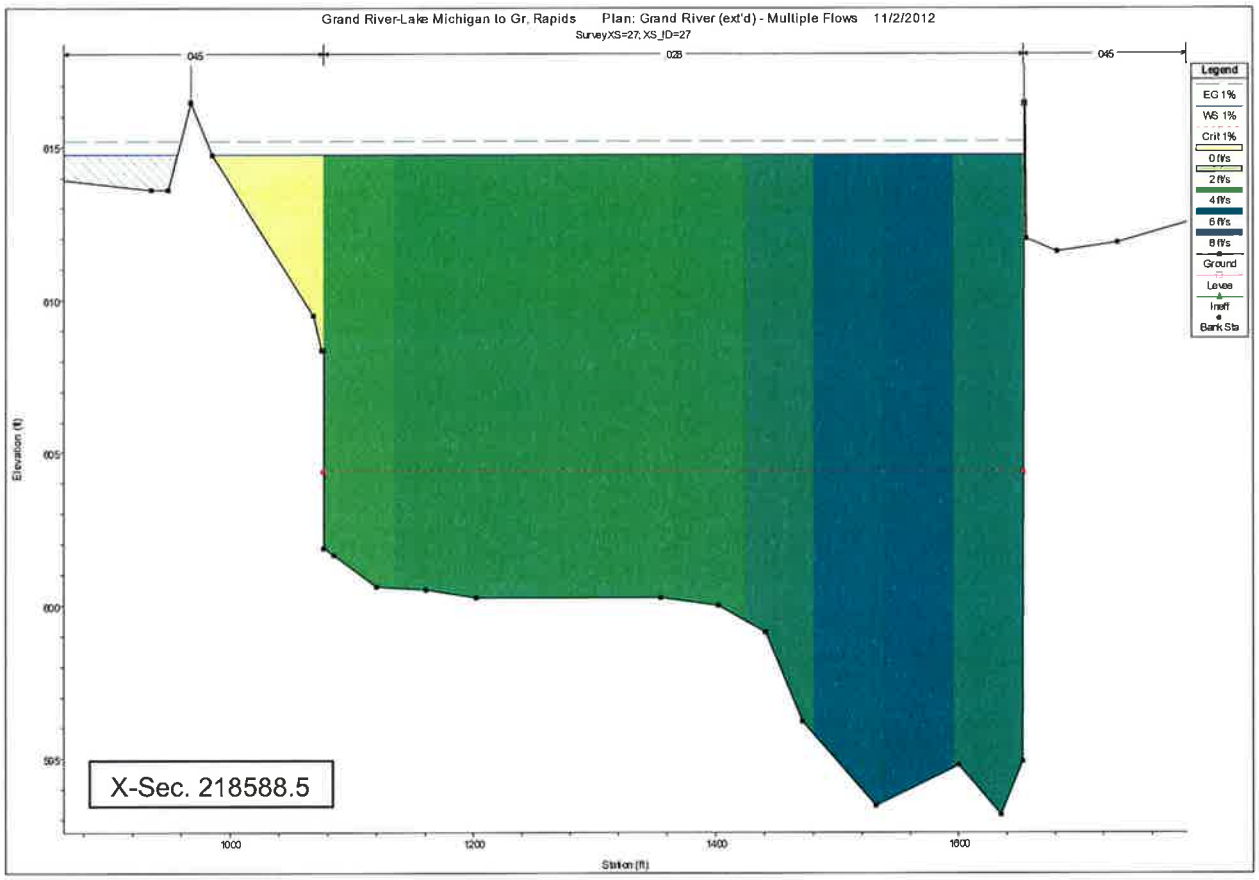

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=6TH ST; XS_ID=76
045
026
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
1000
1200
1400
1600
Station (ft)
X-Sec. 216832.0

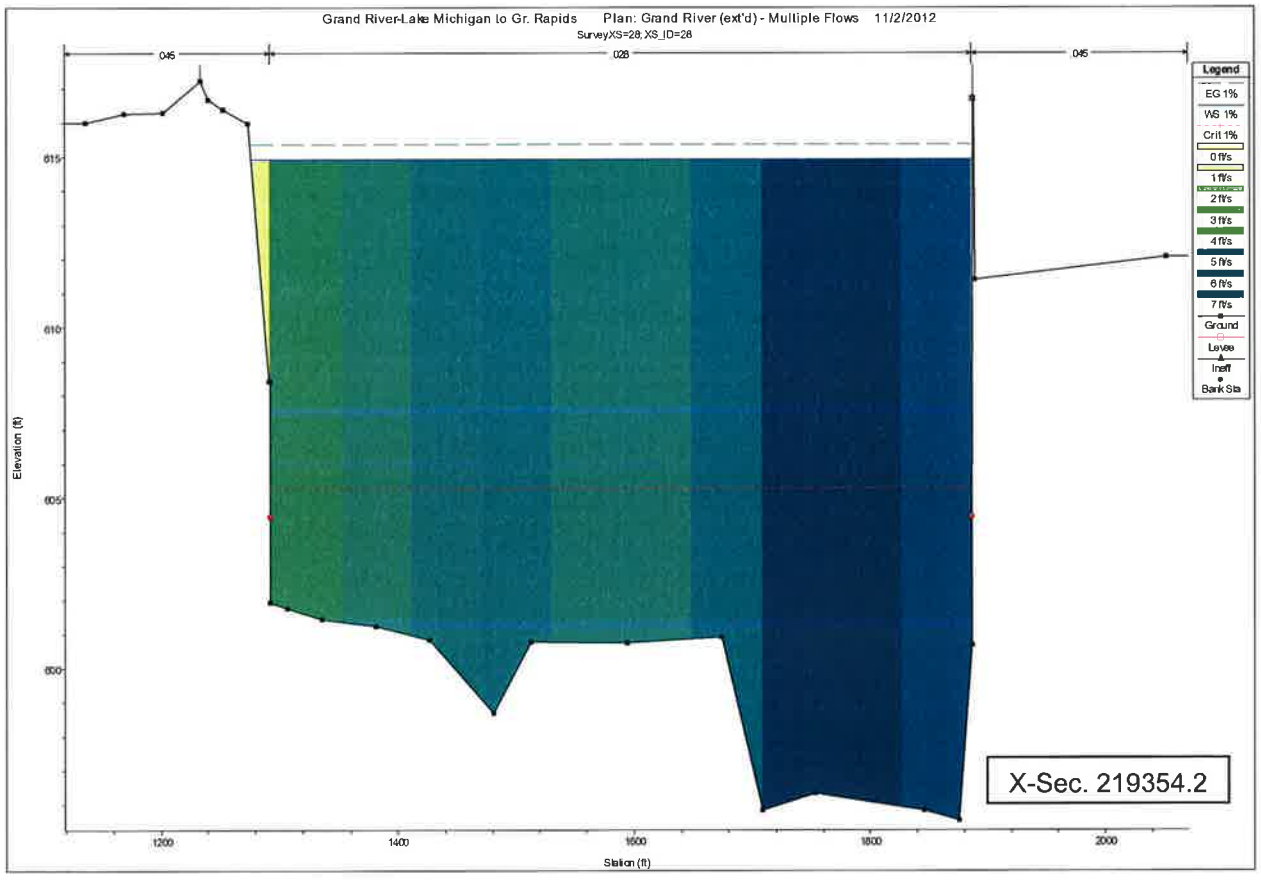

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Newberry Street Northwest / 6th Street bridge
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 216850.9
Downstream

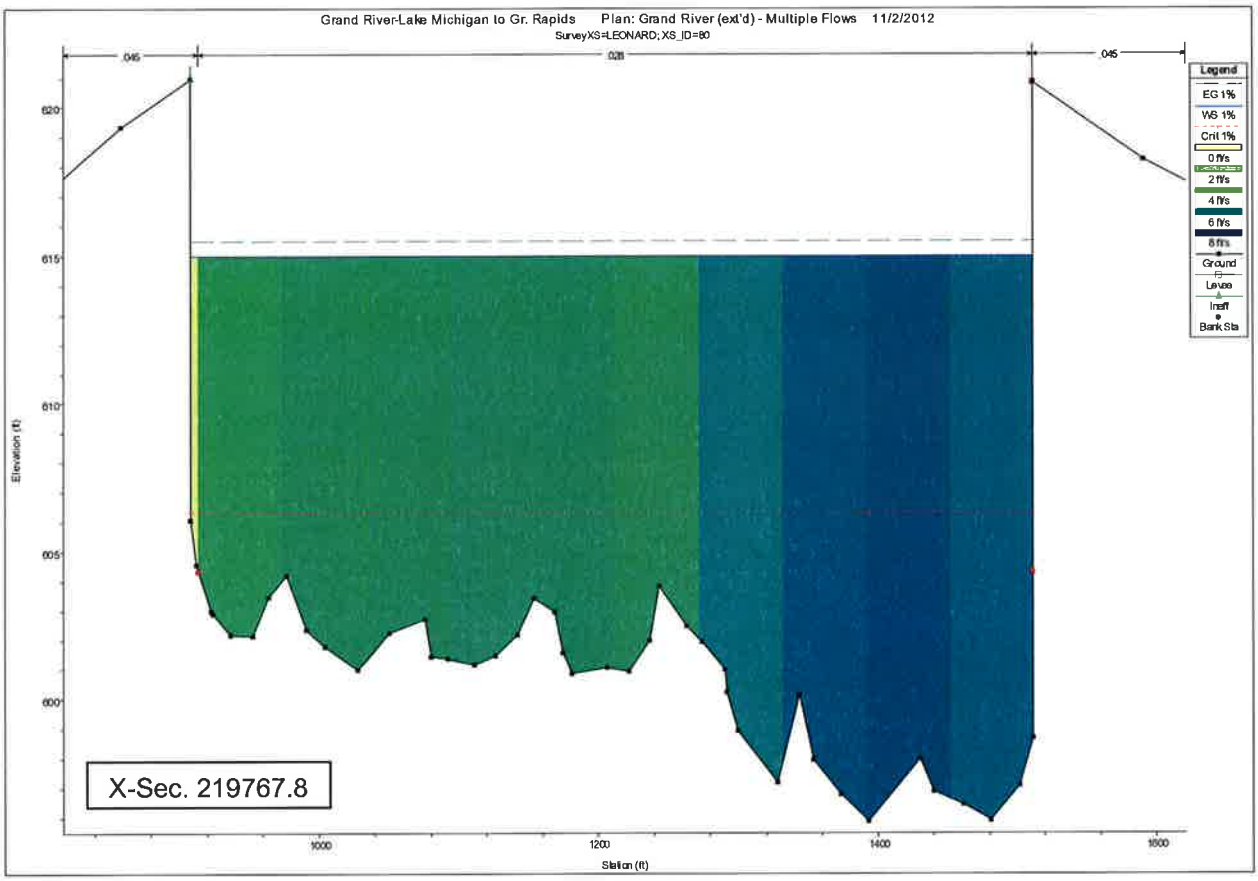

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Newberry Street Northwest / 6th Street bridge
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 216850.9
Upstream

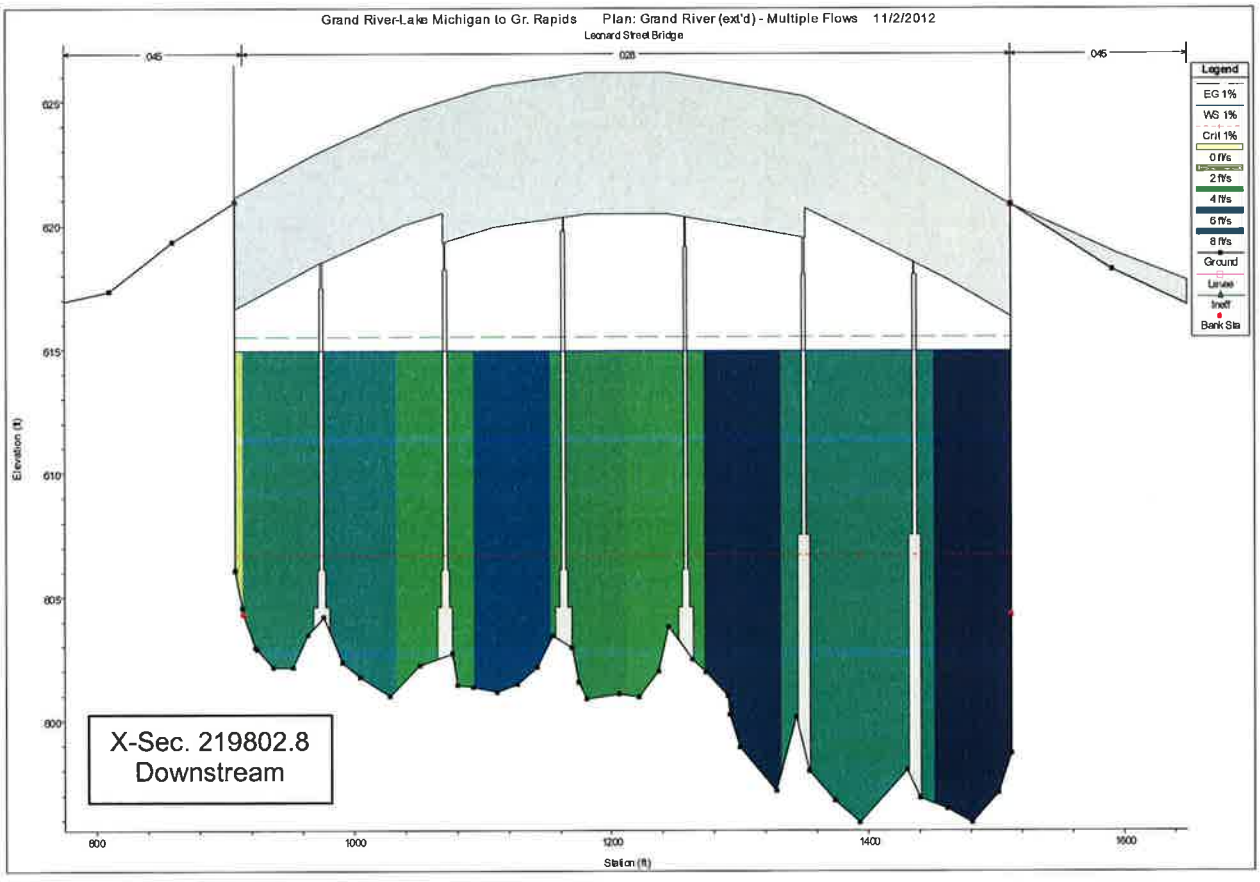

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=6TH ST; XS_ID=77
045
025
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
800
1000
1200
1400
1600
1800
Station (ft)
X-Sec. 216869.4

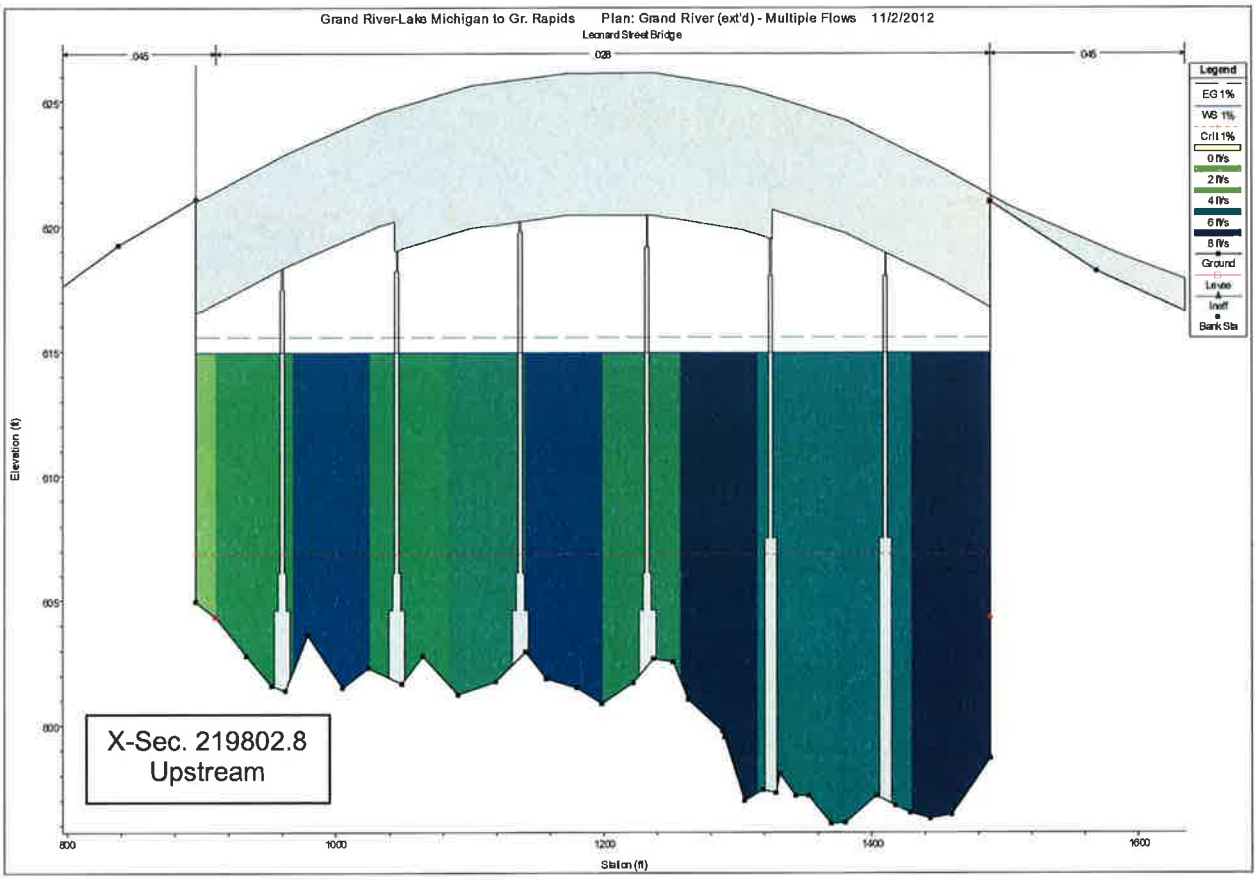

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=26; XS_ID=23
045
025
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 217611.5

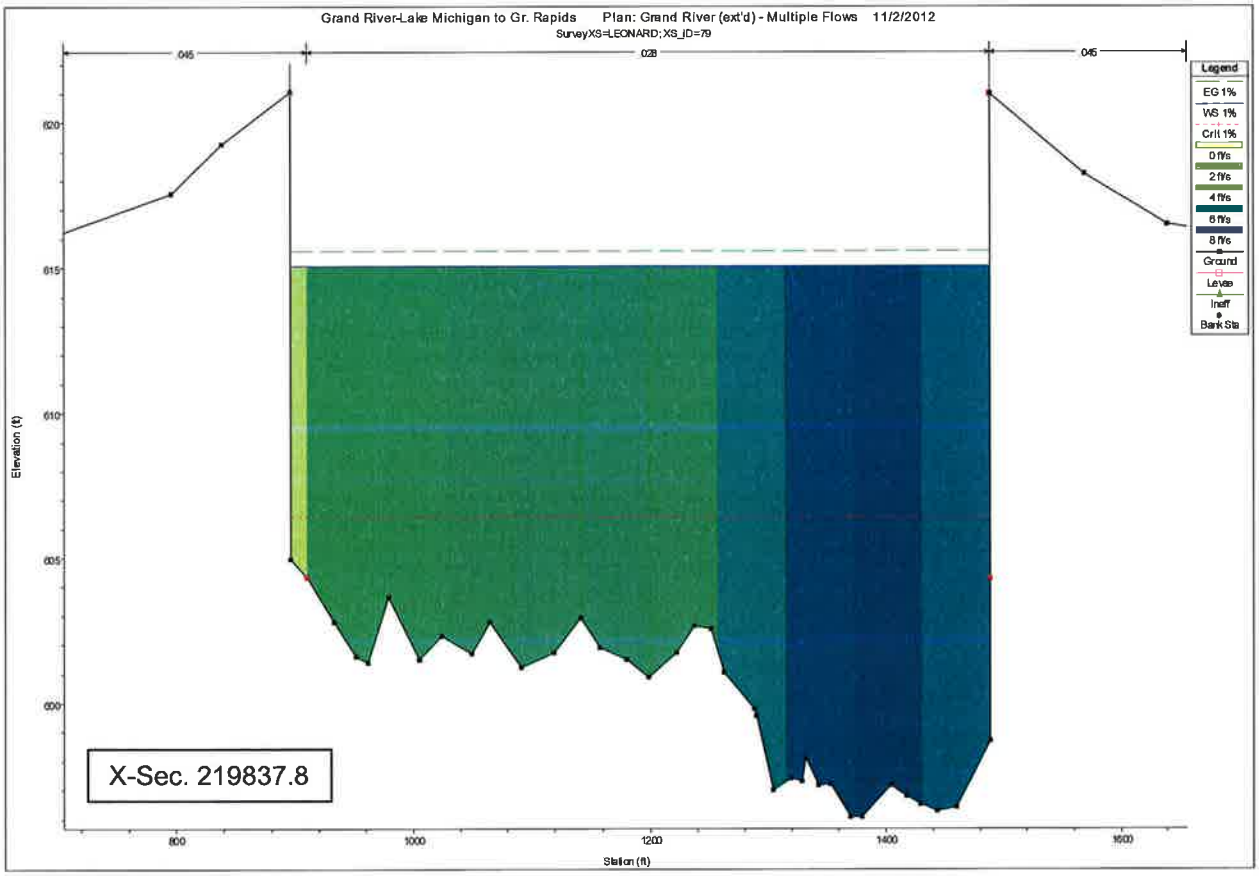

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=27, XS_ID=27
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
X-Sec. 218588.5
1000
1200
1400
1600
Station (ft)

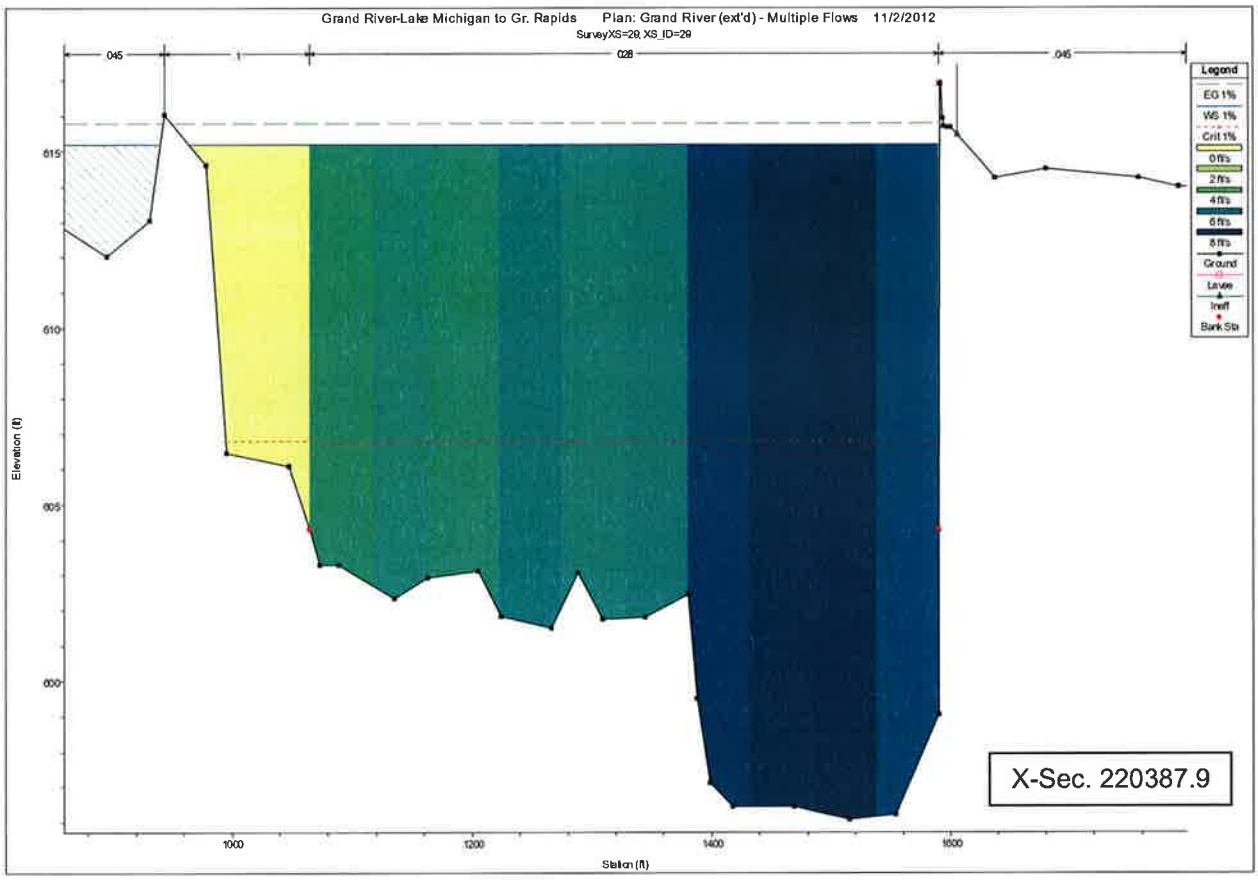

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=28, XS_ID=28
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
X-Sec. 219354.2
1200
1400
1600
1800
2000
Station (ft)

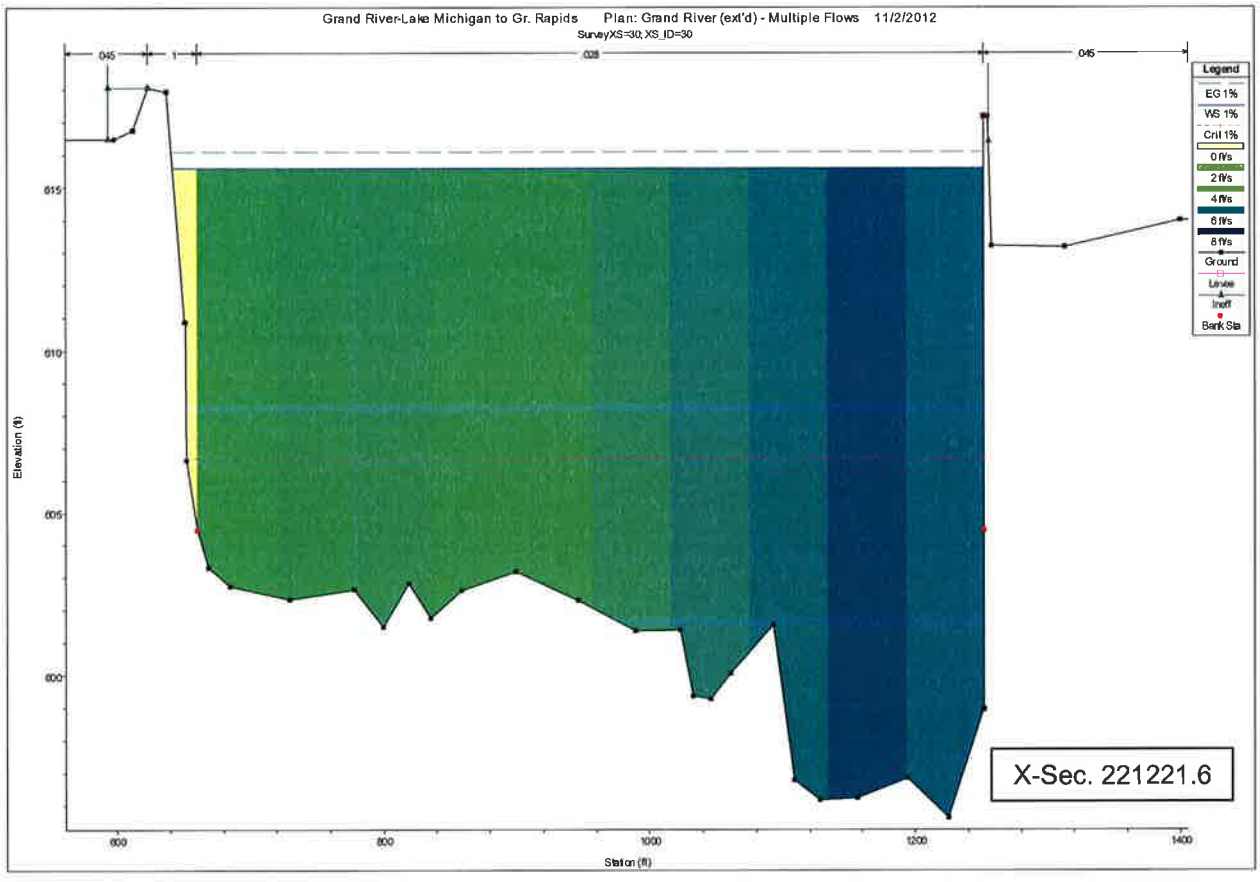

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=LEONARD; XS_ID=80
045
025
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
1000
1200
1400
1600
Station (ft)
X-Sec. 219767.8

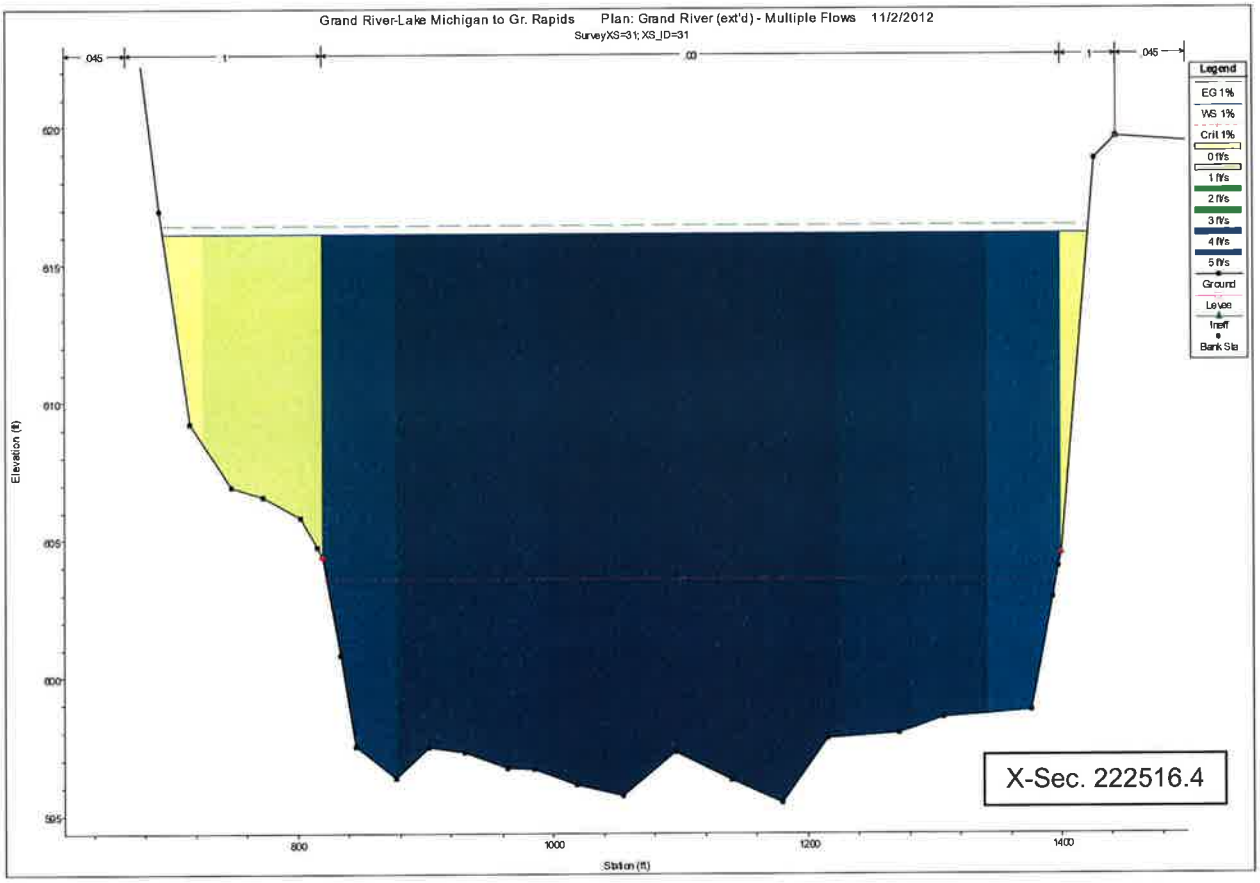

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Leonard Street Bridge
045
025
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 219802.8
Downstream

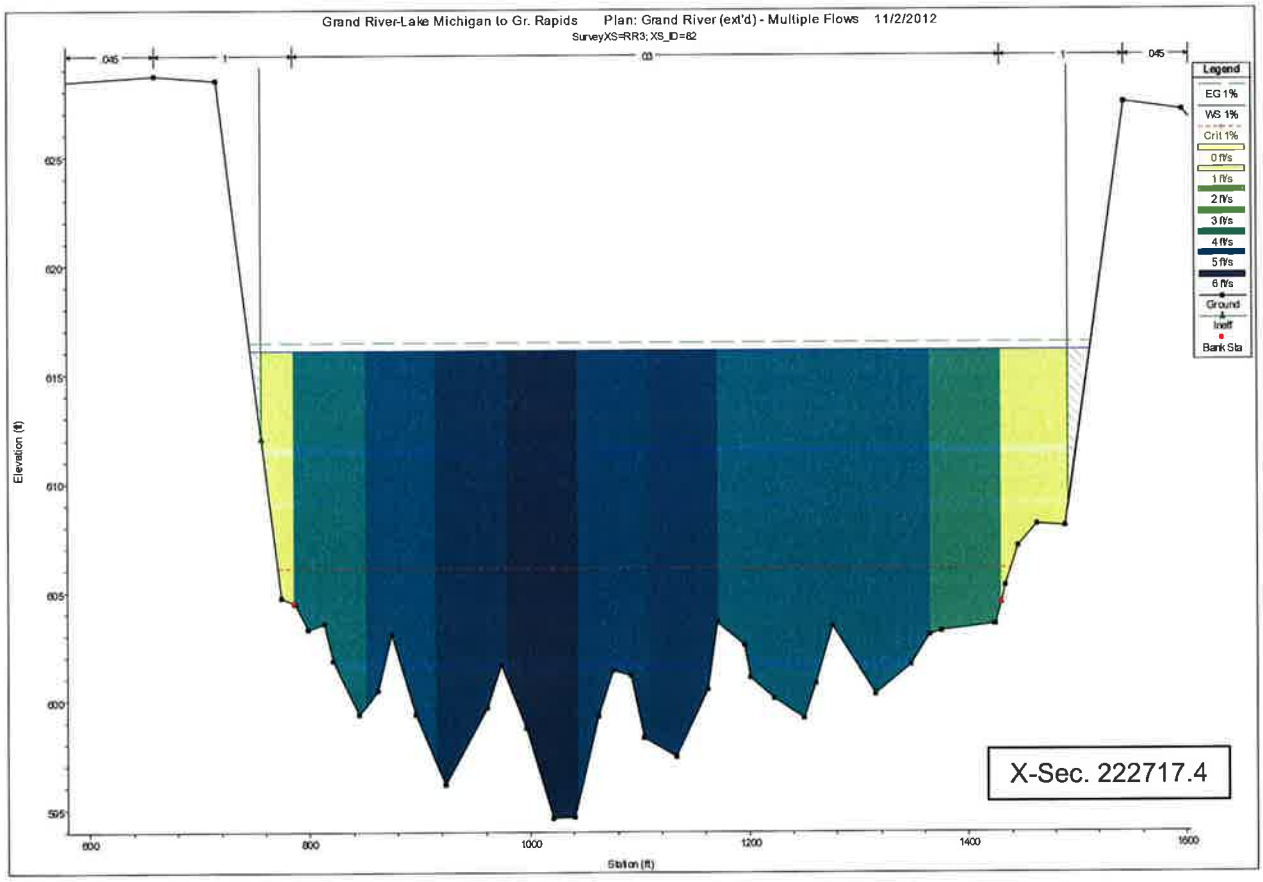

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Leonard Street Bridge
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 219802.8
Upstream

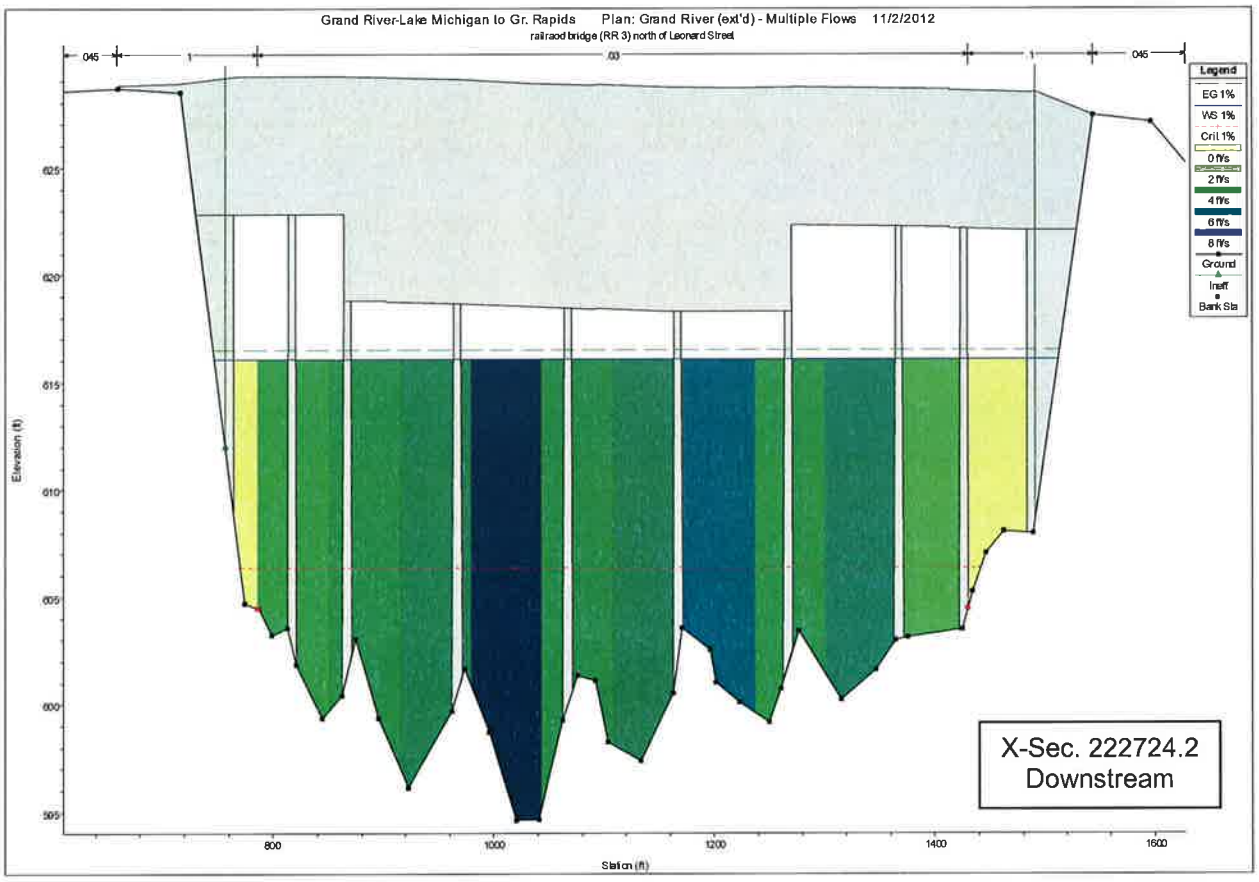

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=LEONARD;XS_ID=79
045
028
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 219837.8

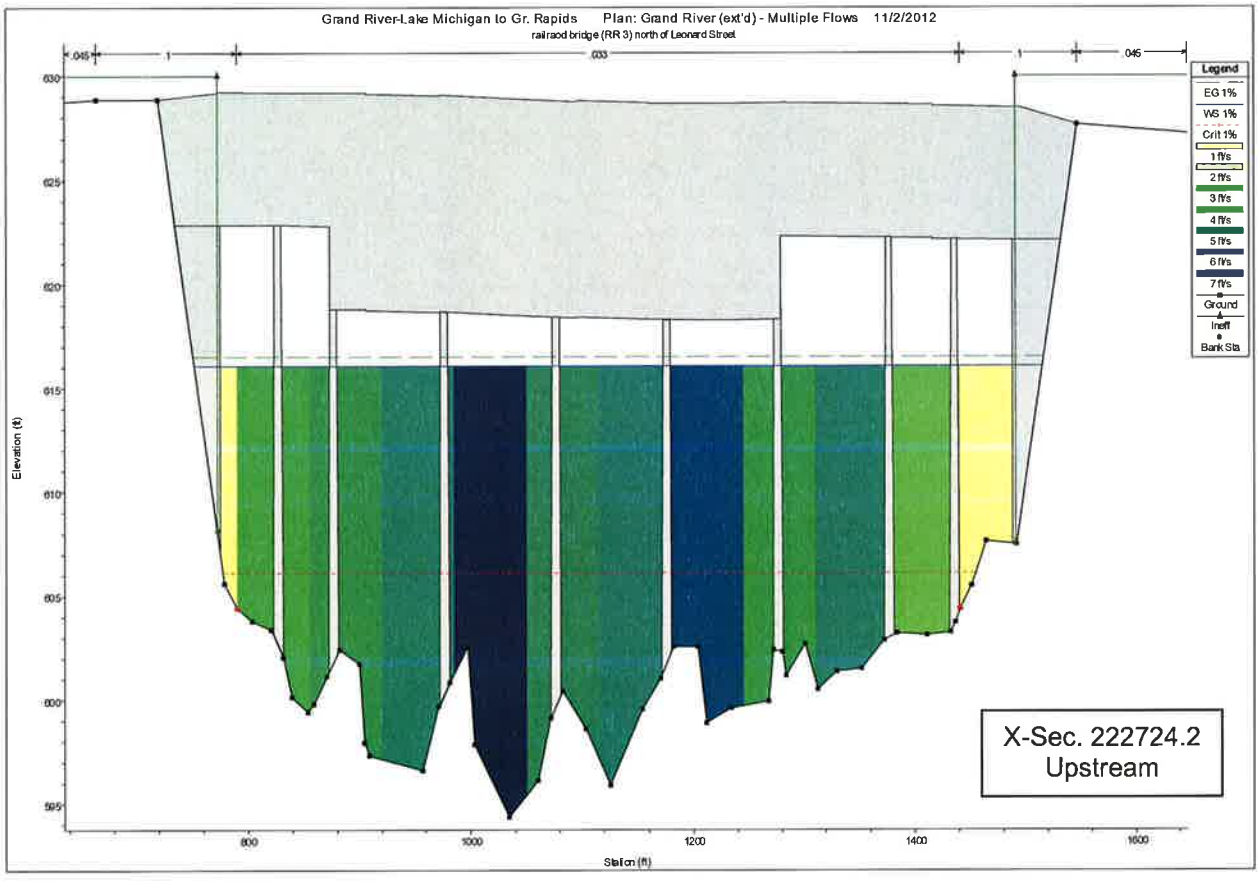

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=29, XS_ID=29
.045
1
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
1000
1200
1400
1600
Station (ft)
X-Sec. 220387.9

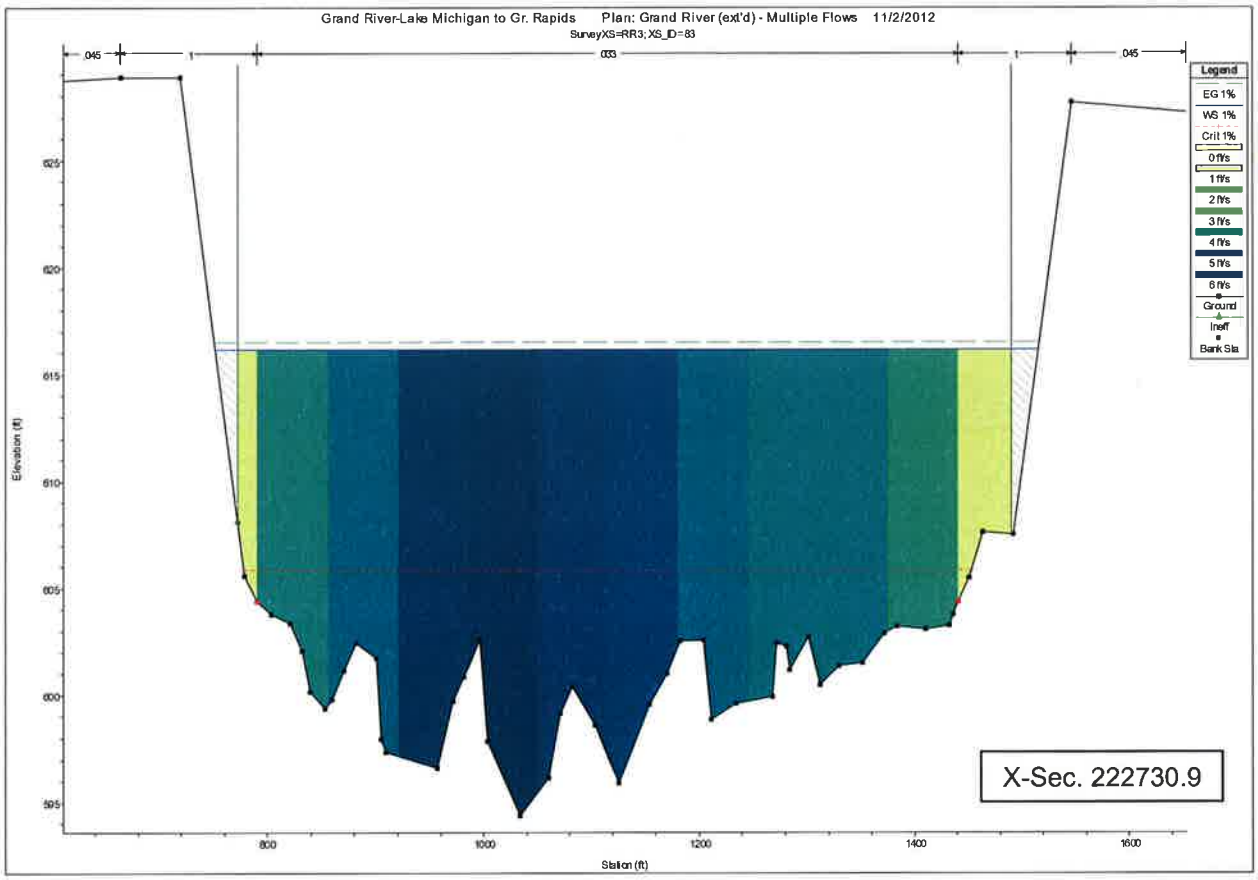

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=30, XS_ID=30
.045
1
.028
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
600
800
1000
1200
1400
Station (ft)
X-Sec. 221221.6

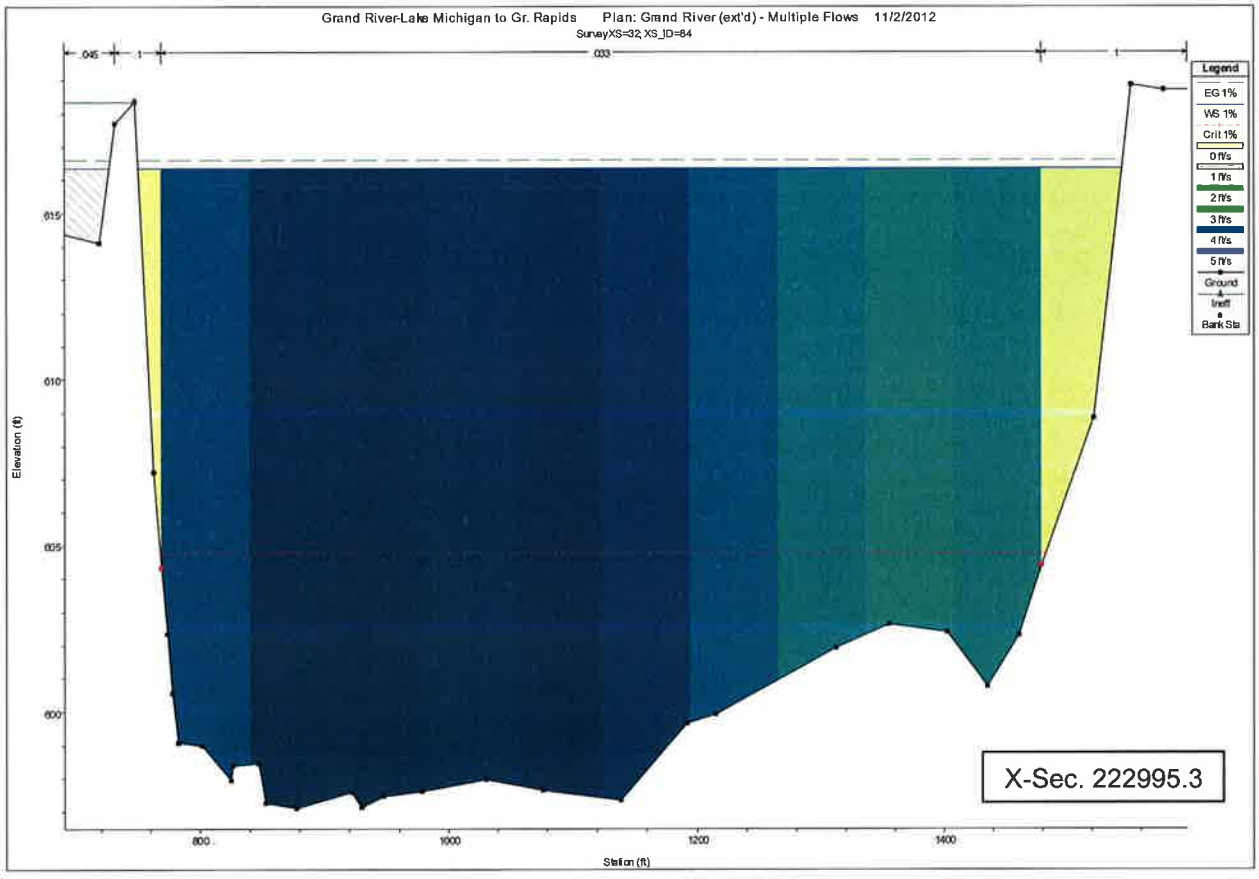

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=31; XS_ID=31
045
00
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
595
800
1000
1200
1400
Station (ft)
X-Sec. 222516.4

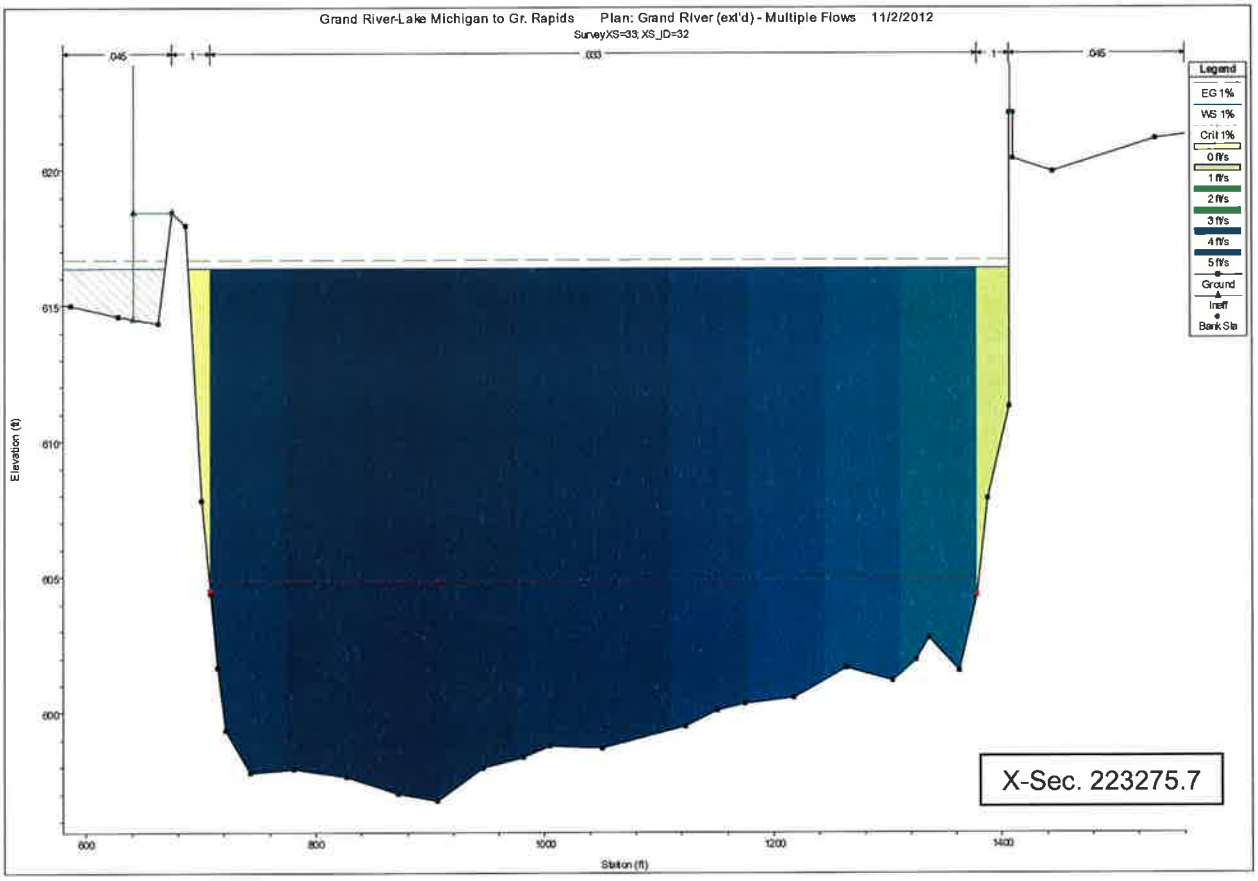

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=RR3; XS_ID=82
045
00
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
595
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 222717.4

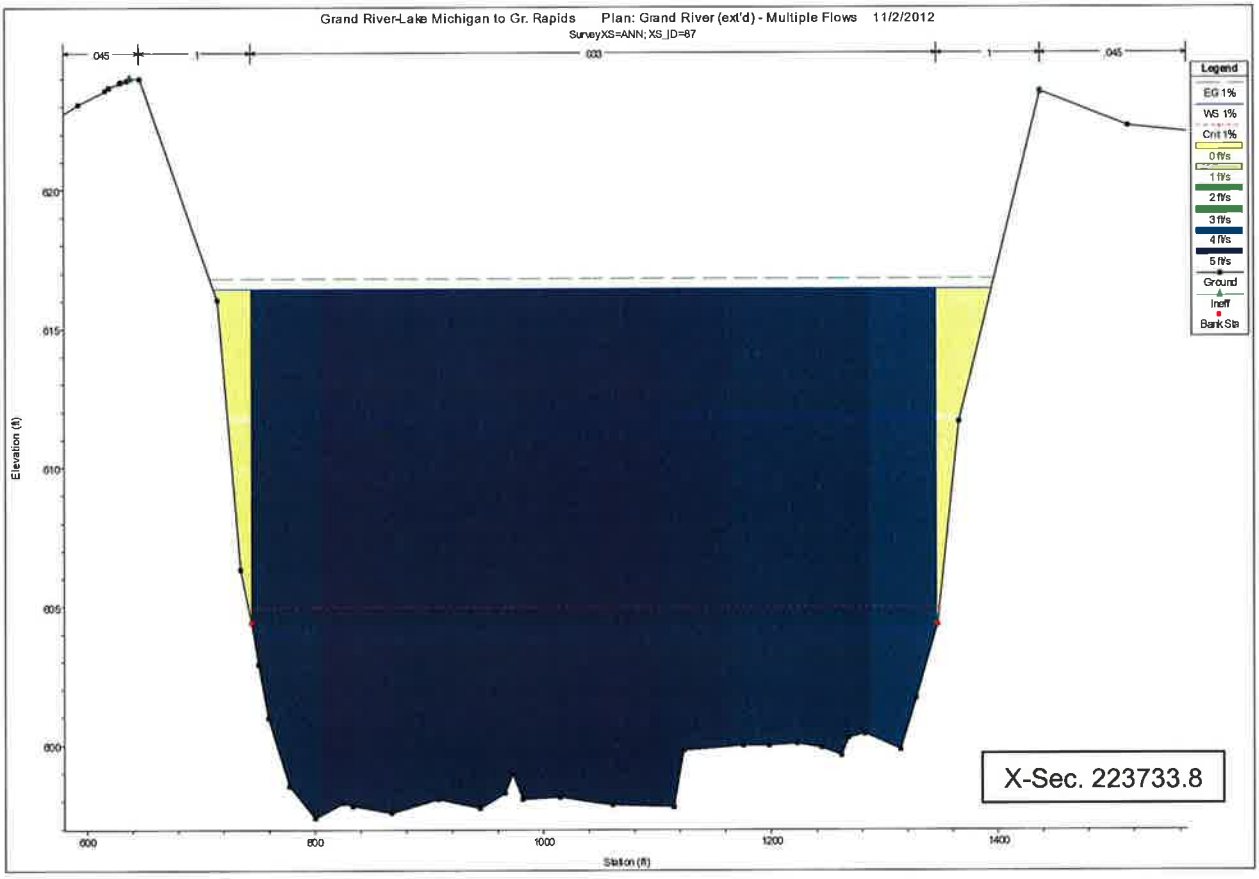

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
railraod bridge (RR 3) north of Leonard Street
.045
.03
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
595
800
1000
1200
1400
1600
Station (ft)
X-Sec. 222724.2
Downstream

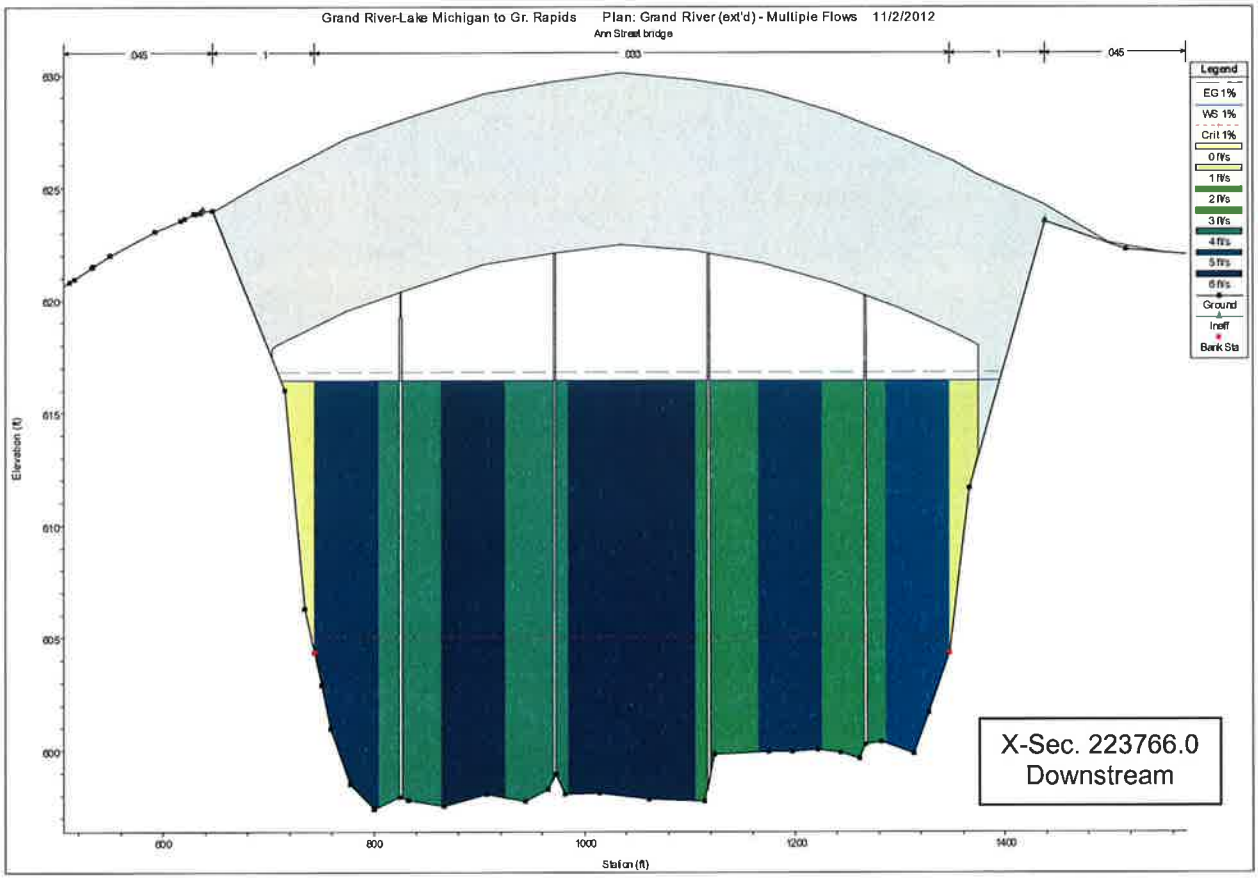

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
railraod bridge (RR 3) north of Leonard Street
.045
.03
.045
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
625
620
615
610
605
600
595
800
1000
1200
1400
1600
Station (ft)
X-Sec. 222724.2
Upstream

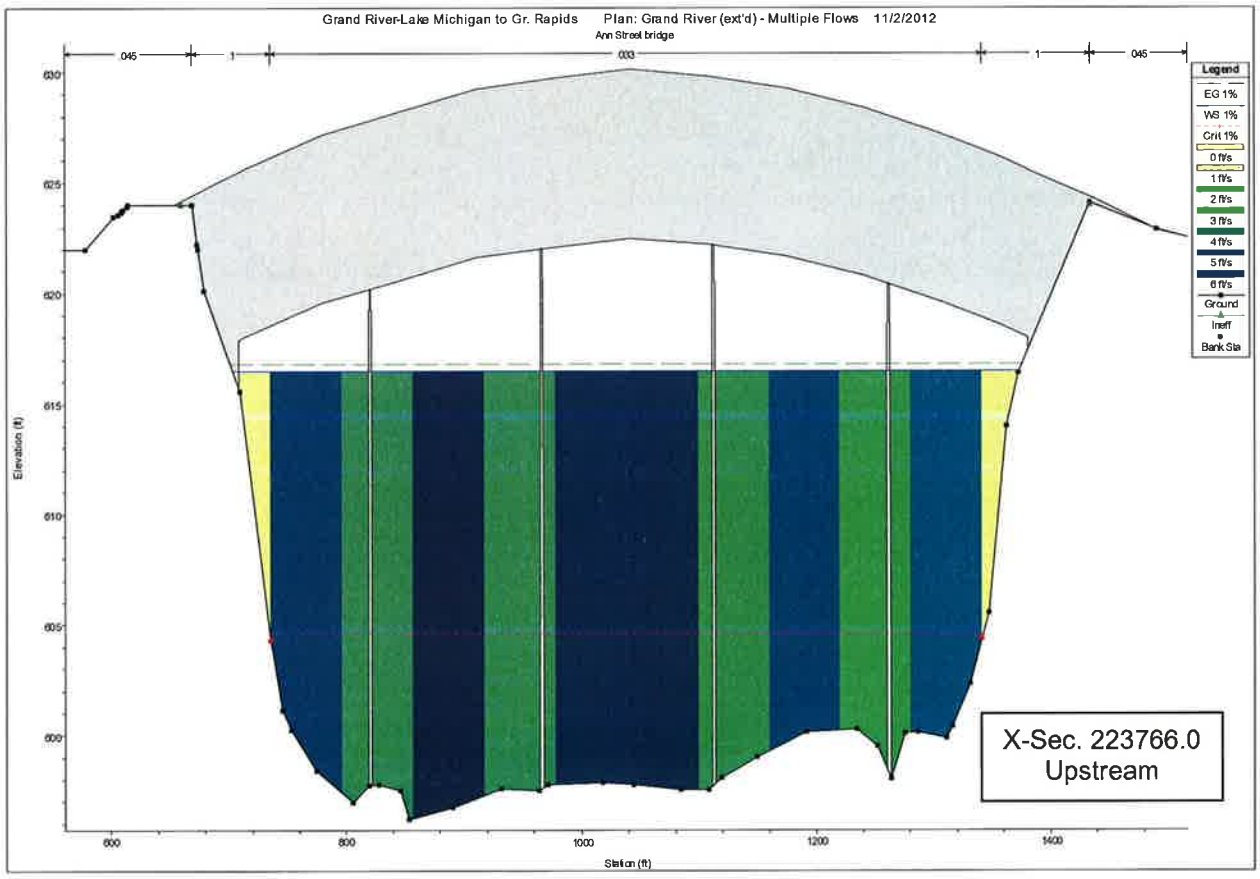

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=RR3; XS_ID=83
.045
.033
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
595
800
1000
1200
1400
1600
Station (ft)
X-Sec. 222730.9

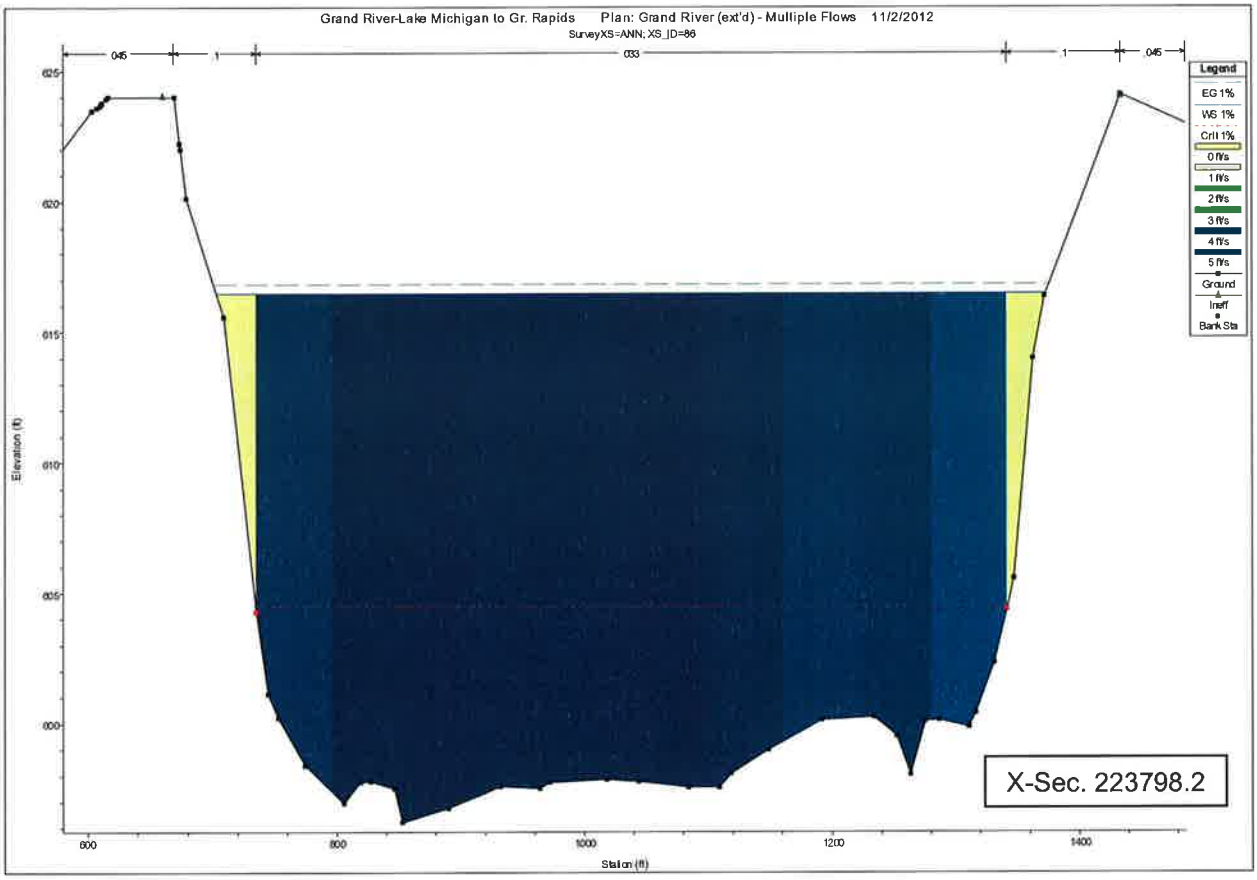

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=32; XS_ID=84
.045
.033
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
800
1000
1200
1400
Station (ft)
X-Sec. 222995.3

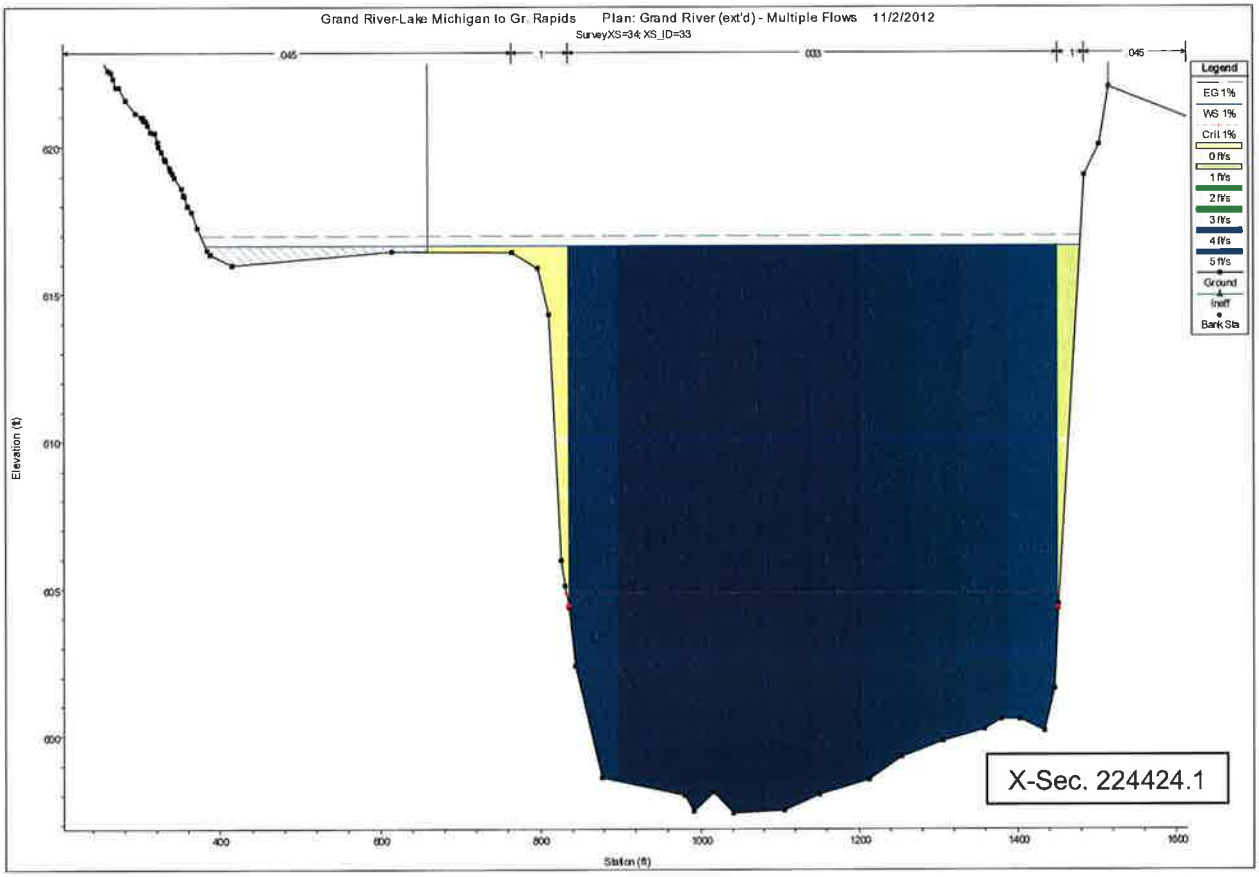

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=33; XS_ID=32
.045
.033
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
600
800
1000
1200
1400
Station (ft)
X-Sec. 223275.7

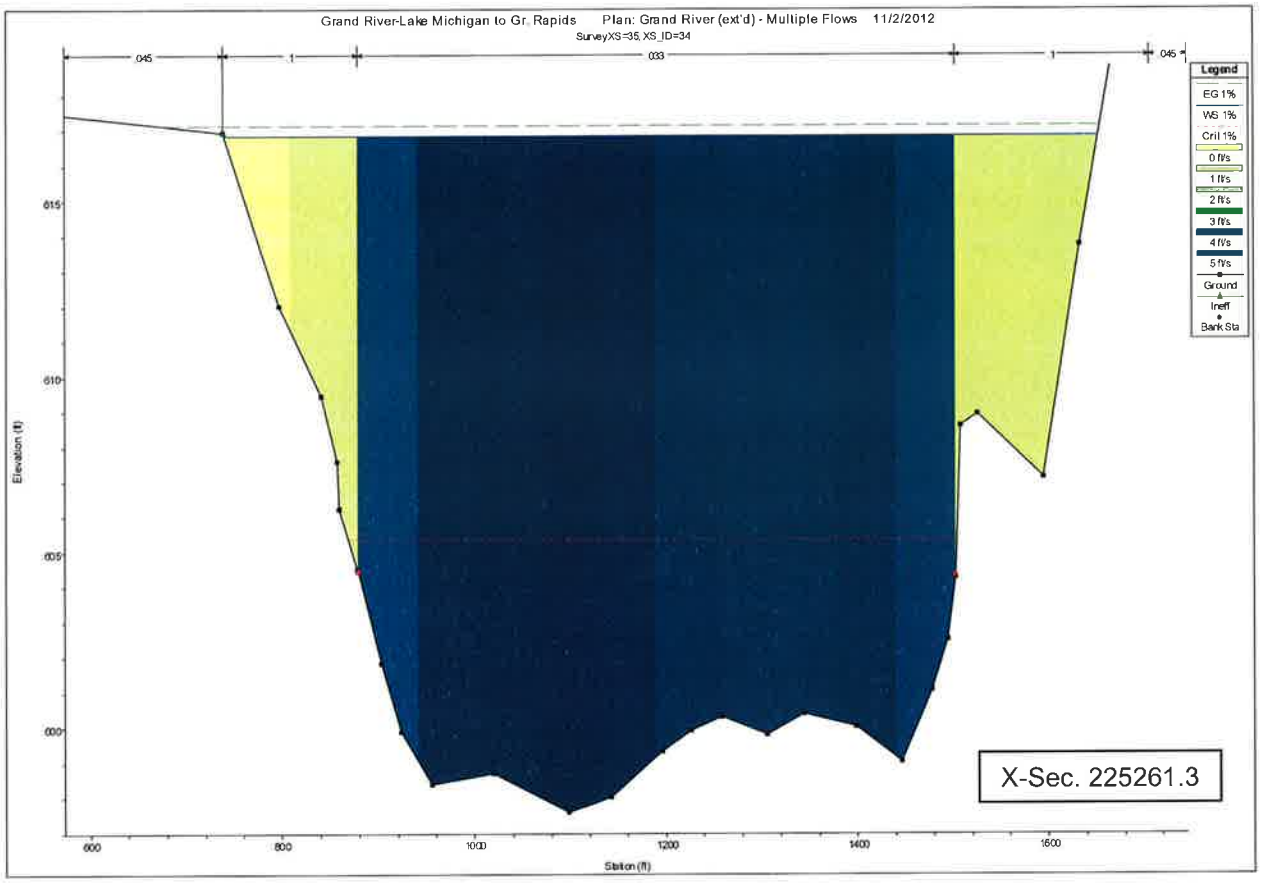

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=ANN; XS_ID=87
.045
.033
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
600
800
1000
1200
1400
Station (ft)
X-Sec. 223733.8

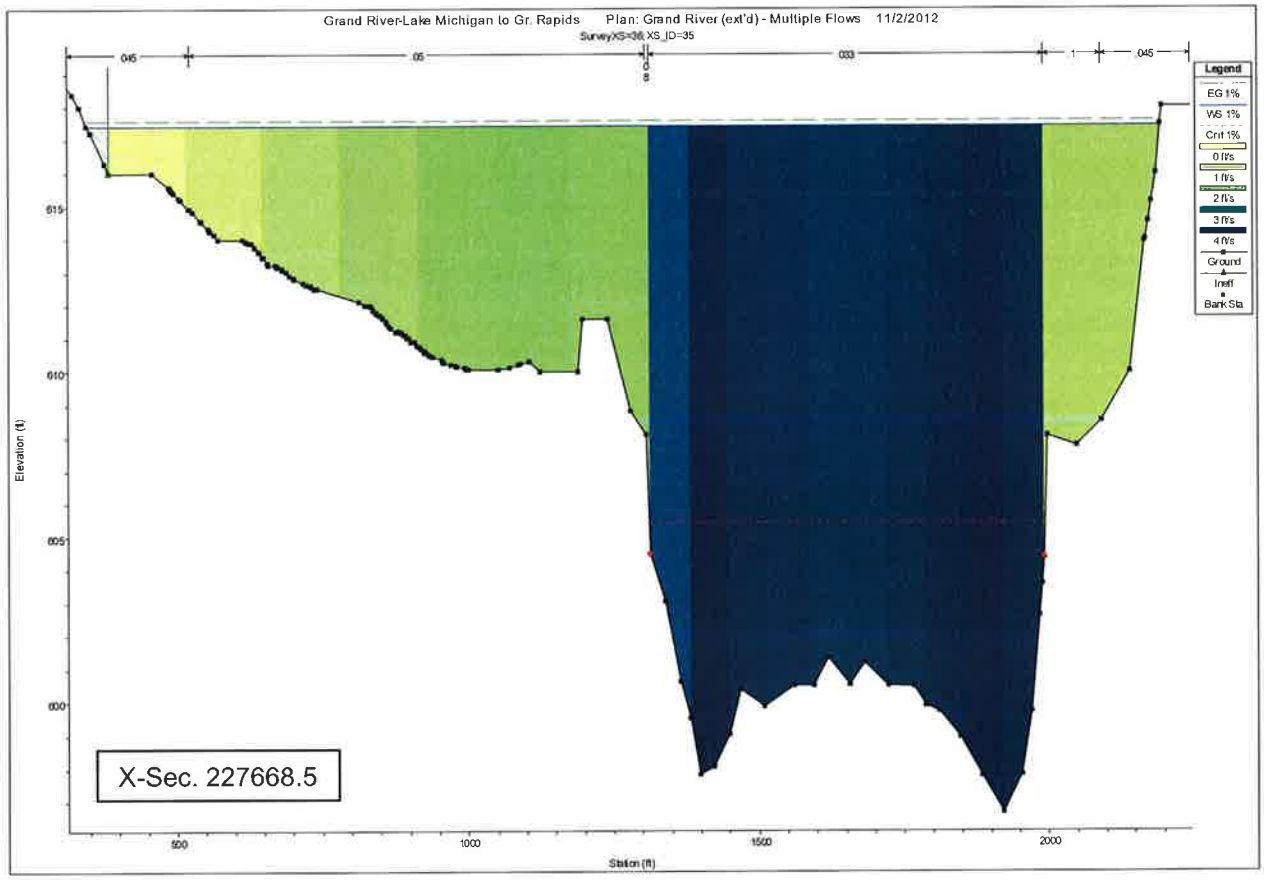

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Ann Street bridge
045
003
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
625
620
615
610
605
600
600
800
1000
1200
1400
Station (ft)
X-Sec. 223766.0
Downstream

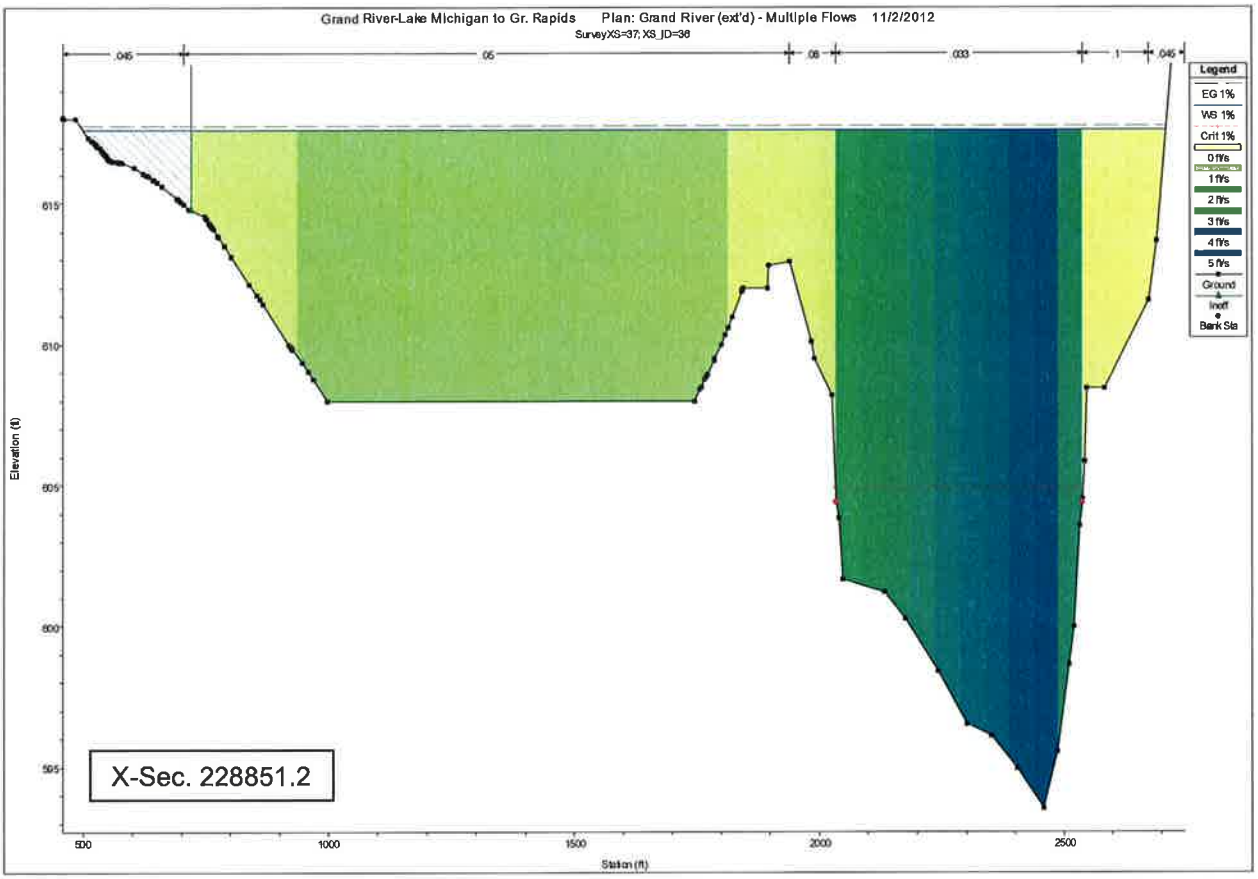

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
Ann Street bridge
045
003
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
625
620
615
610
605
600
600
800
1000
1200
1400
Station (ft)
X-Sec. 223766.0
Upstream

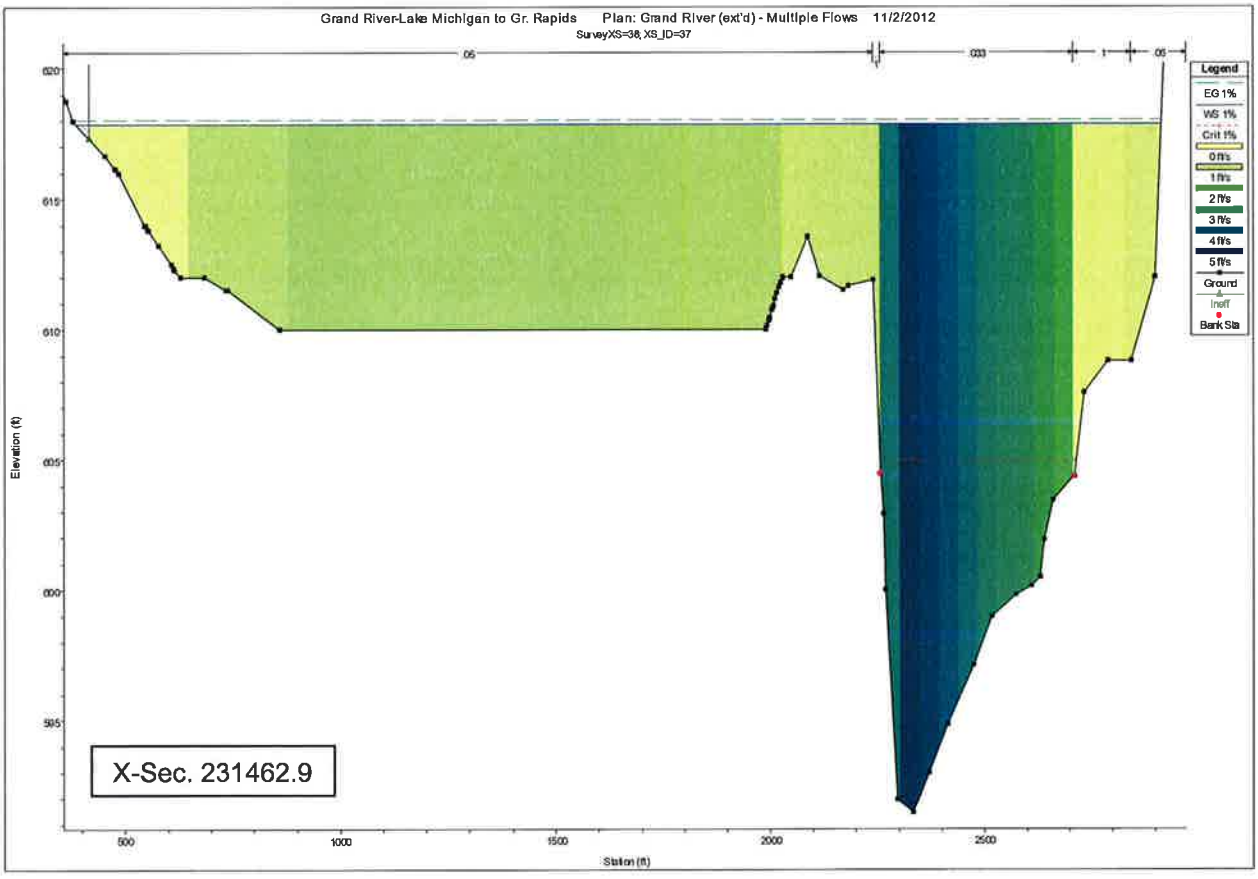

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=ANN; XS_ID=86
045
033
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
625
620
615
610
605
600
600
800
1000
1200
1400
Station (ft)
X-Sec. 223798.2

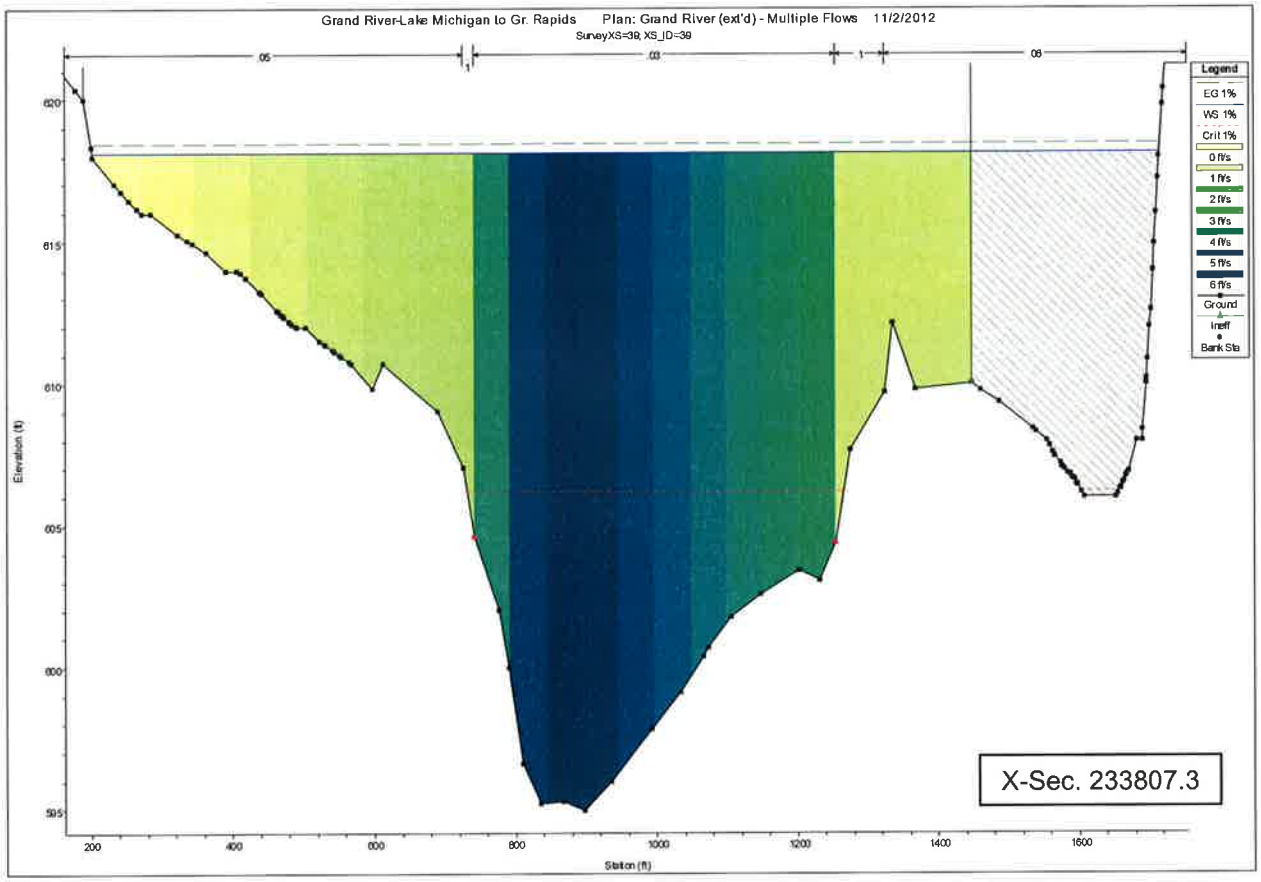

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=34; XS_ID=33
045
033
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
400
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 224424.1

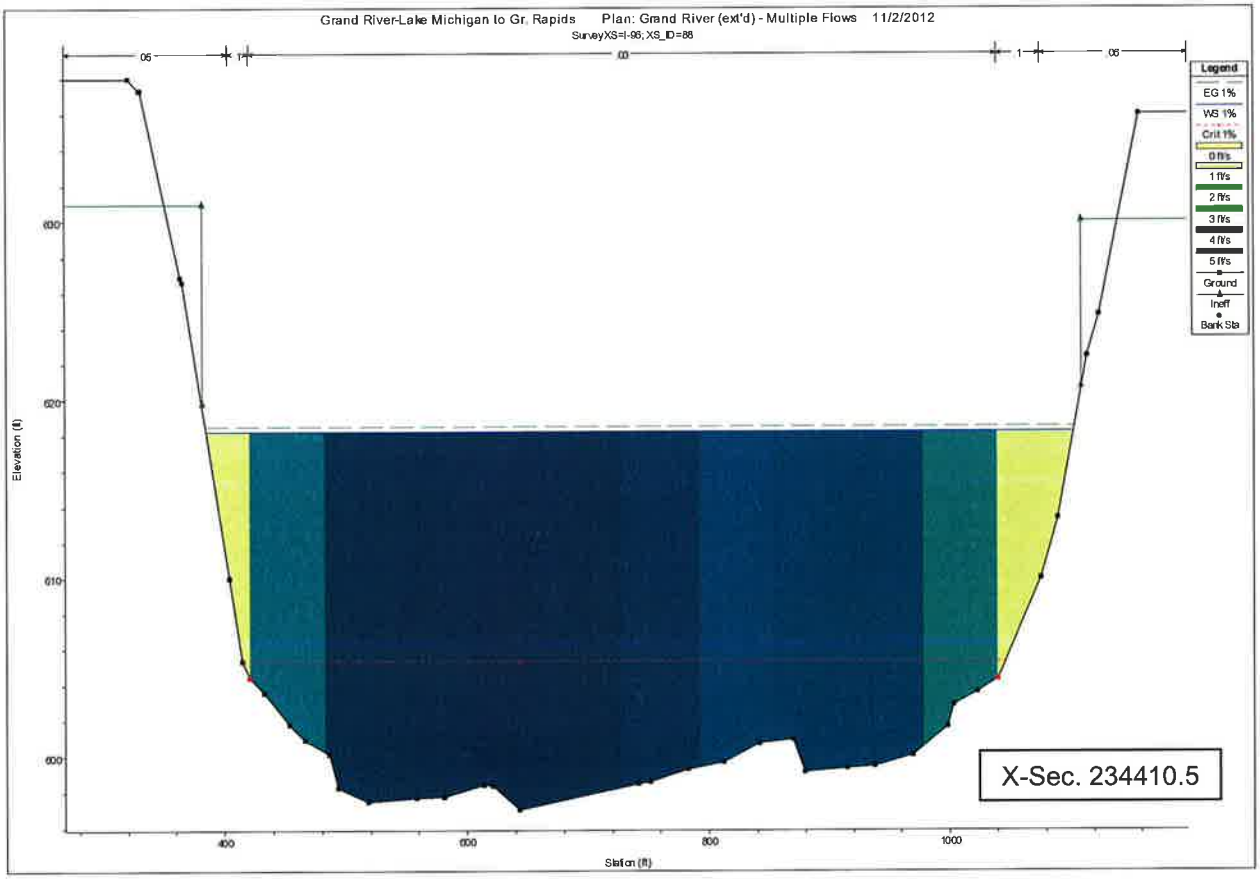

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=35, XS_ID=34
045
033
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
600
800
1000
1200
1400
1600
Station (ft)
X-Sec. 225261.3

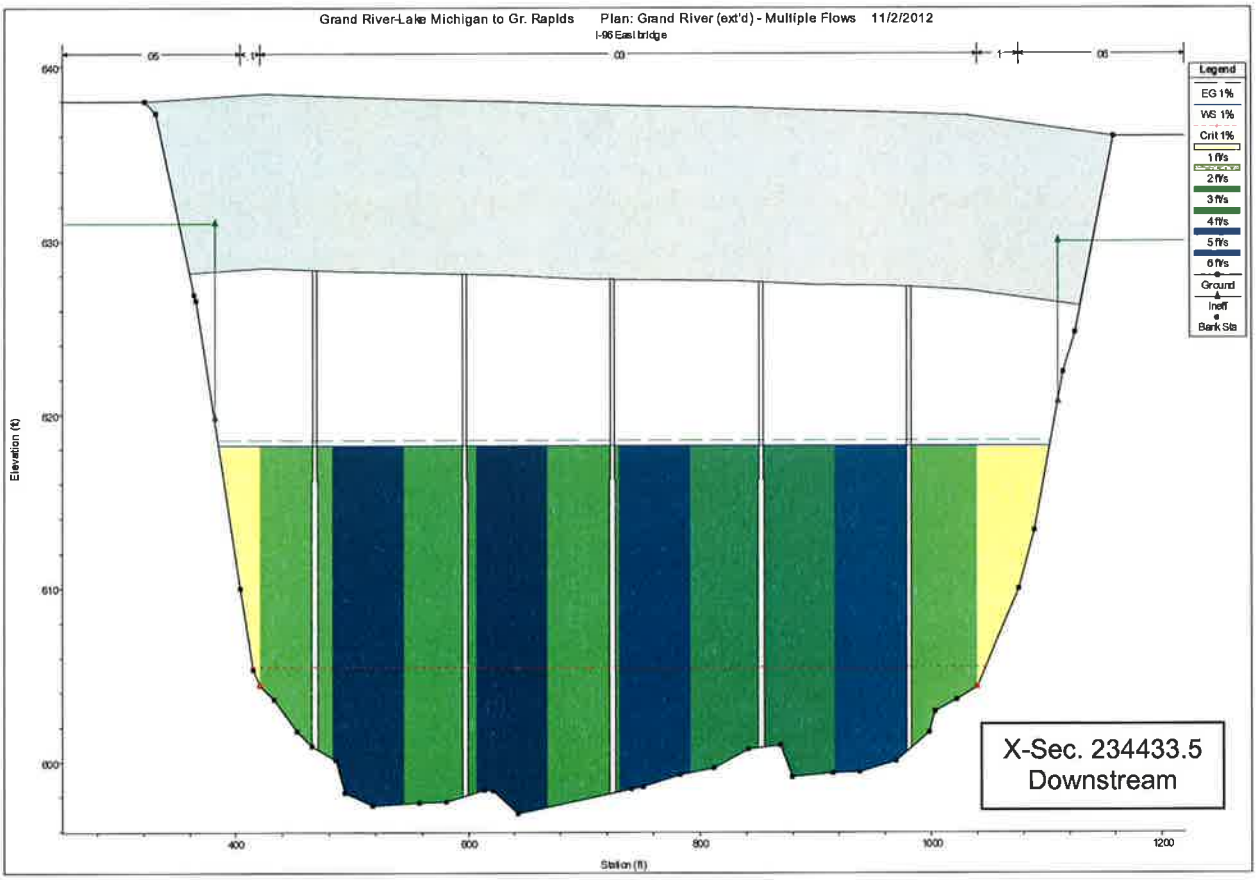

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=36, XS_ID=35
045
05
033
045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
500
1000
1500
2000
Station (ft)
X-Sec. 227668.5

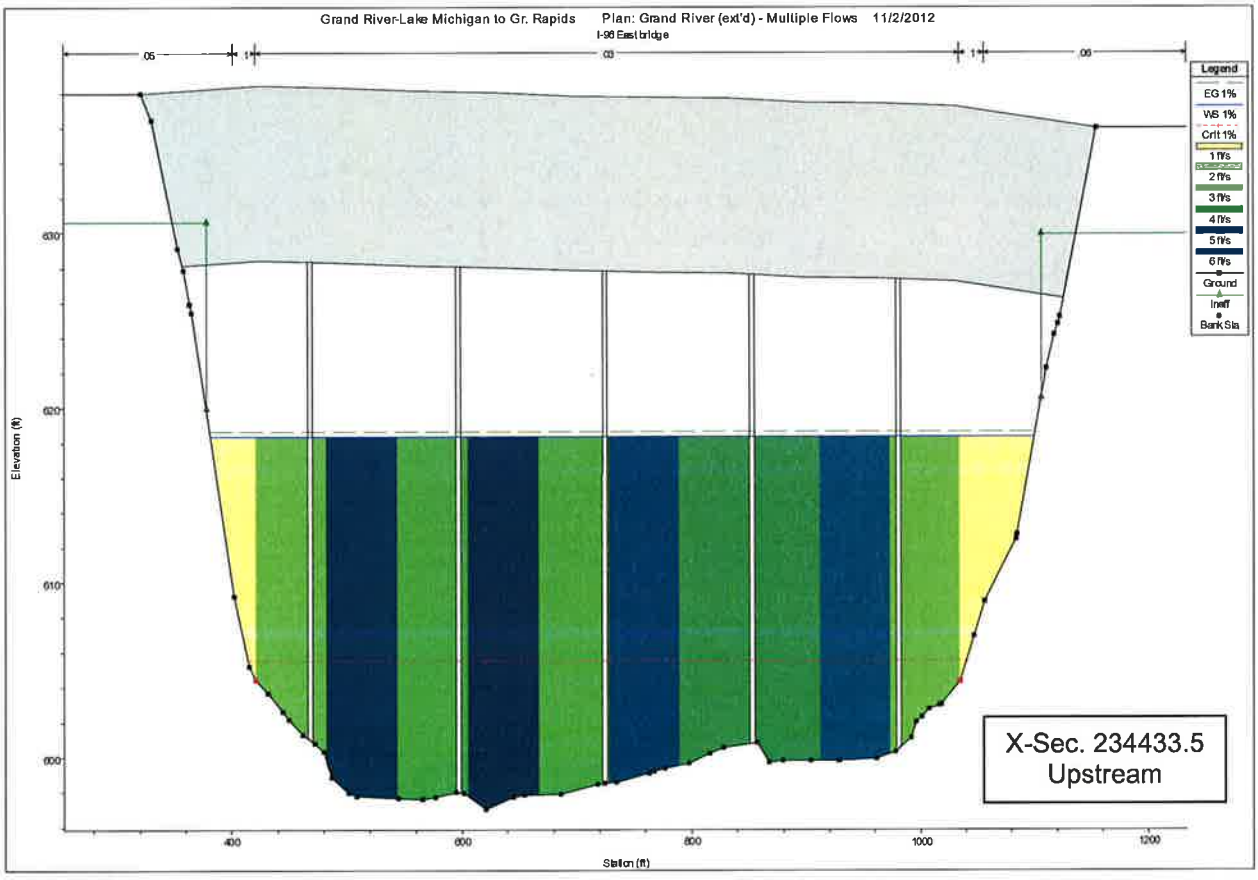

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=37, XS_ID=36
.045
.05
.08
.033
.045
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
615
610
605
600
595
500
1000
1500
2000
2500
Station (ft)
X-Sec. 228851.2

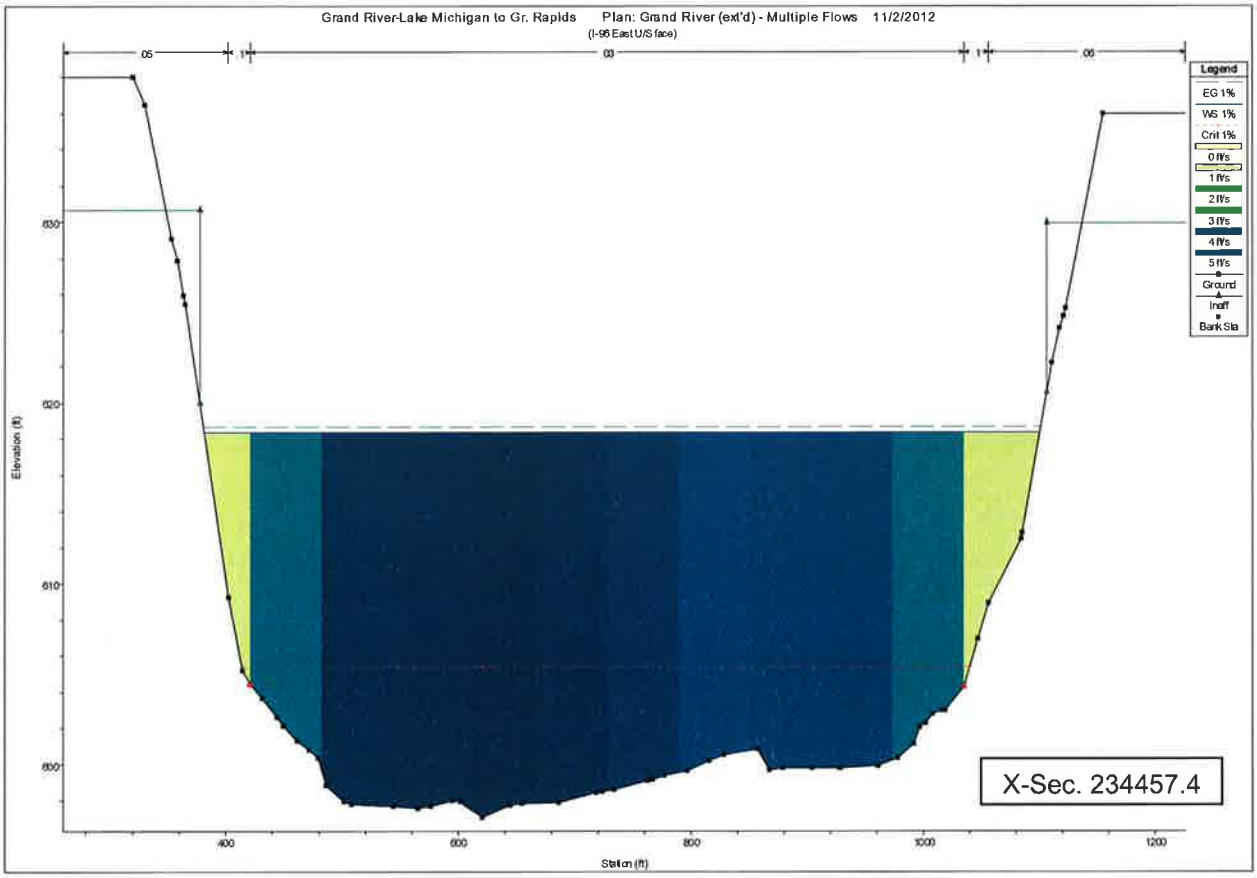

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=38, XS_ID=37
.05
.033
.05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
595
500
1000
1500
2000
2500
Station (ft)
X-Sec. 231462.9

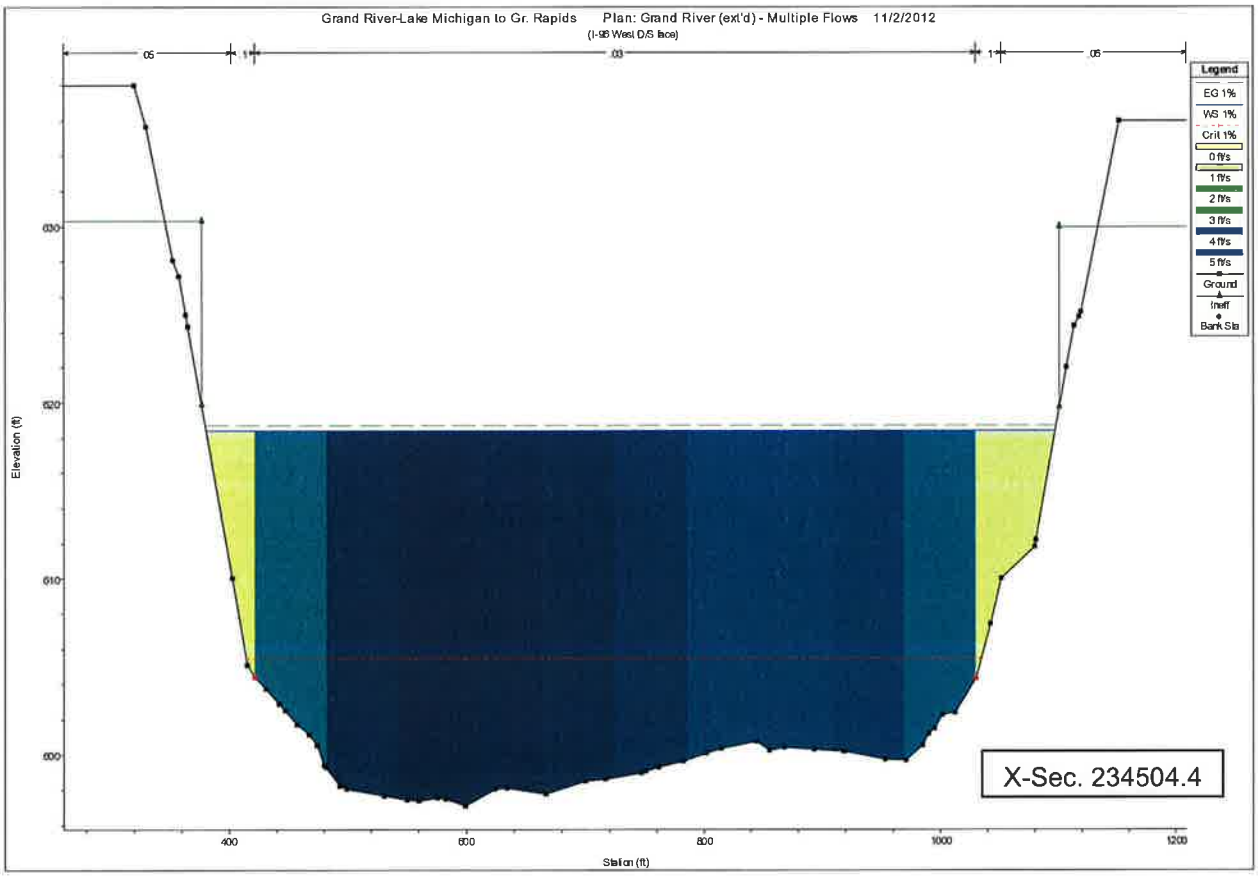

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=39; XS_ID=39
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 233807.3

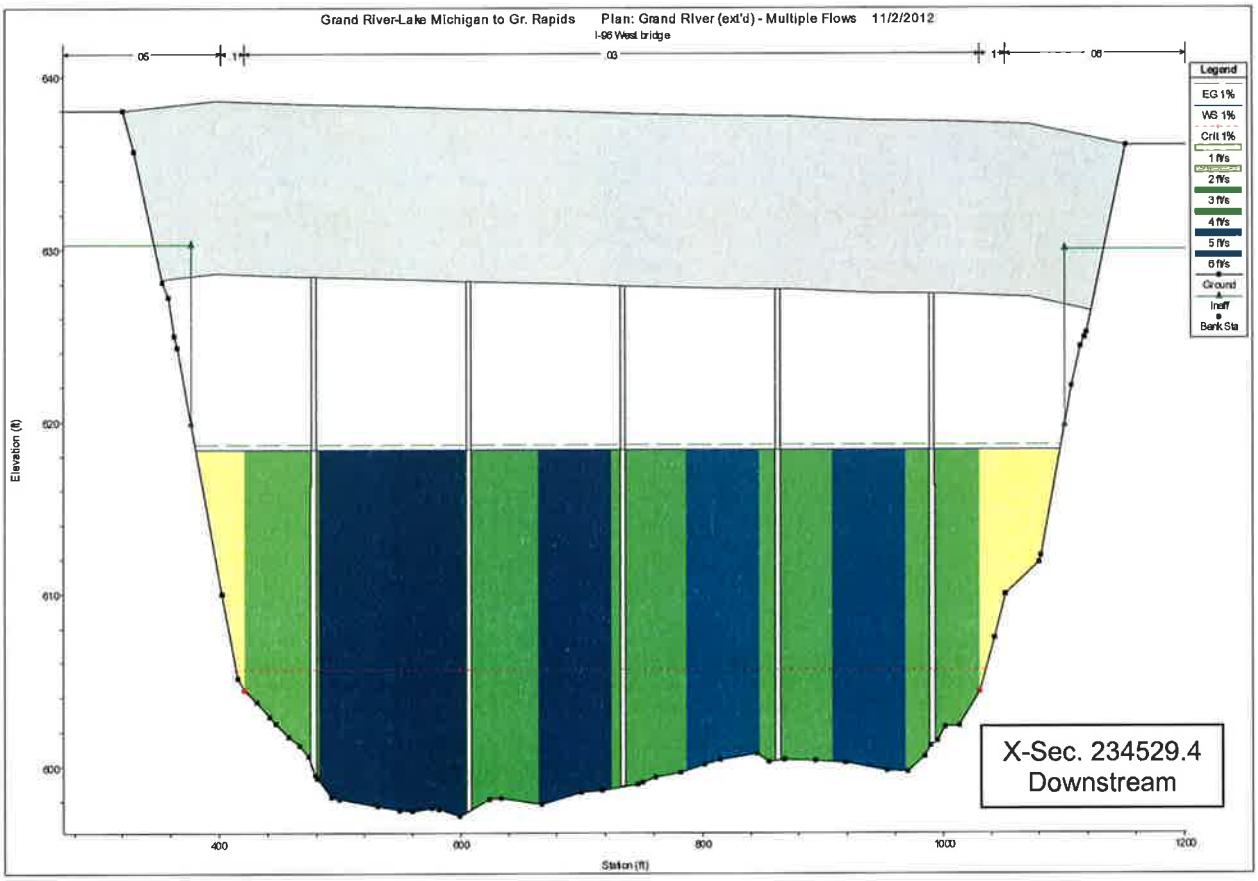

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=I-96; XS_ID=88
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 234410.5

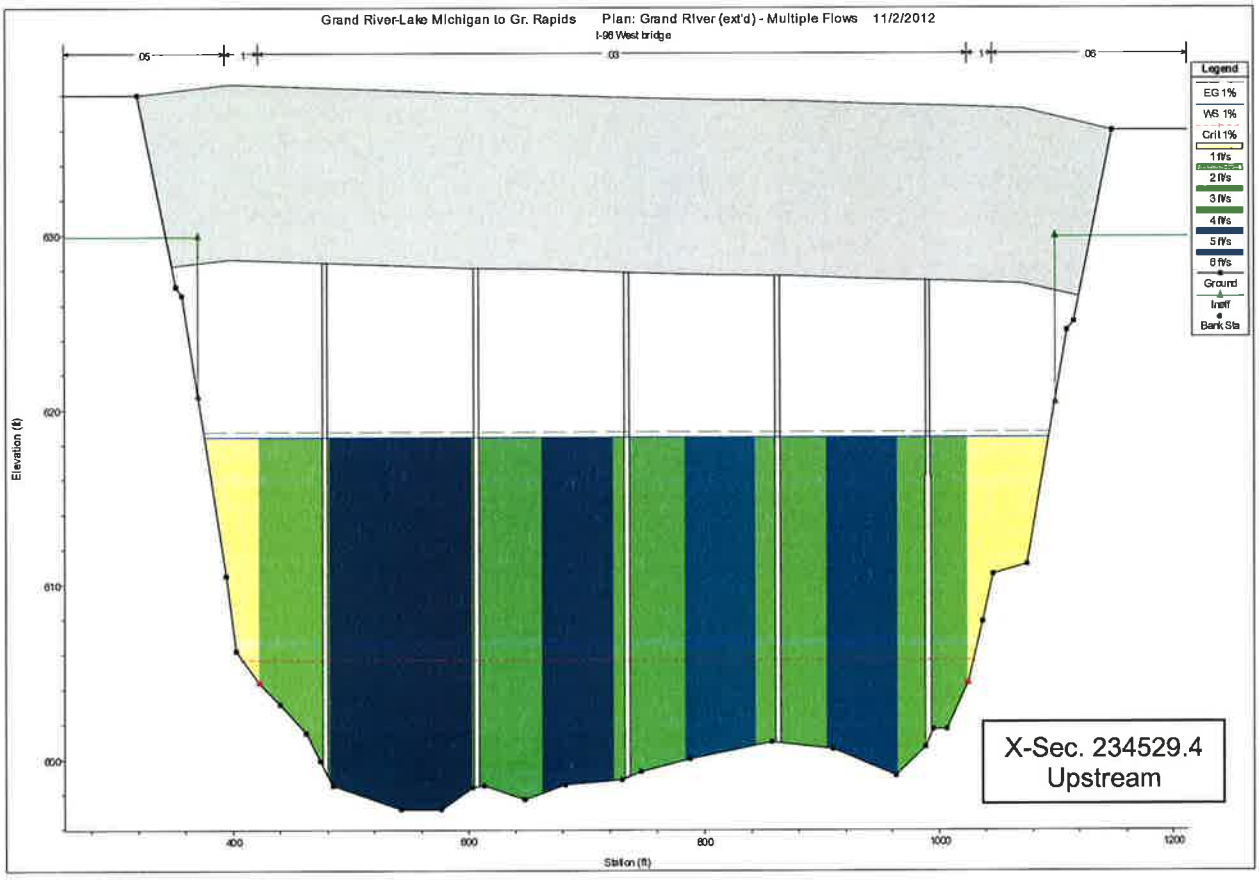

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-96 East bridge
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 234433.5
Downstream

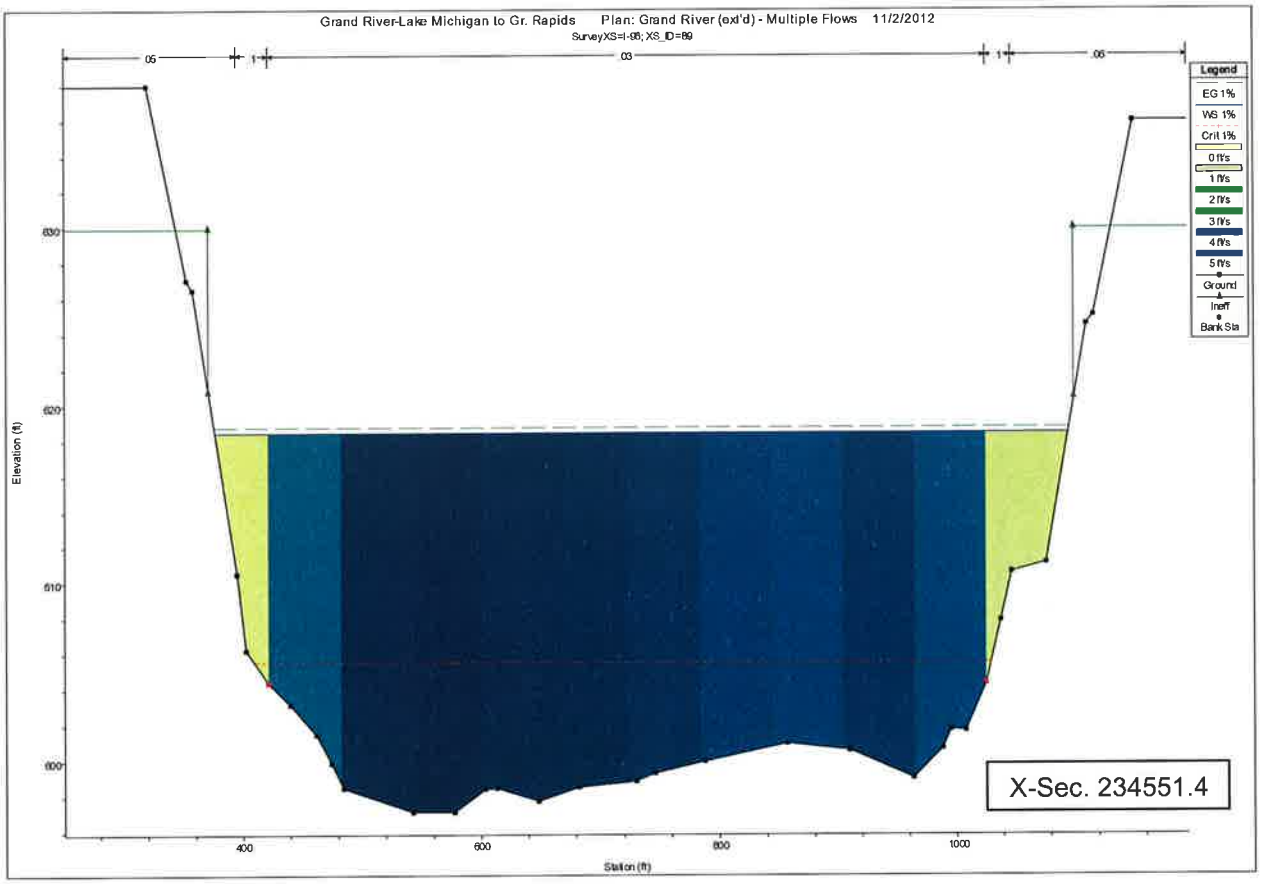

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-96 East bridge
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
X-Sec. 234433.5
Upstream

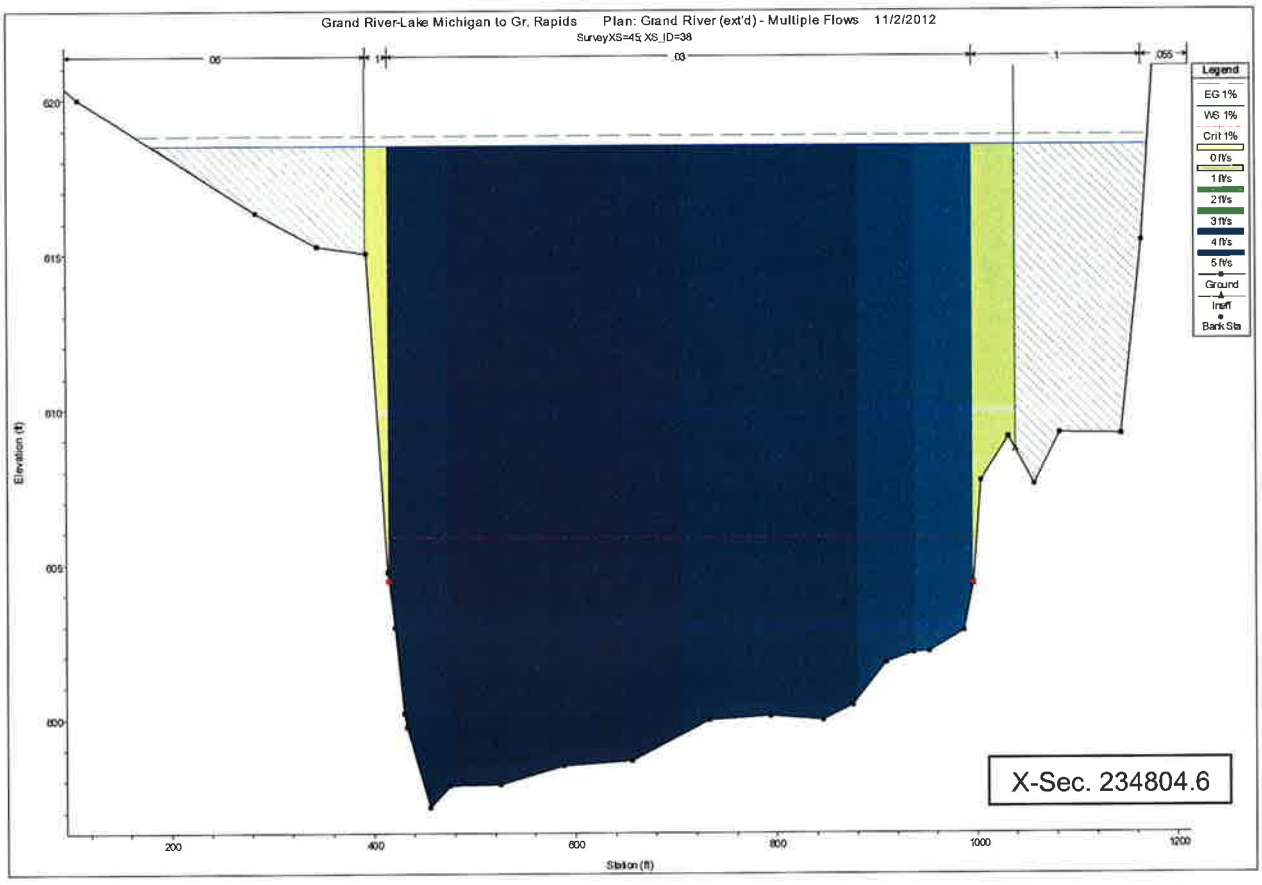

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(I-96 East U/S face)
.05
.03
.05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
1200
Station (ft)
X-Sec. 234457.4

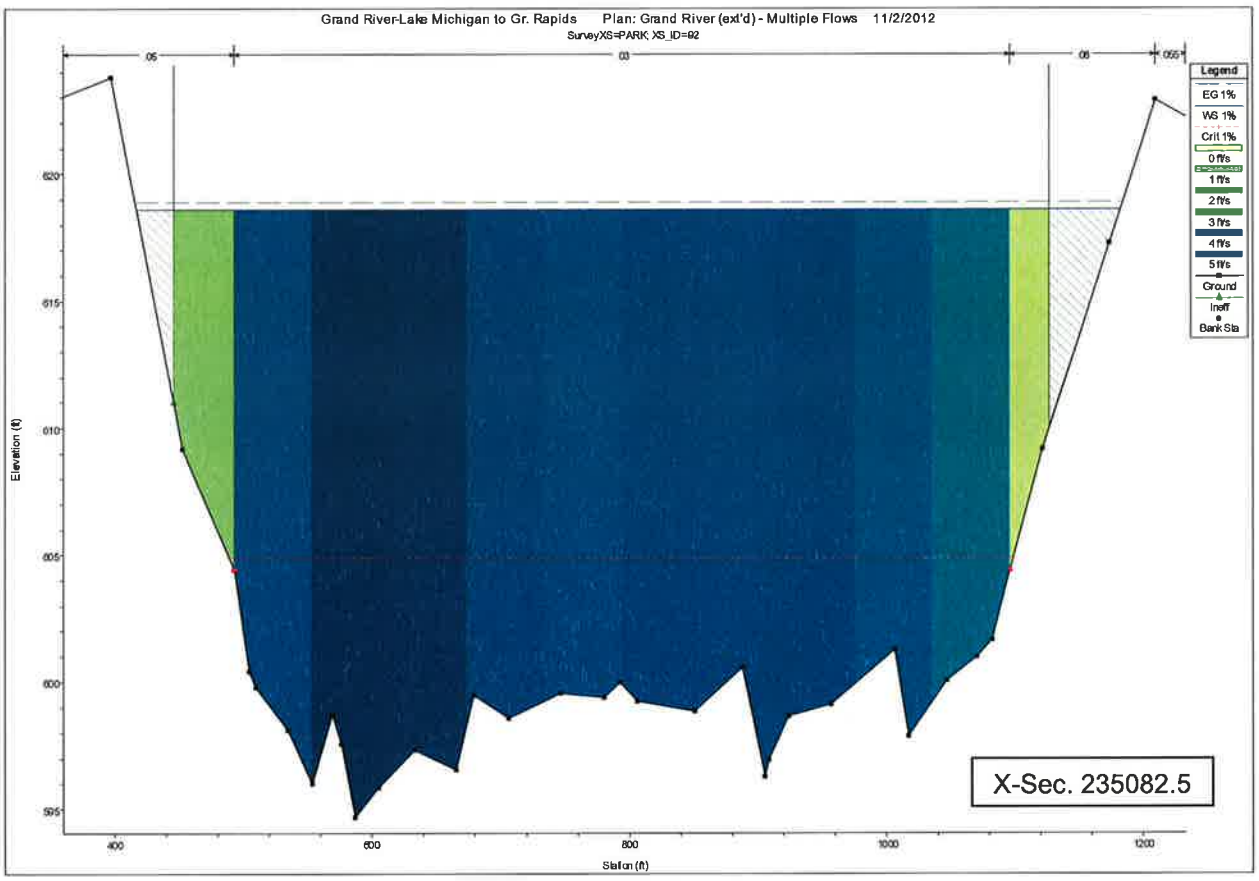

Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
(I-96 West D/S face)
.05
.03
.05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
1200
Station (ft)
X-Sec. 234504.4

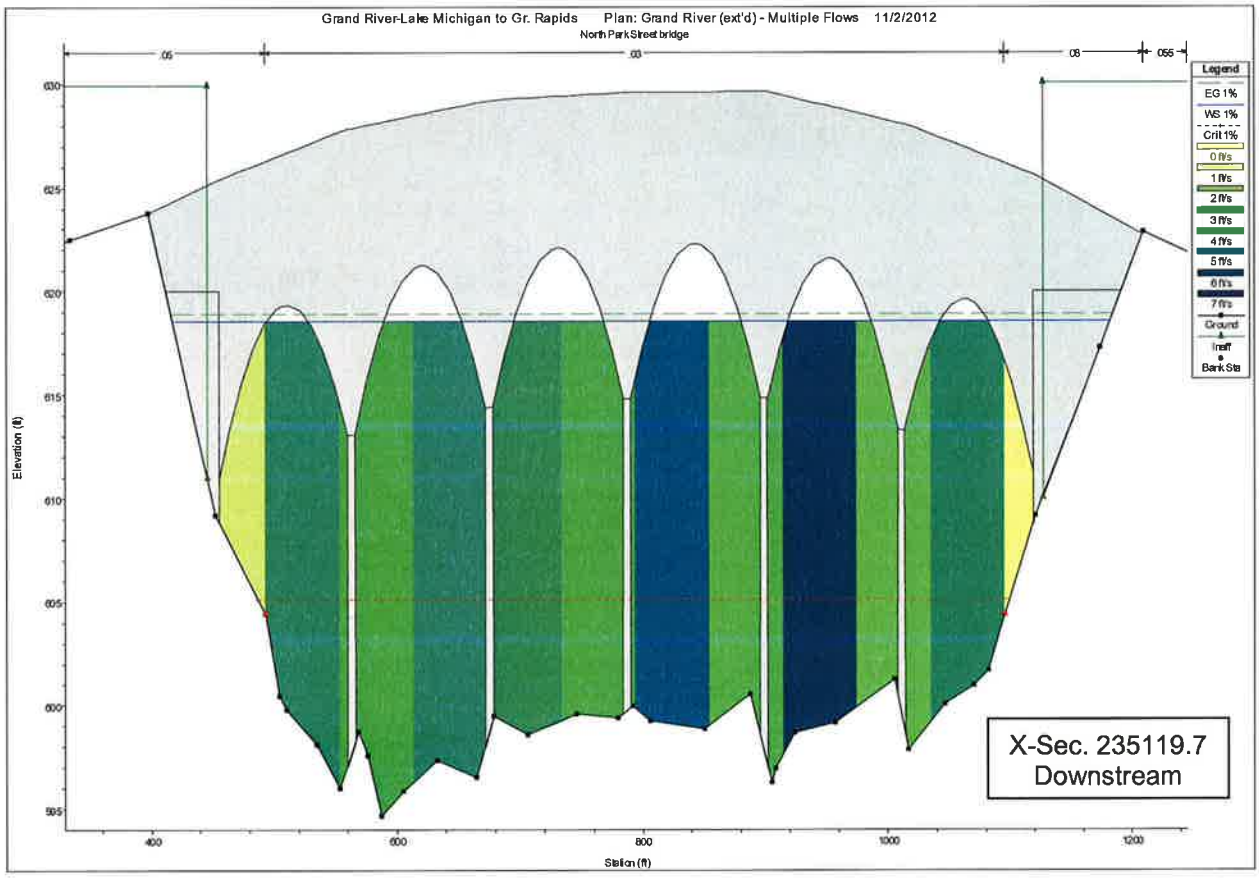

Grand River-Lake Michigan to Gr. Rapids
Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-96 West bridge
05
03
06
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
640
630
620
610
600
400
600
800
1000
1200
Station (ft)
X-Sec. 234529.4
Downstream

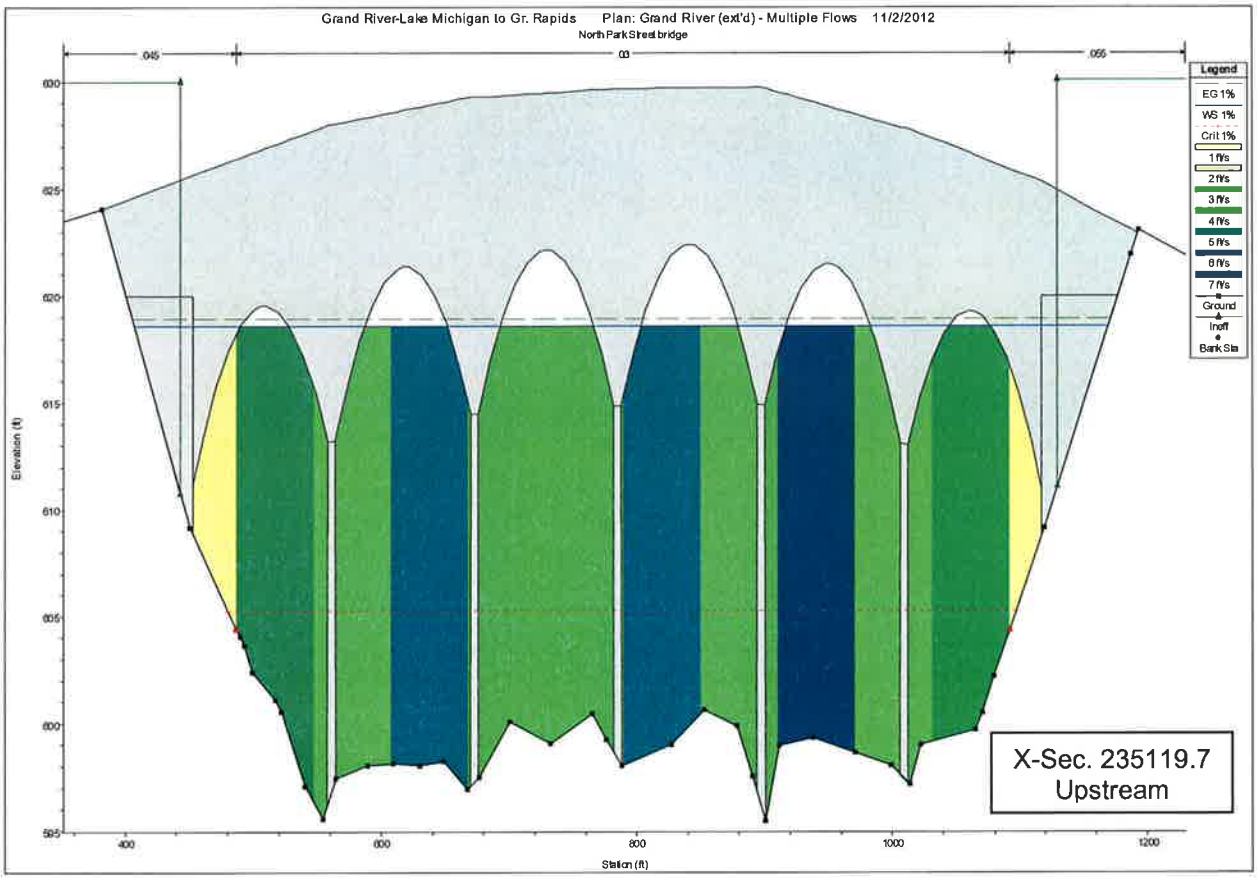

Grand River-Lake Michigan to Gr. Rapids
Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
I-96 West bridge
05
03
06
Legend
EG 1%
WS 1%
Crit 1%
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
1200
Station (ft)
X-Sec. 234529.4
Upstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=I-95; XS_ID=89
.05
1
.03
1
.05
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
620
610
600
400
600
800
1000
Station (ft)
X-Sec. 234551.4


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=45; XS_ID=38
.06
1
.03
1
.055
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
200
400
600
800
1000
1200
Station (ft)
X-Sec. 234804.6


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
SurveyXS=PARK XS_ID=92
.05
.03
.08
.055
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
620
615
610
605
600
595
400
600
800
1000
1200
Station (ft)
X-Sec. 235082.5


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
North Park Street bridge
.05
.03
.08
.055
Legend
EG 1%
WS 1%
Crit 1%
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
625
620
615
610
605
600
595
400
600
800
1000
1200
Station (ft)
X-Sec. 235119.7
Downstream


Grand River-Lake Michigan to Gr. Rapids Plan: Grand River (ext'd) - Multiple Flows 11/2/2012
North Park Street bridge
.045
03
.055
Legend
EG 1%
WS 1%
Crit 1%
1 f/s
2 f/s
3 f/s
4 f/s
5 f/s
6 f/s
7 f/s
Ground
Ineff
Bank Sta
Elevation (ft)
630
625
620
615
610
605
600
595
400
600
800
1000
1200
Station (ft)
X-Sec. 235119.7
Upstream

Plan: Grand Rvr 2017 Grand River Upper RS: 235119.7BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	443.20	487.02	461.58	291.71	71.12	0.92	8.63	1.58	0.09	0.14
2	Chan	487.02	547.54	5129.53	1065.15	83.96	10.26	17.60	4.82	0.28	1.33
3	Chan	547.54	608.05	3908.25	1050.40	121.93	7.82	19.05	3.72	0.19	0.70
4	Chan	608.05	668.57	6774.58	1221.20	77.86	13.55	20.18	5.55	0.34	1.90
5	Chan	668.57	729.08	4043.62	1022.27	108.25	8.09	18.51	3.96	0.21	0.82
6	Chan	729.08	789.60	3992.23	1005.07	105.77	7.98	18.19	3.97	0.21	0.82
7	Chan	789.60	850.11	6432.10	1164.42	74.72	12.86	19.24	5.52	0.34	1.88
8	Chan	850.11	910.63	3726.70	1012.43	119.43	7.45	18.32	3.68	0.19	0.68
9	Chan	910.63	971.14	7076.19	1178.34	66.71	14.15	19.47	6.01	0.39	2.32
10	Chan	971.14	1031.66	3338.06	980.69	130.10	6.68	17.79	3.40	0.16	0.56
11	Chan	1031.66	1092.17	4906.17	1064.91	89.71	9.81	17.60	4.61	0.26	1.19
12	ROB	1092.17	1128.80	210.99	182.02	52.38	0.42	7.39	1.16	0.08	0.09

Plan: Grand Rvr 2017 Grand River Upper RS: 235119.7BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	445.20	493.09	466.76	330.70	79.00	0.93	8.73	1.41	0.09	0.12
2	Chan	493.09	553.34	5379.49	1128.56	87.88	10.76	18.73	4.77	0.27	1.28
3	Chan	553.34	613.59	4385.52	1119.63	117.04	8.77	20.41	3.92	0.20	0.78
4	Chan	613.59	673.84	5901.04	1227.21	94.32	11.80	20.88	4.81	0.27	1.31
5	Chan	673.84	734.09	4856.62	1066.62	88.96	9.71	18.90	4.55	0.25	1.14
6	Chan	734.09	794.34	3857.99	994.76	105.54	7.72	18.09	3.88	0.20	0.76
7	Chan	794.34	854.58	6403.10	1156.09	71.87	12.81	19.19	5.54	0.34	1.86
8	Chan	854.58	914.83	3631.62	1003.76	118.20	7.26	18.25	3.62	0.18	0.64
9	Chan	914.83	975.08	7126.31	1177.94	64.15	14.25	19.55	6.05	0.38	2.32
10	Chan	975.08	1035.33	2927.11	906.35	126.55	5.85	16.52	3.23	0.15	0.48
11	Chan	1035.33	1095.58	4924.42	1037.11	81.23	9.85	17.21	4.75	0.27	1.27
12	ROB	1095.58	1126.80	140.02	177.29	49.99	0.28	7.64	0.79	0.07	0.06

Plan: Grand Rvr 2017 Grand River Upper RS: 235082.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	395.73	445.20	0.00	108.54	29.55	0.00	3.80	0.00	0.03	0.00
2	LOB	445.20	493.09	921.69	542.71	48.40	1.84	11.33	1.70	0.09	0.15
3	Chan	493.09	553.34	4736.85	1172.56	61.13	9.47	19.46	4.04	0.16	0.63
4	Chan	553.34	613.59	5896.84	1336.19	61.01	11.79	22.18	4.41	0.18	0.79
5	Chan	613.59	673.84	5681.55	1302.20	60.49	11.36	21.61	4.36	0.17	0.76
6	Chan	673.84	734.09	4844.10	1182.58	60.39	9.69	19.63	4.10	0.16	0.65
7	Chan	734.09	794.34	4620.42	1148.63	60.27	9.24	19.06	4.02	0.15	0.62
8	Chan	794.34	854.58	4779.19	1172.16	60.27	9.56	19.46	4.08	0.16	0.64
9	Chan	854.58	914.83	4819.40	1182.98	60.90	9.64	19.63	4.07	0.16	0.64
10	Chan	914.83	975.08	4840.48	1181.57	60.32	9.68	19.61	4.10	0.16	0.65
11	Chan	975.08	1035.33	4496.69	1134.30	60.83	8.99	18.83	3.96	0.15	0.60
12	Chan	1035.33	1095.58	3990.87	1054.19	60.59	7.98	17.50	3.79	0.14	0.54
13	ROB	1095.58	1126.80	371.92	352.52	31.73	0.74	11.29	1.06	0.09	0.10
14	ROB	1126.80	1348.64	0.00	313.22	110.08	0.00	2.86	0.00	0.02	0.00
15	ROB	1348.64	1570.48	0.00	490.32	221.96	0.00	2.21	0.00	0.02	0.00
16	ROB	1570.48	1792.32	0.00	584.47	221.85	0.00	2.63	0.00	0.02	0.00
17	ROB	1792.32	2014.16	0.00	840.03	221.88	0.00	3.79	0.00	0.03	0.00
18	ROB	2014.16	2236.01	0.00	336.33	222.01	0.00	1.52	0.00	0.01	0.00
19	ROB	2236.01	2457.85	0.00	451.62	221.93	0.00	2.04	0.00	0.02	0.00
20	ROB	2457.85	2679.69	0.00	577.34	221.84	0.00	2.60	0.00	0.02	0.00
21	ROB	2679.69	2901.53	0.00	659.38	222.94	0.00	2.97	0.00	0.02	0.00
22	ROB	2901.53	3123.37	0.00	96.76	82.42	0.00	1.18	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 234804.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	174.56	218.21	0.00	14.01	36.76	0.00	0.38	0.00	0.00	0.00
2	LOB	218.21	261.85	0.00	53.03	43.65	0.00	1.22	0.00	0.01	0.00
3	LOB	261.85	305.49	0.00	91.89	43.65	0.00	2.11	0.00	0.02	0.00
4	LOB	305.49	349.13	0.00	126.60	43.65	0.00	2.90	0.00	0.03	0.00
5	LOB	349.13	392.77	0.00	145.66	43.64	0.00	3.34	0.00	0.04	0.00
6	LOB	392.77	414.84	143.11	188.65	24.57	0.29	8.55	0.76	0.08	0.06
7	Chan	414.84	473.04	5079.29	1117.23	59.00	10.16	19.20	4.55	0.20	0.90
8	Chan	473.04	531.23	5777.82	1200.41	58.20	11.56	20.63	4.81	0.22	1.04
9	Chan	531.23	589.43	5616.47	1180.19	58.20	11.23	20.28	4.76	0.21	1.01
10	Chan	589.43	647.62	5456.38	1159.87	58.20	10.91	19.93	4.70	0.21	0.98
11	Chan	647.62	705.81	5248.28	1133.18	58.20	10.50	19.47	4.63	0.20	0.95
12	Chan	705.81	764.01	4869.19	1083.31	58.20	9.74	18.62	4.49	0.20	0.88
13	Chan	764.01	822.21	4792.76	1073.04	58.20	9.59	18.44	4.47	0.19	0.86
14	Chan	822.21	880.40	4747.93	1067.07	58.20	9.50	18.34	4.45	0.19	0.86
15	Chan	880.40	938.60	4132.11	981.85	58.22	8.26	16.87	4.21	0.18	0.74
16	Chan	938.60	996.79	3734.36	924.63	58.32	7.47	15.89	4.04	0.17	0.67
17	ROB	996.79	1038.87	402.28	441.03	42.79	0.80	10.48	0.91	0.11	0.10
18	ROB	1038.87	1254.46	0.00	1157.01	133.82	0.00	8.76	0.00	0.09	0.00
19	ROB	1254.46	1470.05	0.00	42.03	25.46	0.00	1.71	0.00	0.02	0.00
20	ROB	1470.05	1685.63	0.00	185.97	31.98	0.00	6.22	0.00	0.06	0.00
21	ROB	1685.63	1901.22	0.00	1936.40	215.88	0.00	8.98	0.00	0.09	0.00
22	ROB	1901.22	2116.81	0.00	51.85	21.30	0.00	2.52	0.00	0.03	0.00
23	ROB	2116.81	2332.40	0.00	341.74	79.06	0.00	4.34	0.00	0.05	0.00
24	ROB	2332.40	2547.99	0.00	330.14	156.23	0.00	2.12	0.00	0.02	0.00
25	ROB	2547.99	2763.57	0.00	926.67	215.67	0.00	4.30	0.00	0.05	0.00
26	ROB	2763.57	2979.16	0.00	663.04	215.60	0.00	3.08	0.00	0.03	0.00
27	ROB	2979.16	3194.75	0.00	217.72	93.06	0.00	2.35	0.00	0.02	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 234551.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	371.03	421.97	378.08	406.56	48.40	0.76	8.92	0.93	0.08	0.07
2	Chan	421.97	482.28	3881.22	992.34	60.60	7.76	16.46	3.91	0.15	0.60
3	Chan	482.28	542.58	5675.01	1244.29	60.34	11.35	20.63	4.56	0.19	0.89
4	Chan	542.58	602.89	5871.98	1270.02	60.34	11.74	21.06	4.62	0.20	0.92
5	Chan	602.89	663.19	5546.24	1227.10	60.32	11.09	20.35	4.52	0.19	0.87
6	Chan	663.19	723.50	5342.73	1199.83	60.31	10.69	19.90	4.45	0.19	0.84
7	Chan	723.50	783.81	4979.08	1150.19	60.32	9.96	19.07	4.33	0.18	0.78
8	Chan	783.81	844.11	4553.73	1090.15	60.31	9.11	18.08	4.18	0.17	0.71
9	Chan	844.11	904.42	4367.82	1063.19	60.31	8.74	17.63	4.11	0.17	0.68
10	Chan	904.42	964.72	4768.28	1120.82	60.33	9.54	18.59	4.25	0.18	0.75
11	Chan	964.72	1025.03	4141.68	1032.06	60.64	8.28	17.11	4.01	0.16	0.64
12	ROB	1025.03	1099.40	494.14	525.94	71.60	0.99	7.58	0.94	0.07	0.07

Plan: Grand Rvr 2017 Grand River Upper RS: 234529.4BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	371.03	421.97	469.52	405.27	48.33	0.94	8.90	1.16	0.12	0.14
2	Chan	421.97	482.28	2951.27	907.41	94.79	5.90	16.12	3.25	0.14	0.46
3	Chan	482.28	542.58	6734.71	1242.58	60.34	13.47	20.60	5.42	0.30	1.64
4	Chan	542.58	602.89	6968.78	1268.31	60.34	13.94	21.03	5.49	0.31	1.70
5	Chan	602.89	663.19	4260.73	1138.29	96.31	8.52	20.22	3.74	0.17	0.65
6	Chan	663.19	723.50	6339.85	1198.13	60.31	12.68	19.87	5.29	0.29	1.54
7	Chan	723.50	783.81	3835.65	1063.81	95.21	7.67	18.89	3.61	0.16	0.59
8	Chan	783.81	844.11	5402.31	1088.44	60.31	10.80	18.05	4.96	0.26	1.31
9	Chan	844.11	904.42	3472.40	985.43	91.28	6.94	17.50	3.52	0.16	0.56
10	Chan	904.42	964.72	5657.24	1119.11	60.33	11.31	18.56	5.06	0.27	1.38
11	Chan	964.72	1025.03	3294.45	954.86	91.29	6.59	16.96	3.45	0.15	0.53
12	ROB	1025.03	1099.40	613.09	523.98	71.52	1.23	7.56	1.17	0.11	0.13

Plan: Grand Rvr 2017 Grand River Upper RS: 234529.4BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	376.89	421.64	355.45	313.80	43.28	0.71	7.69	1.13	0.11	0.12
2	Chan	421.64	482.49	2963.86	909.40	94.27	5.93	16.00	3.26	0.14	0.46
3	Chan	482.49	543.34	6648.69	1239.84	60.90	13.30	20.38	5.36	0.30	1.59
4	Chan	543.34	604.19	6968.73	1274.99	60.86	13.94	20.95	5.47	0.31	1.67
5	Chan	604.19	665.04	4270.38	1153.51	98.78	8.54	20.29	3.70	0.17	0.63
6	Chan	665.04	725.89	6470.76	1219.50	60.86	12.94	20.04	5.31	0.29	1.55
7	Chan	725.89	786.73	3907.16	1080.84	95.92	7.81	19.01	3.61	0.16	0.59
8	Chan	786.73	847.58	5419.88	1096.51	60.86	10.84	18.02	4.94	0.26	1.30
9	Chan	847.58	908.43	3614.65	1018.50	92.92	7.23	17.92	3.55	0.16	0.57
10	Chan	908.43	969.28	5620.58	1120.63	60.85	11.24	18.42	5.02	0.27	1.35
11	Chan	969.28	1030.13	3164.03	933.88	91.34	6.33	16.43	3.39	0.15	0.50
12	ROB	1030.13	1100.90	595.84	510.68	69.12	1.19	7.61	1.17	0.11	0.13

Plan: Grand Rvr 2017 Grand River Upper RS: 234504.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	376.89	421.64	285.87	314.57	43.34	0.57	7.70	0.91	0.07	0.06
2	Chan	421.64	482.49	3840.49	991.71	61.10	7.68	16.30	3.87	0.15	0.59
3	Chan	482.49	543.34	5593.37	1240.99	60.90	11.19	20.39	4.51	0.19	0.86
4	Chan	543.34	604.19	5862.36	1276.13	60.86	11.72	20.97	4.59	0.20	0.90
5	Chan	604.19	665.04	5633.18	1246.02	60.87	11.27	20.48	4.52	0.19	0.87
6	Chan	665.04	725.89	5443.82	1220.64	60.86	10.89	20.06	4.46	0.19	0.84
7	Chan	725.89	786.73	5051.39	1167.07	60.86	10.10	19.18	4.33	0.18	0.78
8	Chan	786.73	847.58	4560.52	1097.66	60.86	9.12	18.04	4.15	0.17	0.70
9	Chan	847.58	908.43	4563.87	1098.12	60.86	9.13	18.05	4.16	0.17	0.70
10	Chan	908.43	969.28	4729.22	1121.78	60.85	9.46	18.44	4.22	0.17	0.73
11	Chan	969.28	1030.13	3956.62	1009.46	61.08	7.91	16.59	3.92	0.15	0.61
12	ROB	1030.13	1100.90	479.28	511.95	69.17	0.96	7.62	0.94	0.07	0.06

Plan: Grand Rvr 2017 Grand River Upper RS: 234457.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	378.04	421.32	295.89	320.55	42.30	0.59	8.07	0.92	0.07	0.06
2	Chan	421.32	482.71	3812.65	998.24	61.61	7.63	16.26	3.82	0.15	0.57
3	Chan	482.71	544.10	5560.77	1251.12	61.51	11.12	20.38	4.44	0.19	0.83
4	Chan	544.10	605.49	5682.41	1266.56	61.40	11.36	20.63	4.49	0.19	0.85
5	Chan	605.49	666.88	5774.28	1278.96	61.42	11.55	20.83	4.51	0.19	0.86
6	Chan	666.88	728.27	5513.96	1243.88	61.40	11.03	20.26	4.43	0.18	0.82
7	Chan	728.27	789.66	5107.22	1188.01	61.40	10.21	19.35	4.30	0.18	0.76
8	Chan	789.66	851.05	4580.00	1112.88	61.40	9.16	18.13	4.12	0.17	0.68
9	Chan	851.05	912.44	4695.19	1129.98	61.46	9.39	18.41	4.16	0.17	0.70
10	Chan	912.44	973.83	4731.91	1134.80	61.39	9.46	18.49	4.17	0.17	0.70
11	Chan	973.83	1035.22	3764.00	990.39	61.58	7.53	16.13	3.80	0.15	0.56
12	ROB	1035.22	1106.21	481.73	511.14	66.94	0.96	7.84	0.94	0.07	0.07

Plan: Grand Rvr 2017 Grand River Upper RS: 234433.5BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	378.04	421.32	365.83	319.44	42.23	0.73	8.06	1.15	0.11	0.12
2	Chan	421.32	482.71	3050.20	921.01	92.31	6.10	16.05	3.31	0.14	0.47
3	Chan	482.71	544.10	6646.71	1249.40	61.51	13.29	20.35	5.32	0.29	1.52
4	Chan	544.10	605.49	4400.25	1176.03	98.16	8.80	20.49	3.74	0.17	0.63
5	Chan	605.49	666.88	6902.26	1277.24	61.42	13.80	20.81	5.40	0.29	1.59
6	Chan	666.88	728.27	4306.14	1155.73	97.07	8.61	20.14	3.73	0.17	0.63
7	Chan	728.27	789.66	6103.85	1186.29	61.40	12.21	19.32	5.15	0.27	1.40
8	Chan	789.66	851.05	4601.96	1107.19	78.93	9.20	18.05	4.16	0.20	0.82
9	Chan	851.05	912.44	4397.69	1055.86	75.03	8.80	18.38	4.17	0.20	0.83
10	Chan	912.44	973.83	5654.65	1133.08	61.39	11.31	18.46	4.99	0.26	1.30
11	Chan	973.83	1035.22	2974.98	911.01	93.25	5.95	15.87	3.27	0.14	0.45

Plan: Grand Rvr 2017 Grand River Upper RS: 234433.5BR U Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
12	ROB	1035.22	1106.21	595.49	509.31	66.86	1.19	7.82	1.17	0.11	0.13

Plan: Grand Rvr 2017 Grand River Upper RS: 234433.5BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	381.42	420.99	298.44	273.01	38.65	0.60	7.60	1.09	0.10	0.11
2	Chan	420.99	482.92	3056.46	924.76	92.88	6.11	15.96	3.31	0.14	0.46
3	Chan	482.92	544.86	6621.30	1252.39	62.18	13.24	20.22	5.29	0.28	1.50
4	Chan	544.86	606.79	4393.41	1175.78	98.24	8.79	20.30	3.74	0.17	0.63
5	Chan	606.79	668.72	6817.74	1272.92	61.98	13.64	20.55	5.36	0.29	1.55
6	Chan	668.72	730.66	4387.12	1173.18	97.91	8.77	20.25	3.74	0.17	0.63
7	Chan	730.66	792.59	6185.50	1200.46	61.94	12.37	19.38	5.15	0.27	1.41
8	Chan	792.59	854.52	4371.60	1057.02	75.85	8.74	18.10	4.14	0.20	0.81
9	Chan	854.52	916.45	4761.62	1130.93	79.00	9.52	18.40	4.21	0.20	0.85
10	Chan	916.45	978.39	5719.38	1145.41	61.95	11.44	18.49	4.99	0.26	1.30
11	Chan	978.39	1040.32	2833.97	884.60	93.10	5.67	15.27	3.20	0.13	0.43
12	ROB	1040.32	1109.86	553.45	515.79	64.37	1.11	8.23	1.07	0.11	0.12

Plan: Grand Rvr 2017 Grand River Upper RS: 234410.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	381.42	420.99	241.76	273.68	38.70	0.48	7.61	0.88	0.06	0.06
2	Chan	420.99	482.92	3823.33	1001.69	62.08	7.65	16.17	3.82	0.15	0.57
3	Chan	482.92	544.86	5550.85	1253.55	62.18	11.10	20.24	4.43	0.19	0.82
4	Chan	544.86	606.79	5648.58	1264.81	61.94	11.30	20.42	4.47	0.19	0.84
5	Chan	606.79	668.72	5715.39	1274.07	61.98	11.43	20.57	4.49	0.19	0.85
6	Chan	668.72	730.66	5623.77	1261.47	61.94	11.25	20.37	4.46	0.19	0.83
7	Chan	730.66	792.59	5185.85	1201.61	61.94	10.37	19.40	4.32	0.18	0.77
8	Chan	792.59	854.52	4628.99	1122.52	61.95	9.26	18.12	4.12	0.17	0.69
9	Chan	854.52	916.45	4766.36	1143.49	62.10	9.53	18.46	4.17	0.17	0.70
10	Chan	916.45	978.39	4795.43	1146.56	61.95	9.59	18.51	4.18	0.17	0.71
11	Chan	978.39	1040.32	3571.47	961.90	62.14	7.14	15.53	3.71	0.14	0.53
12	ROB	1040.32	1109.86	448.24	516.96	64.43	0.90	8.24	0.87	0.07	0.06

Plan: Grand Rvr 2017 Grand River Upper RS: 233807.3 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	188.29	267.32	26.77	72.07	66.18	0.05	1.09	0.37	0.01	0.00
2	LOB	267.32	346.35	133.02	202.47	79.04	0.27	2.56	0.66	0.03	0.02
3	LOB	346.35	425.38	266.58	307.25	79.04	0.53	3.89	0.87	0.04	0.04
4	LOB	425.38	504.41	476.49	435.36	79.05	0.95	5.51	1.09	0.06	0.07
5	LOB	504.41	583.44	708.38	552.30	79.05	1.42	6.99	1.28	0.08	0.10
6	LOB	583.44	662.47	879.00	628.71	79.07	1.76	7.96	1.40	0.09	0.13
7	LOB	662.47	741.50	1129.06	793.25	79.29	2.26	10.04	1.42	0.11	0.16
8	Chan	741.50	792.70	3240.29	796.21	51.48	6.48	15.55	4.07	0.17	0.71
9	Chan	792.70	843.90	5578.82	1103.16	51.49	11.16	21.55	5.06	0.24	1.22
10	Chan	843.90	895.10	6207.31	1173.49	51.20	12.41	22.92	5.29	0.26	1.37
11	Chan	895.10	946.30	6023.13	1152.63	51.22	12.05	22.51	5.23	0.25	1.33
12	Chan	946.30	997.50	5351.55	1073.76	51.23	10.70	20.97	4.98	0.24	1.18
13	Chan	997.50	1048.70	4661.12	988.39	51.23	9.32	19.30	4.72	0.22	1.03
14	Chan	1048.70	1099.90	3932.43	892.57	51.23	7.86	17.43	4.41	0.20	0.87
15	Chan	1099.90	1151.10	3395.77	817.21	51.21	6.79	15.96	4.16	0.18	0.75
16	Chan	1151.10	1202.30	3086.86	771.72	51.21	6.17	15.07	4.00	0.17	0.68
17	Chan	1202.30	1253.50	2946.06	750.61	51.24	5.89	14.66	3.92	0.17	0.65
18	ROB	1253.50	1448.07	1957.35	1698.18	195.21	3.91	8.73	1.15	0.10	0.11
19	ROB	1448.07	1728.73	0.00	2648.72	269.11	0.00	9.92	0.00	0.11	0.00
20	ROB	1728.73	2009.39							0.00	0.00
21	ROB	2009.39	2290.05							0.00	0.00
22	ROB	2290.05	2570.71							0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 233807.3 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
23	ROB	2570.71	2851.37							0.00	0.00
24	ROB	2851.37	3132.03							0.00	0.00
25	ROB	3132.03	3412.69							0.00	0.00
26	ROB	3412.69	3693.35	0.00	6.05	9.34	0.00	0.65	0.00	0.01	0.00
27	ROB	3693.35	3974.01	0.00	62.13	54.60	0.00	1.14	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 231462.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	208.00	416.00	0.00	8.60	30.71	0.00	0.28	0.00	0.00	0.00
2	LOB	416.00	646.24	548.15	768.63	230.31	1.10	3.34	0.71	0.03	0.02
3	LOB	646.24	876.48	1767.71	1551.59	230.25	3.54	6.74	1.14	0.05	0.06
4	LOB	876.48	1106.72	2295.98	1815.10	230.24	4.59	7.88	1.26	0.06	0.08
5	LOB	1106.72	1336.97	2295.98	1815.10	230.24	4.59	7.88	1.26	0.06	0.08
6	LOB	1336.97	1567.21	2295.98	1815.10	230.24	4.59	7.88	1.26	0.06	0.08
7	LOB	1567.21	1797.45	2295.98	1815.10	230.24	4.59	7.88	1.26	0.06	0.08
8	LOB	1797.45	2027.69	2223.70	1780.75	230.29	4.45	7.73	1.25	0.06	0.07
9	LOB	2027.69	2257.93	1375.84	1397.04	231.80	2.75	6.07	0.98	0.05	0.05
10	Chan	2257.93	2303.16	3388.88	944.92	47.51	6.78	20.89	3.59	0.15	0.54
11	Chan	2303.16	2348.39	5097.03	1183.73	45.25	10.19	26.17	4.31	0.20	0.86
12	Chan	2348.39	2393.62	4676.95	1124.42	45.27	9.35	24.86	4.16	0.19	0.79
13	Chan	2393.62	2438.85	4098.09	1038.71	45.27	8.20	22.97	3.95	0.17	0.69
14	Chan	2438.85	2484.08	3587.75	959.03	45.27	7.18	21.20	3.74	0.16	0.60
15	Chan	2484.08	2529.31	3091.13	876.98	45.26	6.18	19.39	3.52	0.15	0.52
16	Chan	2529.31	2574.54	2833.29	832.14	45.23	5.67	18.40	3.40	0.14	0.48
17	Chan	2574.54	2619.77	2691.59	806.90	45.23	5.38	17.84	3.34	0.14	0.45
18	Chan	2619.77	2665.00	2234.33	722.62	45.39	4.47	15.98	3.09	0.12	0.38
19	Chan	2665.00	2710.23	1780.51	629.73	45.24	3.56	13.92	2.83	0.11	0.30
20	ROB	2710.23	2831.62	910.98	1203.88	121.62	1.82	9.92	0.76	0.08	0.06
21	ROB	2831.62	2953.00	510.15	575.24	84.47	1.02	6.91	0.89	0.05	0.05
22	ROB	2953.00	3064.27							0.00	0.00
23	ROB	3064.27	3175.54							0.00	0.00
24	ROB	3175.54	3286.81	0.00	198.80	88.86	0.00	2.24	0.00	0.02	0.00
25	ROB	3286.81	3398.08	0.00	666.39	111.43	0.00	5.99	0.00	0.05	0.00
26	ROB	3398.08	3509.35	0.00	877.20	111.27	0.00	7.88	0.00	0.06	0.00
27	ROB	3509.35	3620.62	0.00	875.47	111.30	0.00	7.87	0.00	0.06	0.00
28	ROB	3620.62	3731.89	0.00	139.71	30.90	0.00	4.71	0.00	0.03	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 228851.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	358.81	538.22	0.00	14.81	38.86	0.00	0.38	0.00	0.00	0.00
2	LOB	538.22	717.62	0.00	301.16	179.42	0.00	1.68	0.00	0.01	0.00
3	LOB	717.62	936.97	1092.46	1140.79	219.42	2.18	5.20	0.96	0.04	0.04
4	LOB	936.97	1156.32	2915.19	2055.54	219.37	5.83	9.37	1.42	0.07	0.10
5	LOB	1156.32	1375.67	3032.20	2104.57	219.35	6.06	9.59	1.44	0.07	0.11
6	LOB	1375.67	1595.01	3032.20	2104.57	219.35	6.06	9.59	1.44	0.07	0.11
7	LOB	1595.01	1814.36	2826.41	2017.85	219.40	5.65	9.20	1.40	0.07	0.10
8	LOB	1814.36	2033.71	1225.41	1401.84	220.52	2.45	6.39	0.87	0.05	0.04
9	Chan	2033.71	2084.16	2370.85	780.18	50.80	4.74	15.46	3.04	0.12	0.36
10	Chan	2084.16	2134.61	2589.66	820.39	50.45	5.18	16.26	3.16	0.12	0.39
11	Chan	2134.61	2185.07	2777.26	855.63	50.47	5.55	16.96	3.25	0.13	0.42
12	Chan	2185.07	2235.52	3150.60	922.95	50.47	6.30	18.29	3.41	0.14	0.47
13	Chan	2235.52	2285.97	3594.59	998.95	50.48	7.19	19.80	3.60	0.15	0.54
14	Chan	2285.97	2336.42	3994.63	1064.11	50.46	7.99	21.09	3.75	0.16	0.60
15	Chan	2336.42	2386.87	4198.47	1096.37	50.46	8.40	21.73	3.83	0.17	0.63
16	Chan	2386.87	2437.33	4569.32	1153.54	50.47	9.14	22.86	3.96	0.17	0.69
17	Chan	2437.33	2487.78	4715.29	1176.20	50.54	9.43	23.31	4.01	0.18	0.71
18	Chan	2487.78	2538.23	3067.61	914.19	51.30	6.14	18.12	3.36	0.14	0.45

Plan: Grand Rvr 2017 Grand River Upper RS: 228851.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
19	ROB	2538.23	2782.39	847.85	1246.24	172.88	1.70	7.27	0.68	0.05	0.04
20	ROB	2782.39	3040.03	0.00	1742.61	256.81	0.00	6.81	0.00	0.05	0.00
21	ROB	3040.03	3240.58	0.00	211.14	52.62	0.00	4.16	0.00	0.03	0.00
22	ROB	3240.58	3441.14	0.00	151.27	29.92	0.00	5.33	0.00	0.04	0.00
23	ROB	3441.14	3641.69							0.00	0.00
24	ROB	3641.69	3842.24	0.00	184.46	122.45	0.00	1.51	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 227668.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	255.55	383.32	0.00	25.75	36.64	0.00	0.70	0.00	0.01	0.00
2	LOB	383.32	516.12	111.30	213.15	132.81	0.22	1.60	0.52	0.01	0.01
3	LOB	516.12	648.93	324.05	429.87	132.82	0.65	3.24	0.75	0.03	0.02
4	LOB	648.93	781.73	585.81	615.02	132.81	1.17	4.63	0.95	0.04	0.04
5	LOB	781.73	914.53	842.68	764.96	132.82	1.69	5.76	1.10	0.05	0.06
6	LOB	914.53	1047.33	1209.92	950.35	132.81	2.42	7.16	1.27	0.06	0.08
7	LOB	1047.33	1180.14	1253.11	970.55	132.81	2.51	7.31	1.29	0.07	0.08
8	LOB	1180.14	1312.94	1195.10	965.74	133.94	2.39	7.27	1.24	0.06	0.08
9	Chan	1312.94	1380.92	3415.35	1037.33	68.17	6.83	15.26	3.29	0.14	0.45
10	Chan	1380.92	1448.89	4939.76	1293.78	68.08	9.88	19.03	3.82	0.17	0.65
11	Chan	1448.89	1516.87	4259.99	1183.43	68.03	8.52	17.41	3.60	0.15	0.56
12	Chan	1516.87	1584.85	4117.32	1159.16	67.98	8.23	17.05	3.55	0.15	0.54
13	Chan	1584.85	1652.83	3897.73	1121.79	68.00	7.80	16.50	3.47	0.15	0.51
14	Chan	1652.83	1720.80	3914.80	1124.68	67.99	7.83	16.55	3.48	0.15	0.51
15	Chan	1720.80	1788.78	4097.51	1155.85	67.99	8.20	17.00	3.55	0.15	0.54
16	Chan	1788.78	1856.76	4495.83	1222.04	67.99	8.99	17.98	3.68	0.16	0.59
17	Chan	1856.76	1924.73	5272.21	1344.74	68.01	10.54	19.78	3.92	0.18	0.69
18	Chan	1924.73	1992.71	4570.38	1238.54	68.60	9.14	18.22	3.69	0.16	0.59
19	ROB	1992.71	2275.13	1497.14	1535.27	203.10	2.99	7.63	0.98	0.07	0.07
20	ROB	2275.13	2687.33	0.00	1141.90	323.20	0.00	3.57	0.00	0.03	0.00
21	ROB	2687.33	2972.35	0.00	400.79	285.02	0.00	1.41	0.00	0.01	0.00
22	ROB	2972.35	3257.37	0.00	247.93	191.49	0.00	1.30	0.00	0.01	0.00
23	ROB	3257.37	3542.38	0.00	462.98	285.02	0.00	1.62	0.00	0.01	0.00
24	ROB	3542.38	3827.40	0.00	400.79	285.02	0.00	1.41	0.00	0.01	0.00
25	ROB	3827.40	4112.42	0.00	238.27	253.49	0.00	0.94	0.00	0.01	0.00
26	ROB	4112.42	4397.44							0.00	0.00
27	ROB	4397.44	4682.45	0.00	8.32	10.47	0.00	0.83	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 225261.3 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	738.81	808.97	77.57	196.89	69.07	0.16	2.86	0.39	0.04	0.02
2	LOB	808.97	879.12	473.61	588.57	70.73	0.95	8.39	0.80	0.12	0.09
3	Chan	879.12	941.53	4028.17	967.72	62.67	8.06	15.51	4.16	0.22	0.90
4	Chan	941.53	1003.94	5308.76	1140.29	62.43	10.62	18.27	4.66	0.25	1.19
5	Chan	1003.94	1066.35	5361.35	1146.97	62.41	10.72	18.38	4.67	0.26	1.20
6	Chan	1066.35	1128.76	5689.90	1188.64	62.41	11.38	19.05	4.79	0.27	1.27
7	Chan	1128.76	1191.17	5355.17	1146.26	62.43	10.71	18.37	4.67	0.26	1.20
8	Chan	1191.17	1253.58	4724.33	1063.18	62.42	9.45	17.04	4.44	0.24	1.06
9	Chan	1253.58	1315.99	4613.23	1048.07	62.41	9.23	16.79	4.40	0.23	1.03
10	Chan	1315.99	1378.40	4528.44	1036.47	62.41	9.06	16.61	4.37	0.23	1.01
11	Chan	1378.40	1440.81	4749.30	1066.55	62.42	9.50	17.09	4.45	0.24	1.06
12	Chan	1440.81	1503.22	4211.14	994.24	62.73	8.42	15.93	4.24	0.22	0.94
13	ROB	1503.22	1968.70	879.02	1073.04	151.41	1.76	7.21	0.82	0.10	0.08
14	ROB	1968.70	2424.60	0.00	105.58	170.10	0.00	0.62	0.00	0.01	0.00
15	ROB	2424.60	2880.50	0.00	677.78	455.96	0.00	1.49	0.00	0.02	0.00
16	ROB	2880.50	3336.39	0.00	264.00	447.51	0.00	0.59	0.00	0.01	0.00
17	ROB	3336.39	3792.29							0.00	0.00
18	ROB	3792.29	4248.19	0.00	266.47	337.48	0.00	0.79	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 224424.1 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	330.00	412.50	0.00	11.75	29.60	0.00	0.40	0.00	0.01	0.00
2	LOB	412.50	495.00	0.00	44.96	82.50	0.00	0.54	0.00	0.01	0.00
3	LOB	495.00	577.50	0.00	29.74	82.50	0.00	0.36	0.00	0.01	0.00
4	LOB	577.50	660.00	0.00	16.81	82.50	0.00	0.20	0.00	0.00	0.00
5	LOB	660.00	748.09	2.84	17.11	88.08	0.01	0.19	0.17	0.00	0.00
6	LOB	748.09	836.17	123.92	248.92	90.46	0.25	2.83	0.50	0.04	0.02
7	Chan	836.17	897.64	4353.04	1006.91	61.93	8.71	16.38	4.32	0.23	0.99
8	Chan	897.64	959.11	5275.70	1126.64	61.47	10.55	18.33	4.68	0.26	1.21
9	Chan	959.11	1020.58	5476.78	1152.37	61.49	10.95	18.75	4.75	0.26	1.25
10	Chan	1020.58	1082.05	5655.08	1174.63	61.48	11.31	19.11	4.81	0.27	1.29
11	Chan	1082.05	1143.52	5604.36	1168.25	61.47	11.21	19.01	4.80	0.27	1.28
12	Chan	1143.52	1204.98	5317.93	1132.05	61.47	10.64	18.42	4.70	0.26	1.21
13	Chan	1204.98	1266.45	4969.62	1087.00	61.48	9.94	17.68	4.57	0.25	1.14
14	Chan	1266.45	1327.92	4606.39	1038.57	61.47	9.21	16.90	4.44	0.24	1.05
15	Chan	1327.92	1389.39	4359.07	1004.75	61.47	8.72	16.35	4.34	0.23	1.00
16	Chan	1389.39	1450.86	4130.05	978.17	62.33	8.26	15.91	4.22	0.22	0.93
17	ROB	1450.86	1515.51	125.22	177.20	31.38	0.25	6.13	0.71	0.08	0.06
18	ROB	1515.51	2089.54							0.00	0.00
19	ROB	2089.54	2663.57	0.00	1118.04	484.30	0.00	2.31	0.00	0.03	0.00
20	ROB	2663.57	3237.60	0.00	1305.29	574.03	0.00	2.27	0.00	0.03	0.00
21	ROB	3237.60	3811.63	0.00	329.05	332.23	0.00	0.99	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 223798.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	660.00	735.47	111.89	172.90	34.50	0.22	5.39	0.65	0.07	0.04
2	Chan	735.47	796.07	4497.47	1027.86	61.25	8.99	16.96	4.38	0.23	1.01
3	Chan	796.07	856.67	5526.36	1159.35	60.76	11.05	19.13	4.77	0.26	1.26
4	Chan	856.67	917.27	5835.01	1196.60	60.61	11.67	19.75	4.88	0.27	1.33
5	Chan	917.27	977.87	5432.70	1146.38	60.61	10.87	18.92	4.74	0.26	1.24
6	Chan	977.87	1038.47	5309.82	1130.70	60.60	10.62	18.66	4.70	0.26	1.21
7	Chan	1038.47	1099.06	5396.10	1141.69	60.60	10.79	18.84	4.73	0.26	1.23
8	Chan	1099.06	1159.66	5045.19	1096.77	60.63	10.09	18.10	4.60	0.25	1.15
9	Chan	1159.66	1220.26	4346.09	1002.74	60.61	8.69	16.55	4.33	0.23	0.99
10	Chan	1220.26	1280.86	4472.95	1022.02	60.88	8.95	16.87	4.38	0.23	1.01
11	Chan	1280.86	1341.46	3903.87	942.35	60.96	7.81	15.55	4.14	0.21	0.88
12	ROB	1341.46	1433.40	122.57	181.52	33.98	0.25	5.78	0.68	0.07	0.05
13	ROB	1433.40	1976.19							0.00	0.00
14	ROB	1976.19	2518.99	0.00	132.49	281.68	0.00	0.47	0.00	0.01	0.00
15	ROB	2518.99	3061.78	0.00	267.19	542.79	0.00	0.49	0.00	0.01	0.00
16	ROB	3061.78	3604.57	0.00	101.77	238.90	0.00	0.43	0.00	0.01	0.00
17	ROB	3604.57	4147.37	0.00	218.62	111.34	0.00	1.97	0.00	0.03	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 223766.0BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	660.00	735.47	143.95	170.58	29.33	0.29	6.32	0.84	0.11	0.09
2	Chan	735.47	796.07	5154.45	1027.02	61.25	10.31	16.95	5.02	0.32	1.62
3	Chan	796.07	856.67	4367.39	1109.53	95.27	8.73	19.03	3.94	0.22	0.88
4	Chan	856.67	917.27	6688.67	1195.76	60.61	13.38	19.73	5.59	0.38	2.12
5	Chan	917.27	977.87	4271.11	1095.62	95.45	8.54	18.80	3.90	0.22	0.86
6	Chan	977.87	1038.47	6086.23	1129.85	60.60	12.17	18.64	5.39	0.36	1.93
7	Chan	1038.47	1099.06	6185.20	1140.84	60.60	12.37	18.83	5.42	0.36	1.97
8	Chan	1099.06	1159.66	3967.49	1046.62	95.09	7.93	17.96	3.79	0.21	0.80
9	Chan	1159.66	1220.26	4980.78	1001.90	60.61	9.96	16.53	4.97	0.32	1.58
10	Chan	1220.26	1280.86	3536.68	973.91	94.37	7.07	16.70	3.63	0.20	0.72
11	Chan	1280.86	1341.46	4473.58	941.50	60.96	8.95	15.54	4.75	0.30	1.41
12	ROB	1341.46	1433.40	144.48	181.08	33.87	0.29	5.79	0.80	0.10	0.08

Plan: Grand Rvr 2017 Grand River Upper RS: 223766.0BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	637.64	743.95	186.53	208.77	34.94	0.37	6.44	0.89	0.12	0.11
2	Chan	743.95	804.24	5278.96	1014.05	60.87	10.56	16.82	5.21	0.35	1.81
3	Chan	804.24	864.52	4373.14	1079.69	94.43	8.75	18.62	4.05	0.24	0.96
4	Chan	864.52	924.81	6276.43	1120.74	60.29	12.55	18.59	5.60	0.39	2.17
5	Chan	924.81	985.09	4287.78	1059.04	92.68	8.58	18.28	4.05	0.24	0.96
6	Chan	985.09	1045.38	6152.42	1107.38	60.29	12.30	18.37	5.56	0.38	2.13
7	Chan	1045.38	1105.66	6284.19	1121.54	60.29	12.57	18.60	5.60	0.39	2.17
8	Chan	1105.66	1165.95	3747.19	979.15	93.24	7.49	16.90	3.83	0.22	0.84
9	Chan	1165.95	1226.23	5113.95	991.11	60.29	10.23	16.44	5.16	0.34	1.77
10	Chan	1226.23	1286.52	3631.91	947.14	89.93	7.26	16.33	3.83	0.22	0.84
11	Chan	1286.52	1346.80	4491.95	918.77	60.59	8.98	15.24	4.89	0.32	1.54
12	ROB	1346.80	1437.80	175.55	196.18	32.76	0.35	7.01	0.89	0.12	0.11

Plan: Grand Rvr 2017 Grand River Upper RS: 223733.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	637.64	743.95	159.44	208.98	35.00	0.32	6.43	0.76	0.09	0.07
2	Chan	743.95	804.24	4637.87	1014.44	60.87	9.28	16.83	4.57	0.25	1.16
3	Chan	804.24	864.52	5574.45	1128.53	60.29	11.15	18.72	4.94	0.28	1.40
4	Chan	864.52	924.81	5513.86	1121.13	60.29	11.03	18.60	4.92	0.28	1.39
5	Chan	924.81	985.09	5381.49	1105.50	60.37	10.76	18.34	4.87	0.28	1.35
6	Chan	985.09	1045.38	5404.96	1107.77	60.29	10.81	18.38	4.88	0.28	1.36
7	Chan	1045.38	1105.66	5520.68	1121.94	60.29	11.04	18.61	4.92	0.28	1.39
8	Chan	1105.66	1165.95	4747.92	1026.41	60.51	9.50	17.03	4.63	0.26	1.19
9	Chan	1165.95	1226.23	4492.97	991.50	60.29	8.99	16.45	4.53	0.25	1.13
10	Chan	1226.23	1286.52	4472.42	989.02	60.32	8.94	16.41	4.52	0.25	1.13
11	Chan	1286.52	1346.80	3946.70	919.17	60.59	7.89	15.25	4.29	0.23	0.99
12	ROB	1346.80	1437.80	147.25	229.35	49.76	0.29	4.78	0.64	0.07	0.04
13	ROB	1437.80	1977.61							0.00	0.00
14	ROB	1977.61	2517.41	0.00	104.46	247.87	0.00	0.42	0.00	0.01	0.00
15	ROB	2517.41	3057.22	0.00	489.93	540.13	0.00	0.91	0.00	0.01	0.00
16	ROB	3057.22	3597.02	0.00	2367.20	459.09	0.00	5.20	0.00	0.08	0.00
17	ROB	3597.02	4136.83	0.00	832.23	232.50	0.00	3.59	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 223275.7 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	142.41	213.62	0.00	27.22	53.21	0.00	0.51	0.00	0.01	0.00
2	LOB	213.62	284.83	0.00	90.13	71.21	0.00	1.27	0.00	0.02	0.00
3	LOB	284.83	356.03	0.00	149.18	71.21	0.00	2.09	0.00	0.03	0.00
4	LOB	356.03	427.24	0.00	168.43	71.21	0.00	2.37	0.00	0.03	0.00
5	LOB	427.24	498.45	0.00	145.73	71.21	0.00	2.05	0.00	0.03	0.00
6	LOB	498.45	569.65	0.00	108.79	71.21	0.00	1.53	0.00	0.02	0.00
7	LOB	569.65	640.86	0.00	110.01	71.21	0.00	1.54	0.00	0.02	0.00
8	LOB	640.86	675.11	0.00	48.73	28.33	0.00	1.74	0.00	0.02	0.00
9	LOB	675.11	708.36	87.69	128.31	23.00	0.18	6.55	0.68	0.07	0.05
10	Chan	708.36	775.34	5135.72	1173.98	68.04	10.27	17.53	4.37	0.23	1.01
11	Chan	775.34	842.31	5744.47	1247.73	66.98	11.49	18.63	4.60	0.25	1.15
12	Chan	842.31	909.29	6104.22	1294.06	66.98	12.21	19.32	4.72	0.26	1.22
13	Chan	909.29	976.27	5738.45	1247.07	67.00	11.48	18.62	4.60	0.25	1.14
14	Chan	976.27	1043.25	5282.96	1186.59	66.98	10.57	17.72	4.45	0.24	1.05
15	Chan	1043.25	1110.22	5116.81	1164.05	66.98	10.23	17.38	4.40	0.23	1.02
16	Chan	1110.22	1177.20	4677.34	1103.02	66.99	9.35	16.47	4.24	0.22	0.93
17	Chan	1177.20	1244.18	4340.99	1054.72	66.99	8.68	15.75	4.12	0.21	0.87
18	Chan	1244.18	1311.15	3983.36	1001.72	66.99	7.97	14.96	3.98	0.20	0.79
19	Chan	1311.15	1378.13	3594.34	943.52	67.29	7.19	14.09	3.81	0.19	0.71
20	ROB	1378.13	1407.50	193.63	228.00	34.65	0.39	7.97	0.85	0.09	0.07
21	ROB	1407.50	1944.31							0.00	0.00
22	ROB	1944.31	2481.12	0.00	509.36	135.45	0.00	4.03	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 223275.7 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
23	ROB	2481.12	3017.93	0.00	760.14	507.91	0.00	1.50	0.00	0.02	0.00
24	ROB	3017.93	3554.74	0.00	86.92	232.09	0.00	0.37	0.00	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 222995.3 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	220.29	293.72	0.00	57.79	63.16	0.00	0.92	0.00	0.01	0.00
2	LOB	293.72	367.14	0.00	160.84	73.44	0.00	2.19	0.00	0.03	0.00
3	LOB	367.14	440.57	0.00	167.05	73.43	0.00	2.27	0.00	0.03	0.00
4	LOB	440.57	514.00	0.00	163.26	73.43	0.00	2.22	0.00	0.03	0.00
5	LOB	514.00	587.43	0.00	159.47	73.43	0.00	2.17	0.00	0.03	0.00
6	LOB	587.43	660.86	0.00	150.24	73.43	0.00	2.05	0.00	0.02	0.00
7	LOB	660.86	747.13	0.00	123.15	66.03	0.00	1.87	0.00	0.02	0.00
8	LOB	747.13	769.01	80.36	124.38	22.58	0.16	6.54	0.65	0.07	0.04
9	Chan	769.01	840.01	4986.73	1216.09	72.06	9.97	17.13	4.10	0.20	0.84
10	Chan	840.01	911.01	5932.61	1342.65	71.13	11.87	18.91	4.42	0.23	1.01
11	Chan	911.01	982.01	5907.22	1338.35	71.01	11.81	18.85	4.41	0.23	1.01
12	Chan	982.01	1053.01	5717.68	1312.32	71.00	11.44	18.48	4.36	0.22	0.98
13	Chan	1053.01	1124.01	5843.14	1329.51	71.00	11.69	18.73	4.39	0.23	1.00
14	Chan	1124.01	1195.00	5465.77	1277.66	71.05	10.93	18.00	4.28	0.22	0.93
15	Chan	1195.00	1266.00	4520.53	1139.84	71.01	9.04	16.05	3.97	0.19	0.77
16	Chan	1266.00	1337.00	3876.18	1039.38	71.01	7.75	14.64	3.73	0.18	0.66
17	Chan	1337.00	1408.00	3528.68	982.41	71.01	7.06	13.84	3.59	0.17	0.60
18	Chan	1408.00	1479.00	3745.47	1019.31	71.20	7.49	14.36	3.67	0.17	0.64
19	ROB	1479.00	1615.00	395.64	499.20	66.71	0.79	7.65	0.79	0.09	0.07
20	ROB	1615.00	2142.51							0.00	0.00
21	ROB	2142.51	2670.02	0.00	269.02	197.26	0.00	1.37	0.00	0.02	0.00
22	ROB	2670.02	3197.53	0.00	822.45	527.55	0.00	1.56	0.00	0.02	0.00
23	ROB	3197.53	3725.04	0.00	49.99	156.47	0.00	0.32	0.00	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 222730.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	154.45	231.68	0.00	10.76	62.47	0.00	0.17	0.00	0.00	0.00
2	LOB	231.68	308.90	0.00	1.45	8.50	0.00	0.17	0.00	0.00	0.00
3	LOB	308.90	386.13							0.00	0.00
4	LOB	386.13	463.35							0.00	0.00
5	LOB	463.35	540.58							0.00	0.00
6	LOB	540.58	617.80							0.00	0.00
7	LOB	617.80	695.03							0.00	0.00
8	LOB	695.03	772.25	0.00	83.03	22.20	0.00	4.01	0.00	0.06	0.00
9	LOB	772.25	790.68	225.73	193.56	18.97	0.45	10.50	1.17	0.18	0.21
10	Chan	790.68	855.70	3876.27	903.01	65.38	7.75	13.89	4.29	0.24	1.03
11	Chan	855.70	920.72	4788.40	1033.15	66.67	9.58	15.89	4.63	0.27	1.25
12	Chan	920.72	985.74	6081.13	1183.57	65.44	12.16	18.20	5.14	0.31	1.61
13	Chan	985.74	1050.76	6408.35	1231.30	66.77	12.82	18.94	5.20	0.32	1.67
14	Chan	1050.76	1115.78	5851.69	1158.41	65.70	11.70	17.82	5.05	0.31	1.55
15	Chan	1115.78	1180.79	5625.56	1129.77	65.47	11.25	17.38	4.98	0.30	1.49
16	Chan	1180.79	1245.81	4635.01	1008.21	65.86	9.27	15.51	4.60	0.27	1.22
17	Chan	1245.81	1310.83	4352.44	972.57	66.15	8.70	14.96	4.48	0.26	1.14
18	Chan	1310.83	1375.85	4200.49	946.11	65.12	8.40	14.55	4.44	0.25	1.12
19	Chan	1375.85	1440.87	3441.99	839.42	65.09	6.88	12.91	4.10	0.22	0.92
20	ROB	1440.87	1490.55	512.92	466.42	49.91	1.03	9.39	1.10	0.16	0.18
21	ROB	1490.55	2038.98	0.00	112.61	26.29	0.00	4.55	0.00	0.07	0.00
22	ROB	2038.98	2587.42	0.00	258.63	129.61	0.00	2.00	0.00	0.03	0.00
23	ROB	2587.42	3135.85	0.00	1188.22	548.44	0.00	2.17	0.00	0.04	0.00
24	ROB	3135.85	3684.29	0.00	57.50	67.84	0.00	0.85	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 222724.2BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	772.25	790.68	204.19	170.47	25.16	0.41	10.73	1.20	0.21	0.26
2	Chan	790.68	855.70	3506.43	792.44	83.27	7.01	13.60	4.42	0.30	1.33
3	Chan	855.70	920.72	4356.40	914.97	86.13	8.71	15.70	4.76	0.34	1.60
4	Chan	920.72	985.74	5418.83	1050.96	87.79	10.84	18.04	5.16	0.38	1.95
5	Chan	985.74	1050.76	8403.70	1225.70	66.77	16.81	18.85	6.86	0.58	3.98
6	Chan	1050.76	1115.78	5111.04	1020.62	89.07	10.22	17.52	5.01	0.36	1.82
7	Chan	1115.78	1180.79	5261.71	1010.74	83.22	10.52	17.35	5.21	0.38	2.00
8	Chan	1180.79	1245.81	5952.45	1002.44	67.76	11.90	15.42	5.94	0.47	2.78
9	Chan	1245.81	1310.83	3963.80	859.00	84.75	7.93	14.74	4.61	0.32	1.48
10	Chan	1310.83	1375.85	4643.38	897.27	74.54	9.29	14.41	5.18	0.38	1.97
11	Chan	1375.85	1440.87	2593.86	678.99	88.94	5.19	12.51	3.82	0.24	0.92
12	ROB	1440.87	1490.55	584.21	441.18	56.01	1.17	9.34	1.32	0.25	0.33

Plan: Grand Rvr 2017 Grand River Upper RS: 222724.2BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	756.82	786.61	280.41	231.01	30.14	0.56	10.40	1.21	0.21	0.26
2	Chan	786.61	850.94	3669.30	798.96	82.49	7.34	13.88	4.59	0.27	1.23
3	Chan	850.94	915.28	4414.22	903.73	85.07	8.83	15.70	4.88	0.29	1.43
4	Chan	915.28	979.61	5174.08	1000.70	86.49	10.35	17.38	5.17	0.32	1.65
5	Chan	979.61	1043.94	8954.92	1239.75	64.89	17.91	19.27	7.22	0.53	3.81
6	Chan	1043.94	1108.28	4608.16	940.33	88.08	9.22	16.33	4.90	0.29	1.44
7	Chan	1108.28	1172.61	5170.37	986.97	83.65	10.34	17.14	5.24	0.33	1.70
8	Chan	1172.61	1236.94	5692.60	942.81	64.57	11.39	14.66	6.04	0.40	2.43
9	Chan	1236.94	1301.27	3907.57	835.86	84.03	7.82	14.52	4.67	0.27	1.28
10	Chan	1301.27	1365.61	4927.87	917.14	74.83	9.86	14.67	5.37	0.34	1.82
11	Chan	1365.61	1429.94	2664.54	653.34	80.61	5.33	12.41	4.08	0.22	0.91
12	ROB	1429.94	1491.40	535.97	472.58	68.28	1.07	8.77	1.13	0.19	0.22

Plan: Grand Rvr 2017 Grand River Upper RS: 222717.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	151.36	227.05	0.00	6.28	61.78	0.00	0.10	0.00	0.00	0.00
2	LOB	227.05	302.73							0.00	0.00
3	LOB	302.73	378.41							0.00	0.00
4	LOB	378.41	454.09							0.00	0.00
5	LOB	454.09	529.77							0.00	0.00
6	LOB	529.77	605.46							0.00	0.00
7	LOB	605.46	681.14							0.00	0.00
8	LOB	681.14	756.82	0.00	20.67	10.90	0.00	2.05	0.00	0.03	0.00
9	LOB	756.82	786.61	272.37	274.63	31.21	0.54	9.22	0.99	0.13	0.13
10	Chan	786.61	850.94	4057.31	906.65	64.72	8.11	14.09	4.48	0.21	0.96
11	Chan	850.94	915.28	4939.94	1022.53	65.08	9.88	15.89	4.83	0.24	1.16
12	Chan	915.28	979.61	5835.83	1127.83	64.76	11.67	17.53	5.17	0.27	1.38
13	Chan	979.61	1043.94	6849.28	1242.63	64.89	13.70	19.32	5.51	0.29	1.62
14	Chan	1043.94	1108.28	5341.26	1072.84	65.27	10.68	16.68	4.98	0.25	1.25
15	Chan	1108.28	1172.61	5579.53	1099.84	65.05	11.16	17.10	5.07	0.26	1.31
16	Chan	1172.61	1236.94	4359.35	945.68	64.57	8.72	14.70	4.61	0.22	1.03
17	Chan	1236.94	1301.27	4390.18	950.78	64.76	8.78	14.78	4.62	0.22	1.04
18	Chan	1301.27	1365.61	4403.78	950.79	64.46	8.81	14.78	4.63	0.23	1.05
19	Chan	1365.61	1429.94	3442.18	819.98	64.43	6.88	12.75	4.20	0.19	0.82
20	ROB	1429.94	1491.40	528.98	537.66	61.84	1.06	8.75	0.98	0.13	0.13
21	ROB	1491.40	2037.81	0.00	75.76	21.90	0.00	3.67	0.00	0.05	0.00
22	ROB	2037.81	2584.21	0.00	292.55	159.64	0.00	1.83	0.00	0.03	0.00
23	ROB	2584.21	3130.62	0.00	1141.45	546.42	0.00	2.09	0.00	0.03	0.00
24	ROB	3130.62	3677.02	0.00	30.34	45.96	0.00	0.66	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 222516.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	153.74	230.61	0.00	1.86	21.13	0.00	0.09	0.00	0.00	0.00
2	LOB	230.61	307.48	0.00	5.15	58.28	0.00	0.09	0.00	0.00	0.00
3	LOB	307.48	384.35							0.00	0.00
4	LOB	384.35	461.22							0.00	0.00
5	LOB	461.22	538.09							0.00	0.00
6	LOB	538.09	631.89							0.00	0.00
7	LOB	631.89	725.68	74.50	147.15	32.92	0.15	4.62	0.51	0.05	0.02
8	LOB	725.68	819.48	756.76	899.46	93.93	1.51	9.59	0.84	0.10	0.09
9	Chan	819.48	877.52	4312.45	1006.08	58.96	8.62	17.34	4.29	0.18	0.78
10	Chan	877.52	935.55	5038.06	1097.72	58.06	10.08	18.91	4.59	0.20	0.93
11	Chan	935.55	993.59	5203.77	1119.09	58.04	10.41	19.28	4.65	0.21	0.96
12	Chan	993.59	1051.62	5530.11	1160.69	58.04	11.06	20.00	4.76	0.21	1.02
13	Chan	1051.62	1109.66	5290.39	1130.45	58.07	10.58	19.48	4.68	0.21	0.97
14	Chan	1109.66	1167.70	5417.93	1146.57	58.05	10.84	19.76	4.73	0.21	1.00
15	Chan	1167.70	1225.73	5294.71	1131.36	58.12	10.59	19.49	4.68	0.21	0.97
16	Chan	1225.73	1283.77	4707.99	1053.81	58.04	9.42	18.16	4.47	0.19	0.87
17	Chan	1283.77	1341.80	4462.13	1020.45	58.04	8.92	17.58	4.37	0.19	0.82
18	Chan	1341.80	1399.84	3839.41	936.77	58.71	7.68	16.14	4.10	0.17	0.70
19	ROB	1399.84	1443.48	71.82	124.64	24.45	0.14	5.79	0.58	0.05	0.03

Plan: Grand Rvr 2017 Grand River Upper RS: 221221.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	622.90	660.33	82.13	111.73	23.78	0.16	6.02	0.74	0.09	0.07
2	Chan	660.33	719.52	3781.97	751.76	59.28	7.56	12.70	5.03	0.25	1.24
3	Chan	719.52	778.71	3990.84	775.92	59.19	7.98	13.11	5.14	0.25	1.31
4	Chan	778.71	837.89	4155.27	795.54	59.30	8.31	13.44	5.22	0.26	1.36
5	Chan	837.89	897.08	3892.75	764.49	59.21	7.79	12.92	5.09	0.25	1.28
6	Chan	897.08	956.27	3890.19	764.15	59.20	7.78	12.91	5.09	0.25	1.28
7	Chan	956.27	1015.46	4456.70	829.08	59.20	8.91	14.01	5.38	0.27	1.46
8	Chan	1015.46	1074.65	5259.92	917.23	59.44	10.52	15.50	5.73	0.30	1.72
9	Chan	1074.65	1133.83	6095.89	1005.31	59.91	12.19	16.99	6.06	0.33	1.98
10	Chan	1133.83	1193.02	7510.58	1133.93	59.19	15.02	19.16	6.62	0.37	2.46
11	Chan	1193.02	1252.21	6883.74	1113.43	64.45	13.77	18.81	6.18	0.34	2.07
12	ROB	1252.21	1252.31	0.04	0.49	11.11	0.00	5.56	0.07	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 220387.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	314.50	419.33	0.00	73.46	80.30	0.00	0.92	0.00	0.02	0.00
2	LOB	419.33	524.16	0.00	159.28	104.83	0.00	1.52	0.00	0.04	0.00
3	LOB	524.16	628.99	0.00	221.58	104.83	0.00	2.11	0.00	0.05	0.00
4	LOB	628.99	733.83	0.00	209.63	104.83	0.00	2.00	0.00	0.05	0.00
5	LOB	733.83	838.66	0.00	173.47	104.84	0.00	1.65	0.00	0.04	0.00
6	LOB	838.66	943.49	0.00	245.42	101.42	0.00	2.43	0.00	0.06	0.00
7	LOB	943.49	1064.75	772.48	722.74	102.59	1.54	7.18	1.07	0.17	0.18
8	Chan	1064.75	1117.30	3359.24	629.18	52.62	6.72	11.97	5.34	0.29	1.53
9	Chan	1117.30	1169.85	3633.84	659.25	52.56	7.27	12.54	5.51	0.30	1.65
10	Chan	1169.85	1222.41	3515.92	646.47	52.59	7.03	12.30	5.44	0.29	1.60
11	Chan	1222.41	1274.96	4099.15	708.76	52.58	8.20	13.49	5.78	0.32	1.86
12	Chan	1274.96	1327.51	3829.98	680.72	52.63	7.66	12.95	5.63	0.31	1.74
13	Chan	1327.51	1380.06	3935.50	691.56	52.56	7.87	13.16	5.69	0.31	1.79
14	Chan	1380.06	1432.61	6299.03	922.61	53.36	12.60	17.56	6.83	0.41	2.82
15	Chan	1432.61	1485.17	7095.02	984.85	52.55	14.19	18.74	7.20	0.45	3.23
16	Chan	1485.17	1537.72	7261.63	998.67	52.55	14.52	19.00	7.27	0.45	3.31
17	Chan	1537.72	1590.27	6197.98	943.31	57.79	12.40	17.95	6.57	0.39	2.57
18	ROB	1590.27	1590.57	0.23	1.40	10.87	0.00	5.43	0.17	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 219837.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	895.71	909.99	299.65	148.30	24.36	0.60	10.39	2.02	0.13	0.26
2	Chan	909.99	967.87	3724.82	721.27	58.02	7.45	12.46	5.16	0.26	1.35
3	Chan	967.87	1025.74	3803.72	730.65	58.07	7.61	12.62	5.21	0.26	1.38
4	Chan	1025.74	1083.62	3947.57	746.51	57.95	7.90	12.90	5.29	0.27	1.43
5	Chan	1083.62	1141.49	4114.73	765.17	57.93	8.23	13.22	5.38	0.28	1.49
6	Chan	1141.49	1199.37	4163.01	770.54	57.93	8.33	13.31	5.40	0.28	1.51
7	Chan	1199.37	1257.25	4044.33	757.53	57.97	8.09	13.09	5.34	0.27	1.47
8	Chan	1257.25	1315.12	5447.17	907.14	58.20	10.89	15.67	6.00	0.33	1.97
9	Chan	1315.12	1373.00	6817.70	1036.74	58.04	13.64	17.91	6.58	0.38	2.47
10	Chan	1373.00	1430.87	7125.11	1063.60	57.91	14.25	18.38	6.70	0.39	2.59
11	Chan	1430.87	1488.75	6512.21	1046.09	63.58	13.02	18.07	6.23	0.35	2.15
12	ROB	1488.75	1488.76	0.00	0.03	10.78	0.00	5.31	0.01	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 219802.8BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	895.71	909.99	385.85	147.20	24.28	0.77	10.31	2.62	0.22	0.57
2	Chan	909.99	967.87	3137.17	644.67	81.39	6.27	11.75	4.87	0.28	1.37
3	Chan	967.87	1025.74	4791.50	726.19	58.07	9.58	12.55	6.60	0.45	2.94
4	Chan	1025.74	1083.62	3378.27	672.87	81.06	6.76	12.26	5.02	0.30	1.48
5	Chan	1083.62	1141.49	3765.55	706.48	77.81	7.53	12.87	5.33	0.32	1.72
6	Chan	1141.49	1199.37	5096.11	762.09	59.73	10.19	13.17	6.69	0.45	3.04
7	Chan	1199.37	1257.25	3557.31	691.06	80.19	7.11	12.59	5.15	0.31	1.58
8	Chan	1257.25	1315.12	6875.42	902.68	58.20	13.75	15.60	7.62	0.55	4.20
9	Chan	1315.12	1373.00	5296.42	918.74	89.96	10.59	16.74	5.76	0.36	2.10
10	Chan	1373.00	1430.87	5487.70	942.18	90.84	10.98	17.17	5.82	0.37	2.15
11	Chan	1430.87	1488.75	8228.70	1041.63	63.58	16.46	18.00	7.90	0.58	4.61
12	ROB	1488.75	1488.76	0.00	0.03	10.70	0.00	5.28	0.02	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 219802.8BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	907.89	913.70	103.64	56.69	14.94	0.21	9.76	1.83	0.12	0.22
2	Chan	913.70	973.49	3908.61	714.46	71.01	7.82	11.99	5.47	0.33	1.78
3	Chan	973.49	1033.28	4165.02	731.05	68.37	8.33	12.83	5.70	0.35	1.97
4	Chan	1033.28	1093.07	3546.79	713.45	81.85	7.09	12.56	4.97	0.28	1.40
5	Chan	1093.07	1152.86	5198.21	791.84	59.87	10.40	13.24	6.56	0.43	2.81
6	Chan	1152.86	1212.65	3784.80	737.41	80.65	7.57	12.99	5.13	0.30	1.52
7	Chan	1212.65	1272.43	3482.42	703.49	81.23	6.96	12.39	4.95	0.28	1.39
8	Chan	1272.43	1332.22	6811.43	933.36	60.21	13.62	15.61	7.30	0.50	3.66
9	Chan	1332.22	1392.01	5231.63	932.48	89.23	10.46	16.42	5.61	0.34	1.90
10	Chan	1392.01	1451.80	5382.55	960.13	91.99	10.77	16.91	5.61	0.34	1.89
11	Chan	1451.80	1511.59	8384.92	1094.04	65.57	16.77	18.30	7.66	0.54	4.13
12	ROB	1511.59	1511.60	0.00	0.03	10.55	0.00	5.34	0.02	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 219767.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	907.89	913.70	82.88	56.91	14.95	0.17	9.80	1.46	0.08	0.11
2	Chan	913.70	973.49	3619.07	724.36	60.00	7.24	12.12	5.00	0.25	1.23
3	Chan	973.49	1033.28	4001.20	769.03	59.94	8.00	12.86	5.20	0.26	1.36
4	Chan	1033.28	1093.07	4050.10	775.07	60.02	8.10	12.96	5.23	0.26	1.38
5	Chan	1093.07	1152.86	4224.56	794.12	59.87	8.45	13.28	5.32	0.27	1.44
6	Chan	1152.86	1212.65	4205.33	792.67	60.00	8.41	13.26	5.31	0.27	1.43
7	Chan	1212.65	1272.43	3935.14	762.20	60.10	7.87	12.75	5.16	0.26	1.34
8	Chan	1272.43	1332.22	5531.59	935.65	60.21	11.06	15.65	5.91	0.32	1.88
9	Chan	1332.22	1392.01	6540.05	1035.12	60.29	13.08	17.31	6.32	0.35	2.22
10	Chan	1392.01	1451.80	7004.71	1075.94	59.91	14.01	18.00	6.51	0.37	2.39
11	Chan	1451.80	1511.59	6805.35	1096.33	65.57	13.61	18.34	6.21	0.34	2.12

Plan: Grand Rvr 2017 Grand River Upper RS: 219767.8 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
12	ROB	1511.59	1511.60	0.00	0.03	10.68	0.00	5.31	0.01	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 219354.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1234.08	1292.48	57.77	56.16	21.23	0.12	3.50	1.03	0.04	0.05
2	Chan	1292.48	1351.93	3697.86	790.41	61.88	7.40	13.30	4.68	0.21	0.99
3	Chan	1351.93	1411.38	3989.26	814.04	59.45	7.98	13.69	4.90	0.23	1.11
4	Chan	1411.38	1470.83	4487.73	873.82	59.48	8.98	14.70	5.14	0.24	1.25
5	Chan	1470.83	1530.28	4645.25	892.35	59.53	9.29	15.01	5.21	0.25	1.29
6	Chan	1530.28	1589.73	4210.99	840.89	59.45	8.42	14.14	5.01	0.23	1.17
7	Chan	1589.73	1649.17	4190.77	838.46	59.45	8.38	14.10	5.00	0.23	1.17
8	Chan	1649.17	1708.62	4874.72	920.40	59.83	9.75	15.48	5.30	0.25	1.35
9	Chan	1708.62	1768.07	6733.77	1114.48	59.45	13.47	18.75	6.04	0.31	1.87
10	Chan	1768.07	1827.52	6762.62	1117.32	59.45	13.53	18.79	6.05	0.31	1.88
11	Chan	1827.52	1886.97	6348.89	1110.00	64.29	12.70	18.67	5.72	0.29	1.63
12	ROB	1886.97	1887.44	0.39	2.09	10.46	0.00	5.23	0.18	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 218588.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	644.92	752.41	0.00	13.74	80.19	0.00	0.17	0.00	0.00	0.00
2	LOB	752.41	859.89	0.00	61.51	107.49	0.00	0.57	0.00	0.01	0.00
3	LOB	859.89	967.38	0.00	92.29	96.60	0.00	0.96	0.00	0.01	0.00
4	LOB	967.38	1076.82	265.66	263.17	94.93	0.53	2.90	1.01	0.04	0.04
5	Chan	1076.82	1134.51	3541.99	786.68	60.18	7.08	13.64	4.50	0.20	0.88
6	Chan	1134.51	1192.20	3925.22	822.68	57.69	7.85	14.26	4.77	0.21	1.02
7	Chan	1192.20	1249.89	4024.24	835.07	57.69	8.05	14.47	4.82	0.22	1.05
8	Chan	1249.89	1307.58	4023.61	834.99	57.69	8.05	14.47	4.82	0.22	1.04
9	Chan	1307.58	1365.28	4022.65	834.87	57.69	8.05	14.47	4.82	0.22	1.04
10	Chan	1365.28	1422.97	4153.21	851.06	57.70	8.31	14.75	4.88	0.22	1.08
11	Chan	1422.97	1480.66	5186.91	973.48	57.85	10.37	16.87	5.33	0.25	1.34
12	Chan	1480.66	1538.35	7032.58	1167.71	57.74	14.07	20.24	6.02	0.30	1.82
13	Chan	1538.35	1596.04	7232.48	1187.18	57.70	14.46	20.58	6.09	0.31	1.88
14	Chan	1596.04	1653.73	6590.63	1190.56	66.81	13.18	20.64	5.54	0.27	1.48
15	ROB	1653.73	1654.50	0.84	3.43	10.36	0.00	5.17	0.24	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 217611.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	512.50	615.00	0.00	35.50	99.74	0.00	0.36	0.00	0.01	0.00
2	LOB	615.00	717.50	0.00	152.35	102.51	0.00	1.49	0.00	0.03	0.00
3	LOB	717.50	820.00	0.00	165.51	102.50	0.00	1.61	0.00	0.03	0.00
4	LOB	820.00	922.50	0.00	113.36	83.03	0.00	1.37	0.00	0.03	0.00
5	LOB	922.50	998.53	110.93	96.64	34.63	0.22	3.21	1.15	0.05	0.06
6	Chan	998.53	1053.82	4324.96	808.06	58.50	8.65	14.61	5.35	0.27	1.42
7	Chan	1053.82	1109.12	4894.68	850.95	55.30	9.79	15.39	5.75	0.30	1.70
8	Chan	1109.12	1164.41	4777.23	838.69	55.31	9.55	15.17	5.70	0.29	1.66
9	Chan	1164.41	1219.70	4953.88	857.06	55.29	9.91	15.50	5.78	0.30	1.72
10	Chan	1219.70	1275.00	5127.44	874.98	55.30	10.25	15.82	5.86	0.30	1.78
11	Chan	1275.00	1330.29	5300.72	892.60	55.30	10.60	16.14	5.94	0.31	1.84
12	Chan	1330.29	1385.58	5139.68	876.33	55.31	10.28	15.85	5.87	0.30	1.78
13	Chan	1385.58	1440.87	5077.44	869.86	55.30	10.15	15.73	5.84	0.30	1.76
14	Chan	1440.87	1496.17	5232.94	885.74	55.30	10.47	16.02	5.91	0.31	1.82
15	Chan	1496.17	1551.46	5058.14	896.87	60.03	10.12	16.22	5.64	0.29	1.62
16	ROB	1551.46	1552.77	1.98	5.26	10.01	0.00	4.97	0.38	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 216869.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	206.75	310.13	0.00	52.52	89.66	0.00	0.59	0.00	0.01	0.00
2	LOB	310.13	413.50	0.00	155.87	103.38	0.00	1.51	0.00	0.02	0.00
3	LOB	413.50	516.88	0.00	220.09	103.38	0.00	2.13	0.00	0.03	0.00
4	LOB	516.88	620.25	0.00	207.27	103.38	0.00	2.01	0.00	0.03	0.00
5	LOB	620.25	723.63	0.00	190.52	103.38	0.00	1.84	0.00	0.03	0.00
6	LOB	723.63	827.00	0.00	144.07	103.38	0.00	1.39	0.00	0.02	0.00
7	LOB	827.00	963.54	39.13	98.96	136.54	0.08	0.72	0.40	0.01	0.00
8	LOB	963.54	1100.07	0.18	2.02	26.53	0.00	0.12	0.09	0.00	0.00
9	Chan	1100.07	1153.81	4248.87	845.52	56.30	8.50	15.73	5.03	0.23	1.15
10	Chan	1153.81	1207.55	5081.98	924.05	53.74	10.16	17.19	5.50	0.26	1.44
11	Chan	1207.55	1261.29	4989.44	913.90	53.74	9.98	17.01	5.46	0.26	1.41
12	Chan	1261.29	1315.03	5080.34	923.87	53.74	10.16	17.19	5.50	0.26	1.44
13	Chan	1315.03	1368.77	5025.93	917.97	53.75	10.05	17.08	5.48	0.26	1.42
14	Chan	1368.77	1422.51	5551.71	974.62	53.78	11.10	18.14	5.70	0.28	1.57
15	Chan	1422.51	1476.25	5769.68	997.19	53.75	11.54	18.56	5.79	0.28	1.63
16	Chan	1476.25	1529.99	5179.91	934.82	53.76	10.36	17.40	5.54	0.26	1.46
17	Chan	1529.99	1583.73	4745.10	886.96	53.77	9.49	16.50	5.35	0.25	1.34
18	Chan	1583.73	1637.47	4287.73	860.58	58.05	8.58	16.01	4.98	0.23	1.12
19	ROB	1637.47	1637.48	0.00	0.04	9.54	0.00	4.76	0.01	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 216850.9BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	206.75	310.13	0.00	49.32	0.00	0.00	0.55	0.00	0.00	0.00
2	LOB	310.13	413.50	0.00	152.16	0.00	0.00	1.47	0.00	0.00	0.00
3	LOB	413.50	516.88	0.00	216.39	0.00	0.00	2.09	0.00	0.00	0.00
4	LOB	516.88	620.25	0.00	203.56	0.00	0.00	1.97	0.00	0.00	0.00
5	LOB	620.25	723.63	0.00	186.82	0.00	0.00	1.81	0.00	0.00	0.00
6	LOB	723.63	827.00	0.00	140.36	0.00	0.00	1.36	0.00	0.00	0.00
7	LOB	827.00	963.54	42.19	94.07	136.54	0.08	0.69	0.45	0.01	0.01
8	LOB	963.54	1100.07	0.13	1.46	23.81	0.00	0.10	0.09	0.00	0.00
9	Chan	1100.07	1153.81	4797.25	843.59	56.30	9.59	15.70	5.69	0.31	1.76
10	Chan	1153.81	1207.55	5739.73	922.12	53.74	11.48	17.16	6.22	0.36	2.21
11	Chan	1207.55	1261.29	3547.48	818.83	82.19	7.09	16.14	4.33	0.21	0.89
12	Chan	1261.29	1315.03	5737.88	921.94	53.74	11.48	17.16	6.22	0.36	2.21
13	Chan	1315.03	1368.77	5676.30	916.04	53.75	11.35	17.05	6.20	0.35	2.19
14	Chan	1368.77	1422.51	3830.29	869.86	85.21	7.66	17.14	4.40	0.21	0.93
15	Chan	1422.51	1476.25	6518.11	995.27	53.75	13.04	18.52	6.55	0.38	2.51
16	Chan	1476.25	1529.99	5850.58	932.90	53.76	11.70	17.36	6.27	0.36	2.25
17	Chan	1529.99	1583.73	3418.61	796.00	80.95	6.84	15.69	4.29	0.20	0.87
18	Chan	1583.73	1637.47	4841.45	858.65	58.05	9.68	15.98	5.64	0.31	1.73
19	ROB	1637.47	1637.48	0.00	0.04	9.44	0.00	4.77	0.02	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 216850.9BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	117.14	234.29	0.00	0.97	0.00	0.00	0.12	0.00	0.00	0.00
2	LOB	234.29	351.43	0.00	77.37	0.00	0.00	0.66	0.00	0.00	0.00
3	LOB	351.43	468.57	0.00	204.58	0.00	0.00	1.75	0.00	0.00	0.00
4	LOB	468.57	585.71	0.00	224.27	0.00	0.00	1.91	0.00	0.00	0.00
5	LOB	585.71	702.86	0.00	186.86	0.00	0.00	1.60	0.00	0.00	0.00
6	LOB	702.86	820.00	0.00	114.79	0.00	0.00	0.98	0.00	0.00	0.00
7	LOB	820.00	915.90	5.05	19.50	70.48	0.01	0.28	0.26	0.01	0.00
8	LOB	915.90	1011.80							0.00	0.00
9	LOB	1011.80	1107.70	0.00	0.04	9.42	0.00	4.75	0.02	0.00	0.00
10	Chan	1107.70	1161.41	4927.52	854.11	56.86	9.86	15.90	5.77	0.32	1.84
11	Chan	1161.41	1215.12	5866.25	926.92	53.71	11.73	17.26	6.33	0.37	2.32
12	Chan	1215.12	1268.83	3514.21	800.47	80.28	7.03	15.79	4.39	0.21	0.93
13	Chan	1268.83	1322.54	5362.69	878.43	53.73	10.73	16.36	6.10	0.35	2.12

Plan: Grand Rvr 2017 Grand River Upper RS: 216850.9BR D Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
14	Chan	1322.54	1376.25	5934.43	933.42	53.72	11.87	17.38	6.36	0.37	2.35
15	Chan	1376.25	1429.96	3611.81	819.64	81.75	7.22	16.16	4.41	0.21	0.94
16	Chan	1429.96	1483.67	6431.19	979.71	53.74	12.86	18.24	6.56	0.39	2.54
17	Chan	1483.67	1537.38	5994.06	939.31	53.76	11.99	17.49	6.38	0.37	2.37
18	Chan	1537.38	1591.09	3307.98	768.28	79.33	6.62	15.15	4.31	0.21	0.89
19	Chan	1591.09	1644.80	5044.81	870.70	57.60	10.09	16.21	5.79	0.32	1.86
20	ROB	1644.80	1644.81	0.00	0.04	9.52	0.00	4.70	0.02	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 216832.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	117.14	234.29	0.00	1.14	8.78	0.00	0.13	0.00	0.00	0.00
2	LOB	234.29	351.43	0.00	79.72	117.15	0.00	0.68	0.00	0.01	0.00
3	LOB	351.43	468.57	0.00	206.92	117.15	0.00	1.77	0.00	0.03	0.00
4	LOB	468.57	585.71	0.00	226.61	117.14	0.00	1.93	0.00	0.03	0.00
5	LOB	585.71	702.86	0.00	189.20	117.14	0.00	1.62	0.00	0.03	0.00
6	LOB	702.86	820.00	0.00	117.13	117.15	0.00	1.00	0.00	0.02	0.00
7	LOB	820.00	915.90	4.83	20.93	72.52	0.01	0.29	0.23	0.00	0.00
8	LOB	915.90	1011.80							0.00	0.00
9	LOB	1011.80	1107.70	0.00	0.04	9.49	0.00	4.74	0.01	0.00	0.00
10	Chan	1107.70	1161.41	4414.74	855.18	56.86	8.83	15.92	5.16	0.24	1.24
11	Chan	1161.41	1215.12	5254.91	928.00	53.71	10.51	17.28	5.66	0.28	1.56
12	Chan	1215.12	1268.83	4885.55	888.58	53.76	9.77	16.54	5.50	0.26	1.45
13	Chan	1268.83	1322.54	4804.34	879.51	53.73	9.61	16.38	5.46	0.26	1.43
14	Chan	1322.54	1376.25	5315.91	934.50	53.72	10.63	17.40	5.69	0.28	1.58
15	Chan	1376.25	1429.96	5106.13	912.46	53.76	10.21	16.99	5.60	0.27	1.52
16	Chan	1429.96	1483.67	5760.38	980.79	53.74	11.52	18.26	5.87	0.29	1.71
17	Chan	1483.67	1537.38	5369.27	940.39	53.76	10.74	17.51	5.71	0.28	1.60
18	Chan	1537.38	1591.09	4564.31	853.21	53.78	9.13	15.89	5.35	0.25	1.36
19	Chan	1591.09	1644.80	4519.64	871.77	57.60	9.04	16.23	5.18	0.24	1.25
20	ROB	1644.80	1644.81	0.00	0.04	9.49	0.00	4.75	0.01	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 216378.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	322.82	430.43	0.00	2.96	38.35	0.00	0.08	0.00	0.00	0.00
2	LOB	430.43	538.03	0.00	67.33	107.62	0.00	0.63	0.00	0.01	0.00
3	LOB	538.03	645.64	0.00	245.40	107.62	0.00	2.28	0.00	0.03	0.00
4	LOB	645.64	735.30	293.28	279.70	89.66	0.59	3.12	1.05	0.04	0.05
5	LOB	735.30	824.96	305.60	286.69	89.66	0.61	3.20	1.07	0.04	0.05
6	LOB	824.96	914.62	327.26	298.72	89.66	0.65	3.33	1.10	0.05	0.05
7	LOB	914.62	1004.28	414.83	351.63	94.45	0.83	3.92	1.18	0.05	0.06
8	Chan	1004.28	1057.04	3953.52	831.98	56.34	7.91	15.77	4.75	0.21	0.97
9	Chan	1057.04	1109.80	4770.56	907.13	52.76	9.54	17.19	5.26	0.24	1.26
10	Chan	1109.80	1162.57	4816.31	912.32	52.76	9.63	17.29	5.28	0.24	1.27
11	Chan	1162.57	1215.33	4766.58	906.66	52.76	9.53	17.18	5.26	0.24	1.25
12	Chan	1215.33	1268.09	4842.31	915.29	52.77	9.68	17.35	5.29	0.24	1.27
13	Chan	1268.09	1320.85	5076.40	941.58	52.76	10.15	17.85	5.39	0.25	1.34
14	Chan	1320.85	1373.61	5164.96	951.40	52.76	10.33	18.03	5.43	0.25	1.36
15	Chan	1373.61	1426.38	5322.38	968.69	52.76	10.64	18.36	5.49	0.25	1.40
16	Chan	1426.38	1479.14	5330.69	969.60	52.76	10.66	18.38	5.50	0.26	1.40
17	Chan	1479.14	1531.90	4615.29	938.44	60.36	9.23	17.79	4.92	0.22	1.06
18	ROB	1531.90	1532.00	0.02	0.41	9.71	0.00	4.85	0.06	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 216034.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	908.00	955.53	265.50	215.39	54.38	0.53	4.63	1.23	0.16	0.19
2	Chan	955.53	1009.19	6352.40	797.55	54.82	12.70	14.86	7.96	0.58	4.61

Plan: Grand Rvr 2017 Grand River Upper RS: 216034.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
3	Chan	1009.19	1062.85	8047.98	911.43	53.67	16.10	16.98	8.83	0.68	5.96
4	Chan	1062.85	1116.52	8173.90	919.89	53.66	16.35	17.14	8.89	0.68	6.06
5	Chan	1116.52	1170.18	8100.40	914.91	53.66	16.20	17.05	8.85	0.68	6.00
6	Chan	1170.18	1223.84	3903.20	920.53	53.66	7.81	17.15	4.24	0.68	2.89
7	Chan	1223.84	1277.50	3009.51	948.28	53.66	6.02	17.67	3.17	0.70	2.23
8	Chan	1277.50	1331.16	3066.26	958.96	53.66	6.13	17.87	3.20	0.71	2.27
9	Chan	1331.16	1384.83	3160.31	976.51	53.66	6.32	18.20	3.24	0.72	2.34
10	Chan	1384.83	1438.49	3170.97	978.48	53.66	6.34	18.23	3.24	0.73	2.35
11	Chan	1438.49	1492.15	2748.36	946.85	61.26	5.50	17.64	2.90	0.61	1.78
12	ROB	1492.15	1527.01	1.23	4.44	9.73	0.00	5.22	0.28	0.02	0.01

Plan: Grand Rvr 2017 Grand River Upper RS: 216020.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	908.00	955.53	117.45	196.09	58.12	0.23	4.21	0.60	0.04	0.02
2	Chan	955.53	1009.26	4933.63	980.17	54.66	9.87	18.24	5.03	0.21	1.08
3	Chan	1009.26	1062.99	5008.64	982.36	53.73	10.02	18.28	5.10	0.22	1.12
4	Chan	1062.99	1116.73	5008.64	982.36	53.73	10.02	18.28	5.10	0.22	1.12
5	Chan	1116.73	1170.46	5008.63	982.36	53.73	10.02	18.28	5.10	0.22	1.12
6	Chan	1170.46	1224.19	5008.63	982.36	53.73	10.02	18.28	5.10	0.22	1.12
7	Chan	1224.19	1277.92	5008.64	982.36	53.73	10.02	18.28	5.10	0.22	1.12
8	Chan	1277.92	1331.65	5008.64	982.36	53.73	10.02	18.28	5.10	0.22	1.12
9	Chan	1331.65	1385.39	5008.63	982.36	53.73	10.02	18.28	5.10	0.22	1.12
10	Chan	1385.39	1439.12	5008.63	982.36	53.73	10.02	18.28	5.10	0.22	1.12
11	Chan	1439.12	1492.85	4879.83	982.35	55.87	9.76	18.28	4.97	0.21	1.05
12	ROB	1492.85	1527.01	0.00	0.26	16.27	0.00	1.71	0.02	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215862.7 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	951.80	1026.50	55.55	88.04	51.83	0.11	2.28	0.63	0.02	0.01
2	Chan	1026.50	1077.18	4222.67	883.62	50.70	8.45	17.44	4.78	0.20	0.94
3	Chan	1077.18	1127.85	4566.98	926.47	50.74	9.13	18.28	4.93	0.21	1.01
4	Chan	1127.85	1178.53	5827.54	1072.56	50.77	11.66	21.17	5.43	0.24	1.29
5	Chan	1178.53	1229.20	5192.73	1004.07	51.17	10.39	19.81	5.17	0.22	1.14
6	Chan	1229.20	1279.88	5056.19	984.30	50.68	10.11	19.42	5.14	0.22	1.12
7	Chan	1279.88	1330.55	5318.29	1014.60	50.68	10.64	20.02	5.24	0.23	1.18
8	Chan	1330.55	1381.23	5378.36	1021.51	50.68	10.76	20.16	5.27	0.23	1.19
9	Chan	1381.23	1431.90	4861.29	961.47	50.69	9.72	18.97	5.06	0.21	1.08
10	Chan	1431.90	1482.58	4581.34	927.72	50.67	9.16	18.31	4.94	0.21	1.02
11	Chan	1482.58	1533.25	4367.14	901.80	50.72	8.73	17.80	4.84	0.20	0.97
12	ROB	1533.25	1843.84	571.92	526.46	146.61	1.14	3.65	1.09	0.04	0.04
13	ROB	1843.84	2484.50	0.00	581.51	219.94	0.00	2.64	0.00	0.03	0.00
14	ROB	2484.50	3125.16	0.00	3900.75	640.70	0.00	6.09	0.00	0.07	0.00
15	ROB	3125.16	3765.82	0.00	3696.45	640.68	0.00	5.77	0.00	0.06	0.00
16	ROB	3765.82	4406.48	0.00	1062.53	358.76	0.00	2.96	0.00	0.03	0.00
17	ROB	4406.48	5047.15	0.00	328.02	512.13	0.00	0.64	0.00	0.01	0.00
18	ROB	5047.15	5687.81	0.00	76.93	200.52	0.00	0.38	0.00	0.00	0.00
19	ROB	5687.81	6328.47							0.00	0.00
20	ROB	6328.47	6969.13							0.00	0.00
21	ROB	6969.13	7609.79	0.00	458.66	316.65	0.00	1.45	0.00	0.02	0.00
22	ROB	7609.79	8250.45	0.00	28.44	55.02	0.00	0.52	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215642.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	182.15	273.23	0.00	65.10	87.21	0.00	0.75	0.00	0.01	0.00
2	LOB	273.23	364.31	0.00	88.65	91.08	0.00	0.97	0.00	0.01	0.00
3	LOB	364.31	455.38	0.00	88.65	91.08	0.00	0.97	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215642.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
4	LOB	455.38	546.46	0.00	88.65	91.08	0.00	0.97	0.00	0.01	0.00
5	LOB	546.46	637.53	0.00	88.65	91.08	0.00	0.97	0.00	0.01	0.00
6	LOB	637.53	728.61	0.00	89.18	91.08	0.00	0.98	0.00	0.01	0.00
7	LOB	728.61	820.10	49.18	109.42	91.49	0.10	1.20	0.45	0.01	0.01
8	LOB	820.10	911.58	214.34	279.35	104.71	0.43	3.05	0.77	0.03	0.02
9	Chan	911.58	961.17	5011.52	992.56	49.97	10.02	20.01	5.05	0.21	1.06
10	Chan	961.17	1010.76	5855.33	1086.67	49.63	11.71	21.91	5.39	0.23	1.25
11	Chan	1010.76	1060.36	6268.53	1132.38	49.66	12.54	22.83	5.54	0.24	1.33
12	Chan	1060.36	1109.95	4872.54	974.62	49.80	9.75	19.65	5.00	0.21	1.03
13	Chan	1109.95	1159.54	4679.88	949.71	49.59	9.36	19.15	4.93	0.20	1.00
14	Chan	1159.54	1209.13	4701.62	952.36	49.59	9.40	19.20	4.94	0.20	1.00
15	Chan	1209.13	1258.72	4554.82	934.41	49.59	9.11	18.84	4.87	0.20	0.97
16	Chan	1258.72	1308.32	4495.34	927.06	49.59	8.99	18.69	4.85	0.20	0.96
17	Chan	1308.32	1357.91	4455.78	922.16	49.59	8.91	18.60	4.83	0.20	0.95
18	Chan	1357.91	1407.50	4183.23	888.22	49.64	8.37	17.91	4.71	0.19	0.89
19	ROB	1407.50	1577.61	657.90	486.60	91.31	1.32	5.49	1.35	0.06	0.08
20	ROB	1577.61	2225.33	0.00	53.05	37.42	0.00	1.42	0.00	0.01	0.00
21	ROB	2225.33	2873.05	0.00	3424.33	647.80	0.00	5.29	0.00	0.06	0.00
22	ROB	2873.05	3520.77	0.00	3858.99	647.79	0.00	5.96	0.00	0.06	0.00
23	ROB	3520.77	4168.49	0.00	1982.62	647.84	0.00	3.06	0.00	0.03	0.00
24	ROB	4168.49	4816.21	0.00	125.35	186.53	0.00	0.67	0.00	0.01	0.00
25	ROB	4816.21	5463.92	0.00	87.11	154.64	0.00	0.56	0.00	0.01	0.00
26	ROB	5463.92	6111.64	0.00	128.85	193.61	0.00	0.67	0.00	0.01	0.00
27	ROB	6111.64	6759.36							0.00	0.00
28	ROB	6759.36	7407.08	0.00	1305.24	393.71	0.00	3.32	0.00	0.04	0.00
29	ROB	7407.08	8054.80	0.00	786.34	319.57	0.00	2.46	0.00	0.03	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215385.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	51.59	103.18	0.00	36.87	47.96	0.00	0.77	0.00	0.01	0.00
2	LOB	103.18	154.78	0.00	47.22	51.59	0.00	0.92	0.00	0.01	0.00
3	LOB	154.78	206.37	0.00	3.22	4.23	0.00	1.00	0.00	0.01	0.00
4	LOB	206.37	257.96							0.00	0.00
5	LOB	257.96	309.55							0.00	0.00
6	LOB	309.55	361.15							0.00	0.00
7	LOB	361.15	412.74							0.00	0.00
8	LOB	412.74	464.33	0.00	76.89	46.24	0.00	1.73	0.00	0.02	0.00
9	LOB	464.33	493.92	576.86	314.49	38.96	1.15	10.63	1.83	0.10	0.18
10	Chan	493.92	544.22	5197.75	1015.76	54.99	10.40	20.20	5.12	0.22	1.12
11	Chan	544.22	594.51	4682.82	922.92	50.60	9.37	18.35	5.07	0.22	1.10
12	Chan	594.51	644.81	4784.27	932.64	50.30	9.57	18.54	5.13	0.22	1.13
13	Chan	644.81	695.11	4998.44	957.47	50.30	10.00	19.04	5.22	0.23	1.18
14	Chan	695.11	745.41	5080.12	967.05	50.33	10.16	19.23	5.25	0.23	1.20
15	Chan	745.41	795.70	4976.40	954.98	50.31	9.95	18.99	5.21	0.23	1.18
16	Chan	795.70	846.00	5188.84	979.76	50.37	10.38	19.48	5.30	0.23	1.23
17	Chan	846.00	896.30	4729.38	926.34	50.32	9.46	18.42	5.11	0.22	1.12
18	Chan	896.30	946.59	4768.59	930.91	50.31	9.54	18.51	5.12	0.22	1.13
19	Chan	946.59	996.89	4420.74	889.61	50.32	8.84	17.69	4.97	0.21	1.05
20	ROB	996.89	1120.52	595.78	400.52	55.05	1.19	8.68	1.49	0.09	0.13
21	ROB	1120.52	1738.08							0.00	0.00
22	ROB	1738.08	2355.63	0.00	1096.37	271.15	0.00	4.07	0.00	0.05	0.00
23	ROB	2355.63	2973.19	0.00	811.32	180.48	0.00	4.55	0.00	0.05	0.00
24	ROB	2973.19	3590.75							0.00	0.00
25	ROB	3590.75	4208.31							0.00	0.00
26	ROB	4208.31	4825.86							0.00	0.00
27	ROB	4825.86	5443.42							0.00	0.00
28	ROB	5443.42	6060.98							0.00	0.00
29	ROB	6060.98	6678.53							0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215385.6 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
30	ROB	6678.53	7296.09	0.00	914.30	153.03	0.00	6.10	0.00	0.07	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215358.1BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	51.59	103.18	0.00	34.61	47.20	0.00	0.73	0.00	0.01	0.00
2	LOB	103.18	154.78	0.00	44.76	51.59	0.00	0.87	0.00	0.02	0.00
3	LOB	154.78	206.37	0.00	3.07	4.19	0.00	0.95	0.00	0.01	0.00
4	LOB	206.37	257.96							0.00	0.00
5	LOB	257.96	309.55							0.00	0.00
6	LOB	309.55	361.15							0.00	0.00
7	LOB	361.15	412.74							0.00	0.00
8	LOB	412.74	464.33	0.00	68.67	43.74	0.00	1.70	0.00	0.03	0.00
9	LOB	464.33	493.92	706.26	313.08	40.47	1.41	10.58	2.26	0.15	0.33
10	Chan	493.92	544.22	6234.97	1013.36	54.99	12.47	20.15	6.15	0.35	2.16
11	Chan	544.22	594.51	3375.94	825.39	82.63	6.75	17.83	4.09	0.19	0.78
12	Chan	594.51	644.81	5736.95	930.24	50.30	11.47	18.50	6.17	0.35	2.17
13	Chan	644.81	695.11	3498.27	851.22	84.61	7.00	18.39	4.11	0.19	0.79
14	Chan	695.11	745.41	6092.65	964.66	50.33	12.19	19.18	6.32	0.36	2.30
15	Chan	745.41	795.70	5967.96	952.58	50.31	11.94	18.94	6.27	0.36	2.26
16	Chan	795.70	846.00	3550.94	864.19	85.92	7.10	18.67	4.11	0.19	0.79
17	Chan	846.00	896.30	5670.98	923.94	50.32	11.34	18.37	6.14	0.35	2.15
18	Chan	896.30	946.59	3375.96	829.57	83.68	6.75	17.92	4.07	0.19	0.77
19	Chan	946.59	996.89	5299.94	887.21	50.32	10.60	17.64	5.97	0.34	2.01
20	ROB	996.89	1120.52	489.19	330.78	75.93	0.98	7.87	1.48	0.08	0.12
21	ROB	1120.52	1738.08							0.00	0.00
22	ROB	1738.08	2355.63	0.00	1083.53	270.55	0.00	4.03	0.00	0.08	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215358.1BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	48.71	97.42	0.00	27.60	41.29	0.00	0.67	0.00	0.01	0.00
2	LOB	97.42	146.13	0.00	24.82	34.31	0.00	0.72	0.00	0.01	0.00
3	LOB	146.13	194.84							0.00	0.00
4	LOB	194.84	243.55							0.00	0.00
5	LOB	243.55	292.26							0.00	0.00
6	LOB	292.26	340.97							0.00	0.00
7	LOB	340.97	389.68							0.00	0.00
8	LOB	389.68	441.80							0.00	0.00
9	LOB	441.80	493.92	703.40	313.20	43.08	1.41	9.90	2.25	0.14	0.31
10	Chan	493.92	544.22	6214.10	1012.67	54.99	12.43	20.13	6.14	0.35	2.14
11	Chan	544.22	594.51	3364.89	824.75	82.61	6.73	17.81	4.08	0.19	0.77
12	Chan	594.51	644.81	5717.16	929.55	50.30	11.43	18.48	6.15	0.35	2.15
13	Chan	644.81	695.11	3486.94	850.59	84.58	6.97	18.37	4.10	0.19	0.78
14	Chan	695.11	745.41	6071.91	963.96	50.33	12.14	19.17	6.30	0.36	2.29
15	Chan	745.41	795.70	5947.55	951.89	50.31	11.90	18.93	6.25	0.36	2.24
16	Chan	795.70	846.00	3539.49	863.56	85.89	7.08	18.65	4.10	0.19	0.78
17	Chan	846.00	896.30	5651.38	923.25	50.32	11.30	18.36	6.12	0.35	2.13
18	Chan	896.30	946.59	3364.93	828.93	83.65	6.73	17.90	4.06	0.19	0.76
19	Chan	946.59	996.89	5281.34	886.52	50.32	10.56	17.63	5.96	0.33	1.99
20	ROB	996.89	1066.59	656.93	468.78	96.43	1.31	7.39	1.40	0.09	0.13
21	ROB	1066.59	1688.48							0.00	0.00
22	ROB	1688.48	2310.36	0.00	645.67	144.22	0.00	4.56	0.00	0.08	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215330.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	48.71	97.42	0.00	28.52	41.65	0.00	0.69	0.00	0.01	0.00
2	LOB	97.42	146.13	0.00	25.58	34.57	0.00	0.74	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215330.5 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
3	LOB	146.13	194.84							0.00	0.00
4	LOB	194.84	243.55							0.00	0.00
5	LOB	243.55	292.26							0.00	0.00
6	LOB	292.26	340.97							0.00	0.00
7	LOB	340.97	389.68							0.00	0.00
8	LOB	389.68	441.80							0.00	0.00
9	LOB	441.80	493.92	531.65	318.00	45.29	1.06	8.90	1.67	0.08	0.14
10	Chan	493.92	544.22	5182.90	1013.79	54.99	10.37	20.16	5.11	0.22	1.12
11	Chan	544.22	594.51	4667.92	920.95	50.60	9.34	18.31	5.07	0.22	1.10
12	Chan	594.51	644.81	4769.23	930.67	50.30	9.54	18.50	5.12	0.22	1.13
13	Chan	644.81	695.11	4983.18	955.50	50.30	9.97	19.00	5.22	0.23	1.18
14	Chan	695.11	745.41	5064.78	965.08	50.33	10.13	19.19	5.25	0.23	1.20
15	Chan	745.41	795.70	4961.17	953.01	50.31	9.92	18.95	5.21	0.23	1.17
16	Chan	795.70	846.00	5173.41	977.79	50.37	10.35	19.44	5.29	0.23	1.22
17	Chan	846.00	896.30	4714.40	924.37	50.32	9.43	18.38	5.10	0.22	1.12
18	Chan	896.30	946.59	4753.57	928.94	50.31	9.51	18.47	5.12	0.22	1.12
19	Chan	946.59	996.89	4406.08	887.64	50.32	8.81	17.65	4.96	0.21	1.04
20	ROB	996.89	1066.59	791.71	537.77	75.54	1.58	7.97	1.47	0.08	0.12
21	ROB	1066.59	1688.48							0.00	0.00
22	ROB	1688.48	2310.36	0.00	648.82	144.30	0.00	4.58	0.00	0.05	0.00
23	ROB	2310.36	2932.25	0.00	713.64	156.63	0.00	4.58	0.00	0.05	0.00
24	ROB	2932.25	3554.14	0.00	118.09	29.04	0.00	4.31	0.00	0.05	0.00
25	ROB	3554.14	4176.03							0.00	0.00
26	ROB	4176.03	4797.91							0.00	0.00
27	ROB	4797.91	5419.80							0.00	0.00
28	ROB	5419.80	6041.69							0.00	0.00
29	ROB	6041.69	6663.57							0.00	0.00
30	ROB	6663.57	7285.46	0.00	855.92	152.64	0.00	5.70	0.00	0.07	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215315.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	52.70	105.39	0.00	36.78	49.60	0.00	0.74	0.00	0.01	0.00
2	LOB	105.39	158.09	0.00	11.79	17.26	0.00	0.69	0.00	0.01	0.00
3	LOB	158.09	210.78							0.00	0.00
4	LOB	210.78	263.48							0.00	0.00
5	LOB	263.48	316.17							0.00	0.00
6	LOB	316.17	368.87							0.00	0.00
7	LOB	368.87	412.52							0.00	0.00
8	LOB	412.52	456.18							0.00	0.00
9	LOB	456.18	499.83	156.79	156.32	45.60	0.31	4.99	1.00	0.04	0.04
10	Chan	499.83	549.80	5054.78	993.13	51.58	10.11	19.87	5.09	0.21	1.09
11	Chan	549.80	599.78	5288.51	1007.74	49.99	10.58	20.17	5.25	0.22	1.18
12	Chan	599.78	649.75	4813.42	952.54	50.01	9.63	19.06	5.05	0.21	1.07
13	Chan	649.75	699.72	4953.39	969.06	50.01	9.91	19.39	5.11	0.22	1.10
14	Chan	699.72	749.69	5331.57	1012.92	50.02	10.66	20.27	5.26	0.23	1.19
15	Chan	749.69	799.67	4742.67	944.12	50.01	9.49	18.89	5.02	0.21	1.06
16	Chan	799.67	849.64	5061.93	982.53	50.11	10.12	19.66	5.15	0.22	1.13
17	Chan	849.64	899.61	4792.63	949.81	49.97	9.59	19.01	5.05	0.21	1.07
18	Chan	899.61	949.59	4584.91	926.21	50.15	9.17	18.53	4.95	0.21	1.02
19	Chan	949.59	999.56	4284.48	888.17	49.99	8.57	17.77	4.82	0.20	0.96
20	ROB	999.56	1050.62	934.92	607.21	66.17	1.87	11.89	1.54	0.10	0.16
21	ROB	1050.62	1673.81							0.00	0.00
22	ROB	1673.81	2297.00	0.00	595.90	132.96	0.00	4.57	0.00	0.05	0.00
23	ROB	2297.00	2920.19	0.00	662.18	146.04	0.00	4.56	0.00	0.05	0.00
24	ROB	2920.19	3543.38	0.00	177.31	41.20	0.00	4.49	0.00	0.05	0.00
25	ROB	3543.38	4166.57							0.00	0.00
26	ROB	4166.57	4789.76							0.00	0.00
27	ROB	4789.76	5412.95							0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215315.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
28	ROB	5412.95	6036.14							0.00	0.00
29	ROB	6036.14	6659.33							0.00	0.00
30	ROB	6659.33	7282.52	0.00	841.95	152.67	0.00	5.61	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215284.2BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	52.70	105.39	0.00	34.62	48.88	0.00	0.71	0.00	0.01	0.00
2	LOB	105.39	158.09	0.00	11.04	16.89	0.00	0.66	0.00	0.01	0.00
3	LOB	158.09	210.78							0.00	0.00
4	LOB	210.78	263.48							0.00	0.00
5	LOB	263.48	316.17							0.00	0.00
6	LOB	316.17	368.87							0.00	0.00
7	LOB	368.87	412.52							0.00	0.00
8	LOB	412.52	456.18							0.00	0.00
9	LOB	456.18	499.83	207.45	147.02	46.56	0.41	5.32	1.41	0.06	0.09
10	Chan	499.83	549.80	6263.21	990.94	51.58	12.53	19.83	6.32	0.37	2.33
11	Chan	549.80	599.78	3981.48	928.95	86.59	7.96	19.95	4.29	0.21	0.88
12	Chan	599.78	649.75	5963.20	950.34	50.01	11.93	19.02	6.27	0.36	2.29
13	Chan	649.75	699.72	3716.24	890.73	86.45	7.43	19.13	4.17	0.20	0.82
14	Chan	699.72	749.69	6606.63	1010.72	50.02	13.21	20.23	6.54	0.39	2.53
15	Chan	749.69	799.67	5875.35	941.92	50.01	11.75	18.85	6.24	0.36	2.25
16	Chan	799.67	849.64	3863.31	908.03	85.58	7.73	19.50	4.25	0.20	0.87
17	Chan	849.64	899.61	5937.39	947.61	49.97	11.87	18.96	6.27	0.36	2.28
18	Chan	899.61	949.59	3569.90	857.48	83.49	7.14	18.41	4.16	0.20	0.82
19	Chan	949.59	999.56	3475.57	873.93	91.14	6.95	17.49	3.98	0.18	0.73
20	ROB	999.56	1050.62	540.28	508.22	137.33	1.08	10.66	1.06	0.07	0.08

Plan: Grand Rvr 2017 Grand River Upper RS: 215284.2BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	55.67	111.33	0.00	2.69	10.37	0.00	0.26	0.00	0.01	0.00
2	LOB	111.33	167.00	0.00	40.47	55.69	0.00	0.73	0.00	0.01	0.00
3	LOB	167.00	222.67	0.00	0.24	2.94	0.00	0.08	0.00	0.00	0.00
4	LOB	222.67	278.33							0.00	0.00
5	LOB	278.33	334.00							0.00	0.00
6	LOB	334.00	386.35							0.00	0.00
7	LOB	386.35	438.71							0.00	0.00
8	LOB	438.71	491.06	3.82	5.81	4.79	0.01	2.97	0.66	0.02	0.02
9	LOB	491.06	543.41	546.37	343.48	75.27	1.09	7.02	1.59	0.09	0.14
10	Chan	543.41	593.49	6261.45	991.82	52.74	12.52	19.81	6.31	0.37	2.36
11	Chan	593.49	643.57	4054.30	934.46	87.22	8.11	20.02	4.34	0.21	0.92
12	Chan	643.57	693.64	5903.44	938.23	50.14	11.81	18.74	6.29	0.37	2.34
13	Chan	693.64	743.72	3765.77	887.80	85.72	7.53	19.02	4.24	0.21	0.87
14	Chan	743.72	793.80	6796.83	1020.86	50.12	13.59	20.39	6.66	0.40	2.70
15	Chan	793.80	843.88	5995.54	946.84	50.12	11.99	18.91	6.33	0.38	2.38
16	Chan	843.88	893.96	3663.03	867.78	84.40	7.33	18.59	4.22	0.20	0.86
17	Chan	893.96	944.03	5724.22	920.60	50.08	11.45	18.38	6.22	0.37	2.27
18	Chan	944.03	994.11	3558.48	861.93	86.67	7.12	18.47	4.13	0.20	0.82
19	Chan	994.11	1044.19	3302.87	873.50	100.21	6.61	17.44	3.78	0.17	0.66
20	ROB	1044.19	1210.24	423.88	417.40	130.65	0.85	9.19	1.02	0.06	0.06

Plan: Grand Rvr 2017 Grand River Upper RS: 215253.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	55.67	111.33	0.00	2.92	10.83	0.00	0.27	0.00	0.00	0.00
2	LOB	111.33	167.00	0.00	41.69	55.69	0.00	0.75	0.00	0.01	0.00
3	LOB	167.00	222.67	0.00	0.31	3.33	0.00	0.09	0.00	0.00	0.00
4	LOB	222.67	278.33							0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 215253.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
5	LOB	278.33	334.00							0.00	0.00
6	LOB	334.00	386.35							0.00	0.00
7	LOB	386.35	438.71							0.00	0.00
8	LOB	438.71	491.06	37.97	54.69	25.14	0.08	2.27	0.69	0.02	0.02
9	LOB	491.06	543.41	517.95	374.44	61.18	1.04	7.15	1.38	0.07	0.10
10	Chan	543.41	593.49	5018.29	992.92	52.74	10.04	19.83	5.05	0.21	1.08
11	Chan	593.49	643.57	5372.71	1014.00	50.17	10.75	20.25	5.30	0.23	1.21
12	Chan	643.57	693.64	4731.85	939.33	50.14	9.46	18.76	5.04	0.21	1.07
13	Chan	693.64	743.72	4927.11	962.05	50.09	9.85	19.21	5.12	0.22	1.11
14	Chan	743.72	793.80	5447.09	1021.96	50.12	10.89	20.41	5.33	0.23	1.23
15	Chan	793.80	843.88	4805.60	947.95	50.12	9.61	18.93	5.07	0.21	1.09
16	Chan	843.88	893.96	4719.47	937.42	50.08	9.44	18.72	5.03	0.21	1.07
17	Chan	893.96	944.03	4588.38	921.70	50.08	9.18	18.41	4.98	0.21	1.04
18	Chan	944.03	994.11	4659.58	930.27	50.08	9.32	18.58	5.01	0.21	1.05
19	Chan	994.11	1044.19	4362.03	894.44	50.12	8.72	17.86	4.88	0.20	0.99
20	ROB	1044.19	1210.24	811.98	571.95	80.63	1.62	8.09	1.42	0.08	0.11
21	ROB	1210.24	1851.23							0.00	0.00
22	ROB	1851.23	2492.21	0.00	561.15	129.53	0.00	4.40	0.00	0.05	0.00
23	ROB	2492.21	3133.20	0.00	868.20	195.49	0.00	4.49	0.00	0.05	0.00
24	ROB	3133.20	3774.19							0.00	0.00
25	ROB	3774.19	4415.18	0.00	51.46	86.72	0.00	0.59	0.00	0.01	0.00
26	ROB	4415.18	5056.16	0.00	28.59	93.31	0.00	0.31	0.00	0.00	0.00
27	ROB	5056.16	5697.15	0.00	94.97	216.30	0.00	0.44	0.00	0.00	0.00
28	ROB	5697.15	6338.14							0.00	0.00
29	ROB	6338.14	6979.12	0.00	1588.12	426.24	0.00	3.73	0.00	0.04	0.00
30	ROB	6979.12	7620.11	0.00	2474.54	475.73	0.00	5.20	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214870.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	851.00	851.89	1.23	5.67	16.99	0.00	8.49	0.22	0.00	0.00
2	Chan	851.89	897.23	4991.65	947.58	48.22	9.98	20.90	5.27	0.23	1.20
3	Chan	897.23	942.58	5311.53	959.72	45.35	10.62	21.17	5.53	0.25	1.36
4	Chan	942.58	987.92	5084.66	935.02	45.36	10.17	20.62	5.44	0.24	1.30
5	Chan	987.92	1033.26	4838.78	907.51	45.35	9.68	20.01	5.33	0.23	1.24
6	Chan	1033.26	1078.61	4876.65	911.73	45.35	9.75	20.11	5.35	0.23	1.25
7	Chan	1078.61	1123.95	4811.20	904.36	45.34	9.62	19.94	5.32	0.23	1.23
8	Chan	1123.95	1169.29	5026.32	928.45	45.35	10.05	20.48	5.41	0.24	1.29
9	Chan	1169.29	1214.63	5017.16	927.41	45.35	10.03	20.45	5.41	0.24	1.28
10	Chan	1214.63	1259.98	4846.65	908.35	45.34	9.69	20.03	5.34	0.23	1.24
11	Chan	1259.98	1305.32	4590.72	882.42	45.75	9.18	19.46	5.20	0.22	1.16
12	ROB	1305.32	1332.59	603.47	340.78	36.49	1.21	12.59	1.77	0.11	0.19
13	ROB	1332.59	1941.20							0.00	0.00
14	ROB	1941.20	2549.81	0.00	492.66	288.64	0.00	1.71	0.00	0.02	0.00
15	ROB	2549.81	3158.42	0.00	3497.89	608.66	0.00	5.75	0.00	0.07	0.00
16	ROB	3158.42	3767.03	0.00	3054.95	608.62	0.00	5.02	0.00	0.06	0.00
17	ROB	3767.03	4375.65	0.00	1279.06	608.62	0.00	2.10	0.00	0.02	0.00
18	ROB	4375.65	4984.26	0.00	362.90	584.95	0.00	0.62	0.00	0.01	0.00
19	ROB	4984.26	5592.87	0.00	1600.93	608.62	0.00	2.63	0.00	0.03	0.00
20	ROB	5592.87	6201.48	0.00	460.54	608.62	0.00	0.76	0.00	0.01	0.00
21	ROB	6201.48	6810.09	0.00	453.69	232.32	0.00	1.95	0.00	0.02	0.00
22	ROB	6810.09	7418.70	0.00	3699.98	583.70	0.00	6.35	0.00	0.07	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214720.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	813.73	813.74	0.00	0.06	17.14	0.00	8.60	0.01	0.00	0.00
2	Chan	813.74	858.78	4478.86	812.01	45.80	8.96	18.03	5.52	0.26	1.43
3	Chan	858.78	903.83	4680.10	828.23	45.05	9.36	18.39	5.65	0.27	1.52

Plan: Grand Rvr 2017 Grand River Upper RS: 214720.8 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
4	Chan	903.83	948.87	4816.63	842.63	45.04	9.63	18.71	5.72	0.27	1.56
5	Chan	948.87	993.92	4892.90	850.61	45.04	9.79	18.88	5.75	0.28	1.59
6	Chan	993.92	1038.96	4966.43	858.26	45.04	9.93	19.05	5.79	0.28	1.61
7	Chan	1038.96	1084.00	5040.41	865.91	45.04	10.08	19.22	5.82	0.28	1.63
8	Chan	1084.00	1129.05	5114.82	873.55	45.04	10.23	19.39	5.86	0.28	1.66
9	Chan	1129.05	1174.09	5189.65	881.20	45.04	10.38	19.56	5.89	0.29	1.68
10	Chan	1174.09	1219.14	5264.72	888.83	45.05	10.53	19.73	5.92	0.29	1.71
11	Chan	1219.14	1264.18	4773.51	844.45	45.90	9.55	18.75	5.65	0.27	1.52
12	ROB	1264.18	1308.15	781.98	463.49	53.32	1.56	10.54	1.69	0.13	0.21
13	ROB	1308.15	1917.87	0.00	1651.95	197.97	0.00	9.04	0.00	0.12	0.00
14	ROB	1917.87	2527.59	0.00	464.22	265.61	0.00	1.75	0.00	0.03	0.00
15	ROB	2527.59	3137.30	0.00	3065.07	609.86	0.00	5.03	0.00	0.07	0.00
16	ROB	3137.30	3747.02	0.00	2703.94	609.72	0.00	4.43	0.00	0.06	0.00
17	ROB	3747.02	4356.74	0.00	1698.87	609.73	0.00	2.79	0.00	0.04	0.00
18	ROB	4356.74	4966.46	0.00	613.09	395.07	0.00	1.55	0.00	0.02	0.00
19	ROB	4966.46	5576.18	0.00	1914.03	609.75	0.00	3.14	0.00	0.05	0.00
20	ROB	5576.18	6185.89	0.00	858.44	609.74	0.00	1.41	0.00	0.02	0.00
21	ROB	6185.89	6795.61	0.00	427.93	197.48	0.00	2.17	0.00	0.03	0.00
22	ROB	6795.61	7405.33	0.00	3466.25	584.45	0.00	5.93	0.00	0.09	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214711.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	813.73	813.74	0.00	0.06	17.17	0.00	8.59	0.01	0.00	0.00
2	Chan	813.74	858.78	4618.10	929.46	48.38	9.24	20.63	4.97	0.20	1.02
3	Chan	858.78	903.83	5020.15	949.73	45.05	10.04	21.08	5.29	0.22	1.19
4	Chan	903.83	948.87	5145.74	963.90	45.04	10.29	21.40	5.34	0.23	1.22
5	Chan	948.87	993.92	5104.92	959.30	45.04	10.21	21.30	5.32	0.23	1.21
6	Chan	993.92	1038.96	5055.63	953.73	45.04	10.11	21.17	5.30	0.23	1.19
7	Chan	1038.96	1084.00	5006.55	948.16	45.04	10.01	21.05	5.28	0.22	1.18
8	Chan	1084.00	1129.05	4957.64	942.59	45.04	9.92	20.93	5.26	0.22	1.17
9	Chan	1129.05	1174.09	4908.91	937.02	45.04	9.82	20.80	5.24	0.22	1.16
10	Chan	1174.09	1219.14	4860.39	931.45	45.04	9.72	20.68	5.22	0.22	1.15
11	Chan	1219.14	1264.18	4659.95	916.16	46.04	9.32	20.34	5.09	0.21	1.08
12	ROB	1264.18	1308.15	662.02	460.95	53.21	1.32	10.48	1.44	0.09	0.13
13	ROB	1308.15	1917.87	0.00	1638.12	197.81	0.00	8.96	0.00	0.09	0.00
14	ROB	1917.87	2527.59	0.00	444.47	256.60	0.00	1.73	0.00	0.02	0.00
15	ROB	2527.59	3137.30	0.00	3018.92	609.86	0.00	4.95	0.00	0.05	0.00
16	ROB	3137.30	3747.02	0.00	2657.79	609.72	0.00	4.36	0.00	0.05	0.00
17	ROB	3747.02	4356.74	0.00	1652.73	609.73	0.00	2.71	0.00	0.03	0.00
18	ROB	4356.74	4966.46	0.00	583.41	389.50	0.00	1.50	0.00	0.02	0.00
19	ROB	4966.46	5576.18	0.00	1867.88	609.75	0.00	3.06	0.00	0.03	0.00
20	ROB	5576.18	6185.89	0.00	812.30	609.74	0.00	1.33	0.00	0.01	0.00
21	ROB	6185.89	6795.61	0.00	413.12	194.29	0.00	2.13	0.00	0.02	0.00
22	ROB	6795.61	7405.33	0.00	3422.05	584.12	0.00	5.86	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214608.3 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	824.15	847.67	620.11	347.30	42.09	1.24	14.77	1.79	0.09	0.16
2	Chan	847.67	890.37	5021.52	956.61	46.83	10.04	22.40	5.25	0.22	1.17
3	Chan	890.37	933.07	5091.55	937.33	43.59	10.18	21.95	5.43	0.24	1.28
4	Chan	933.07	975.77	5157.27	936.88	42.71	10.31	21.94	5.50	0.24	1.32
5	Chan	975.77	1018.47	4993.16	918.95	42.72	9.99	21.52	5.43	0.24	1.28
6	Chan	1018.47	1061.17	4812.53	900.21	42.88	9.63	21.08	5.35	0.23	1.23
7	Chan	1061.17	1103.86	4829.07	901.20	42.77	9.66	21.11	5.36	0.23	1.24
8	Chan	1103.86	1146.56	4920.63	912.05	42.85	9.84	21.36	5.40	0.23	1.26
9	Chan	1146.56	1189.26	5002.86	920.10	42.73	10.01	21.55	5.44	0.24	1.28
10	Chan	1189.26	1231.96	4545.26	871.73	43.11	9.09	20.42	5.21	0.22	1.15

Plan: Grand Rvr 2017 Grand River Upper RS: 214608.3 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
11	Chan	1231.96	1274.66	4562.31	872.18	42.92	9.12	20.43	5.23	0.22	1.16
12	ROB	1274.66	1358.17	443.73	257.58	32.94	0.89	11.44	1.72	0.09	0.15
13	ROB	1358.17	1966.98							0.00	0.00
14	ROB	1966.98	2575.80	0.00	348.08	310.50	0.00	1.12	0.00	0.01	0.00
15	ROB	2575.80	3184.61	0.00	2805.81	608.86	0.00	4.61	0.00	0.05	0.00
16	ROB	3184.61	3793.42	0.00	2781.24	608.82	0.00	4.57	0.00	0.05	0.00
17	ROB	3793.42	4402.24	0.00	1925.33	608.82	0.00	3.16	0.00	0.03	0.00
18	ROB	4402.24	5011.05	0.00	989.21	608.86	0.00	1.62	0.00	0.02	0.00
19	ROB	5011.05	5619.86	0.00	2025.90	608.85	0.00	3.33	0.00	0.04	0.00
20	ROB	5619.86	6228.67	0.00	1200.70	608.82	0.00	1.97	0.00	0.02	0.00
21	ROB	6228.67	6837.49	0.00	468.80	197.67	0.00	2.37	0.00	0.03	0.00
22	ROB	6837.49	7446.30	0.00	3136.61	581.09	0.00	5.40	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214566.8BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	824.15	847.67	151.30	103.63	34.22	0.30	9.03	1.46	0.08	0.12
2	Chan	847.67	890.37	6226.99	935.18	57.43	12.45	21.90	6.66	0.45	3.02
3	Chan	890.37	933.07	2776.26	705.47	95.35	5.55	18.87	3.94	0.21	0.81
4	Chan	933.07	975.77	6775.50	924.10	49.11	13.55	21.64	7.33	0.52	3.84
5	Chan	975.77	1018.47	3315.06	748.15	84.64	6.63	19.85	4.43	0.25	1.09
6	Chan	1018.47	1061.17	6168.61	884.46	50.67	12.34	20.71	6.97	0.49	3.39
7	Chan	1061.17	1103.86	6175.87	885.18	50.68	12.35	20.73	6.98	0.49	3.40
8	Chan	1103.86	1146.56	3271.57	741.70	84.48	6.54	19.67	4.41	0.24	1.08
9	Chan	1146.56	1189.26	6728.50	909.90	47.75	13.46	21.31	7.39	0.53	3.93
10	Chan	1189.26	1231.96	2636.53	670.12	90.60	5.27	17.88	3.93	0.21	0.81
11	Chan	1231.96	1274.66	5596.69	851.11	53.26	11.19	19.93	6.58	0.45	2.93
12	ROB	1274.66	1358.17	177.13	111.83	32.69	0.35	10.04	1.58	0.10	0.15

Plan: Grand Rvr 2017 Grand River Upper RS: 214566.8BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	826.21	845.13	183.06	111.99	33.74	0.37	9.35	1.63	0.10	0.17
2	Chan	845.13	887.13	5780.33	858.85	55.31	11.56	20.45	6.73	0.48	3.23
3	Chan	887.13	929.13	2695.91	664.74	91.51	5.39	18.09	4.06	0.22	0.91
4	Chan	929.13	971.12	6709.58	887.17	47.96	13.42	21.12	7.56	0.57	4.32
5	Chan	971.12	1013.12	3539.67	721.20	74.58	7.08	19.49	4.91	0.30	1.47
6	Chan	1013.12	1055.12	5237.00	815.58	56.36	10.47	19.42	6.42	0.45	2.87
7	Chan	1055.12	1097.12	6606.71	863.55	45.88	13.21	20.56	7.65	0.58	4.45
8	Chan	1097.12	1139.12	3044.11	696.42	85.69	6.09	18.82	4.37	0.25	1.10
9	Chan	1139.12	1181.11	7162.03	874.88	42.00	14.32	20.83	8.19	0.64	5.27
10	Chan	1181.11	1223.11	2561.08	645.25	91.75	5.12	17.49	3.97	0.22	0.86
11	Chan	1223.11	1265.11	6016.99	804.74	44.26	12.03	19.16	7.48	0.56	4.20
12	ROB	1265.11	1283.25	463.54	223.53	47.14	0.93	12.33	2.07	0.15	0.30

Plan: Grand Rvr 2017 Grand River Upper RS: 214526.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	826.21	845.13	528.00	281.65	36.00	1.06	14.89	1.87	0.10	0.19
2	Chan	845.13	887.13	4835.36	876.09	45.12	9.67	20.86	5.52	0.25	1.39
3	Chan	887.13	929.13	5071.50	876.20	42.02	10.14	20.86	5.79	0.27	1.56
4	Chan	929.13	971.12	5259.73	895.67	42.03	10.52	21.33	5.87	0.28	1.62
5	Chan	971.12	1013.12	4983.20	867.14	42.03	9.97	20.65	5.75	0.27	1.54
6	Chan	1013.12	1055.12	4702.87	837.27	42.00	9.41	19.94	5.62	0.26	1.45
7	Chan	1055.12	1097.12	4997.86	868.68	42.03	10.00	20.68	5.75	0.27	1.54
8	Chan	1097.12	1139.12	4936.39	862.67	42.09	9.87	20.54	5.72	0.27	1.52
9	Chan	1139.12	1181.11	5088.67	877.82	42.00	10.18	20.90	5.80	0.27	1.57
10	Chan	1181.11	1223.11	4580.91	826.54	42.30	9.16	19.68	5.54	0.25	1.40
11	Chan	1223.11	1265.11	4431.21	808.35	42.06	8.86	19.25	5.48	0.25	1.36

Plan: Grand Rvr 2017 Grand River Upper RS: 214526.8 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
12	ROB	1265.11	1283.25	584.30	298.59	35.78	1.17	16.46	1.96	0.11	0.21
13	ROB	1283.25	1902.66							0.00	0.00
14	ROB	1902.66	2522.08	0.00	219.43	301.84	0.00	0.73	0.00	0.01	0.00
15	ROB	2522.08	3141.49	0.00	2495.55	619.47	0.00	4.03	0.00	0.05	0.00
16	ROB	3141.49	3760.91	0.00	2915.57	619.42	0.00	4.71	0.00	0.06	0.00
17	ROB	3760.91	4380.32	0.00	1828.76	619.43	0.00	2.95	0.00	0.04	0.00
18	ROB	4380.32	4999.73	0.00	1260.12	619.44	0.00	2.03	0.00	0.03	0.00
19	ROB	4999.73	5619.15	0.00	1841.17	619.45	0.00	2.97	0.00	0.04	0.00
20	ROB	5619.15	6238.56	0.00	1147.26	619.43	0.00	1.85	0.00	0.02	0.00
21	ROB	6238.56	6857.98	0.00	596.52	384.95	0.00	1.55	0.00	0.02	0.00
22	ROB	6857.98	7477.39	0.00	2871.12	573.77	0.00	5.01	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214399.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	687.20	687.21	0.00	0.09	18.64	0.00	9.32	0.01	0.00	0.00
2	Chan	687.21	732.58	4859.86	911.90	45.65	9.72	20.10	5.33	0.23	1.24
3	Chan	732.58	777.94	4810.26	904.06	45.37	9.62	19.93	5.32	0.23	1.23
4	Chan	777.94	823.31	4788.12	901.56	45.37	9.58	19.87	5.31	0.23	1.23
5	Chan	823.31	868.68	4798.18	902.69	45.37	9.60	19.90	5.32	0.23	1.23
6	Chan	868.68	914.05	4836.55	907.02	45.37	9.67	19.99	5.33	0.23	1.24
7	Chan	914.05	959.41	4884.46	912.40	45.37	9.77	20.11	5.35	0.23	1.25
8	Chan	959.41	1004.78	4949.35	919.66	45.37	9.90	20.27	5.38	0.24	1.27
9	Chan	1004.78	1050.15	5024.90	928.05	45.37	10.05	20.46	5.41	0.24	1.29
10	Chan	1050.15	1095.51	4985.93	923.73	45.37	9.97	20.36	5.40	0.24	1.28
11	Chan	1095.51	1140.88	4787.18	902.58	45.51	9.57	19.90	5.30	0.23	1.22
12	ROB	1140.88	1428.65	1275.21	1056.19	224.01	2.55	4.80	1.21	0.05	0.07
13	ROB	1428.65	2022.02	0.00	20.42	66.91	0.00	0.31	0.00	0.00	0.00
14	ROB	2022.02	2615.38	0.00	1469.91	593.42	0.00	2.48	0.00	0.03	0.00
15	ROB	2615.38	3208.75	0.00	3245.69	593.47	0.00	5.47	0.00	0.06	0.00
16	ROB	3208.75	3802.12	0.00	2486.82	593.38	0.00	4.19	0.00	0.05	0.00
17	ROB	3802.12	4395.49	0.00	1681.18	593.37	0.00	2.83	0.00	0.03	0.00
18	ROB	4395.49	4988.85	0.00	980.62	593.43	0.00	1.65	0.00	0.02	0.00
19	ROB	4988.85	5582.22	0.00	1966.44	593.41	0.00	3.31	0.00	0.04	0.00
20	ROB	5582.22	6175.59	0.00	813.42	593.47	0.00	1.37	0.00	0.02	0.00
21	ROB	6175.59	6768.95	0.00	763.22	544.58	0.00	1.40	0.00	0.02	0.00
22	ROB	6768.95	7362.32	0.00	2687.94	488.01	0.00	5.51	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214393.3 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	687.20	687.21	0.00	0.09	18.58	0.00	9.29	0.01	0.00	0.00
2	Chan	687.21	732.58	4805.25	952.05	46.21	9.61	20.99	5.05	0.21	1.04
3	Chan	732.58	777.94	4899.28	956.15	45.37	9.80	21.08	5.12	0.21	1.08
4	Chan	777.94	823.31	4891.01	955.18	45.37	9.78	21.05	5.12	0.21	1.08
5	Chan	823.31	868.68	4885.04	954.48	45.37	9.77	21.04	5.12	0.21	1.08
6	Chan	868.68	914.05	4901.50	956.41	45.37	9.80	21.08	5.12	0.21	1.08
7	Chan	914.05	959.41	4924.30	959.08	45.37	9.85	21.14	5.13	0.21	1.09
8	Chan	959.41	1004.78	4938.59	960.74	45.37	9.88	21.18	5.14	0.21	1.09
9	Chan	1004.78	1050.15	4947.99	961.84	45.37	9.90	21.20	5.14	0.21	1.09
10	Chan	1050.15	1095.51	4949.13	961.97	45.37	9.90	21.20	5.14	0.21	1.09
11	Chan	1095.51	1140.88	4691.69	934.15	45.67	9.38	20.59	5.02	0.20	1.03
12	ROB	1140.88	1428.65	1166.22	1044.09	222.30	2.33	4.79	1.12	0.05	0.05
13	ROB	1428.65	2022.02	0.00	16.73	66.85	0.00	0.25	0.00	0.00	0.00
14	ROB	2022.02	2615.38	0.00	1437.14	593.42	0.00	2.42	0.00	0.02	0.00
15	ROB	2615.38	3208.75	0.00	3212.91	593.47	0.00	5.41	0.00	0.05	0.00
16	ROB	3208.75	3802.12	0.00	2454.04	593.38	0.00	4.14	0.00	0.04	0.00
17	ROB	3802.12	4395.49	0.00	1648.41	593.37	0.00	2.78	0.00	0.03	0.00
18	ROB	4395.49	4988.85	0.00	947.84	593.43	0.00	1.60	0.00	0.02	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214393.3 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
19	ROB	4988.85	5582.22	0.00	1933.66	593.41	0.00	3.26	0.00	0.03	0.00
20	ROB	5582.22	6175.59	0.00	780.65	593.47	0.00	1.32	0.00	0.01	0.00
21	ROB	6175.59	6768.95	0.00	733.39	535.75	0.00	1.37	0.00	0.01	0.00
22	ROB	6768.95	7362.32	0.00	2661.03	486.68	0.00	5.47	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 214151.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	268.00	335.00	0.00	8.71	53.37	0.00	0.16	0.00	0.00	0.00
2	LOB	335.00	402.00	0.00	29.19	67.00	0.00	0.44	0.00	0.00	0.00
3	LOB	402.00	469.00	0.00	60.09	67.00	0.00	0.90	0.00	0.01	0.00
4	LOB	469.00	536.00	0.00	94.78	67.00	0.00	1.41	0.00	0.01	0.00
5	LOB	536.00	603.00	0.00	124.33	67.00	0.00	1.86	0.00	0.02	0.00
6	LOB	603.00	670.00	0.00	151.19	67.00	0.00	2.26	0.00	0.02	0.00
7	LOB	670.00	694.00	24.66	54.52	25.49	0.05	2.27	0.45	0.02	0.01
8	LOB	694.00	694.06	0.02	0.61	18.66	0.00	10.09	0.03	0.00	0.00
9	Chan	694.06	742.27	4934.72	1040.26	49.21	9.87	21.58	4.74	0.18	0.86
10	Chan	742.27	790.48	5020.70	1042.53	48.21	10.04	21.62	4.82	0.18	0.89
11	Chan	790.48	838.69	5001.75	1040.17	48.21	10.00	21.58	4.81	0.18	0.89
12	Chan	838.69	886.90	4982.81	1037.81	48.21	9.97	21.53	4.80	0.18	0.88
13	Chan	886.90	935.11	4964.34	1035.50	48.21	9.93	21.48	4.79	0.18	0.88
14	Chan	935.11	983.32	4979.24	1037.36	48.21	9.96	21.52	4.80	0.18	0.88
15	Chan	983.32	1031.53	5015.07	1041.83	48.21	10.03	21.61	4.81	0.18	0.89
16	Chan	1031.53	1079.74	5007.61	1040.91	48.21	10.02	21.59	4.81	0.18	0.89
17	Chan	1079.74	1127.95	4734.34	1006.57	48.23	9.47	20.88	4.70	0.18	0.84
18	Chan	1127.95	1176.16	4574.80	986.77	48.31	9.15	20.47	4.64	0.17	0.81
19	ROB	1176.16	1460.00	759.93	940.13	248.46	1.52	3.82	0.81	0.03	0.03
20	ROB	1460.00	2055.33	0.00	592.77	349.75	0.00	1.70	0.00	0.01	0.00
21	ROB	2055.33	2650.67	0.00	2857.92	595.36	0.00	4.80	0.00	0.04	0.00
22	ROB	2650.67	3246.00	0.00	3434.14	595.35	0.00	5.77	0.00	0.05	0.00
23	ROB	3246.00	3841.34	0.00	2529.81	595.33	0.00	4.25	0.00	0.04	0.00
24	ROB	3841.34	4436.67	0.00	2413.60	595.34	0.00	4.05	0.00	0.03	0.00
25	ROB	4436.67	5032.00	0.00	1973.42	595.35	0.00	3.31	0.00	0.03	0.00
26	ROB	5032.00	5627.34	0.00	2370.37	595.35	0.00	3.98	0.00	0.03	0.00
27	ROB	5627.34	6222.67	0.00	828.48	595.38	0.00	1.39	0.00	0.01	0.00
28	ROB	6222.67	6818.01	0.00	1744.91	595.47	0.00	2.93	0.00	0.03	0.00
29	ROB	6818.01	7413.34	0.00	3012.64	477.84	0.00	6.31	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213856.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	227.90	303.87	0.00	2.81	36.72	0.00	0.08	0.00	0.00	0.00
2	LOB	303.87	379.83	0.00	17.12	75.97	0.00	0.23	0.00	0.00	0.00
3	LOB	379.83	455.80	0.00	30.21	75.97	0.00	0.40	0.00	0.00	0.00
4	LOB	455.80	531.77	0.00	64.20	75.97	0.00	0.85	0.00	0.01	0.00
5	LOB	531.77	607.73	0.00	57.17	61.36	0.00	0.93	0.00	0.01	0.00
6	LOB	607.73	683.70							0.00	0.00
7	LOB	683.70	697.75	19.16	33.23	18.03	0.04	2.37	0.58	0.02	0.01
8	LOB	697.75	728.94	762.38	452.68	42.00	1.52	14.51	1.68	0.09	0.15
9	Chan	728.94	774.59	4518.61	959.38	45.84	9.04	21.02	4.71	0.18	0.84
10	Chan	774.59	820.24	4559.69	963.02	45.65	9.12	21.10	4.73	0.18	0.85
11	Chan	820.24	865.88	4601.74	968.34	45.65	9.20	21.21	4.75	0.18	0.86
12	Chan	865.88	911.53	4606.50	968.94	45.65	9.21	21.23	4.75	0.18	0.86
13	Chan	911.53	957.18	4598.25	967.90	45.65	9.20	21.20	4.75	0.18	0.86
14	Chan	957.18	1002.83	4578.30	965.37	45.65	9.16	21.15	4.74	0.18	0.86
15	Chan	1002.83	1048.48	4554.05	962.30	45.65	9.11	21.08	4.73	0.18	0.85
16	Chan	1048.48	1094.12	4541.67	960.73	45.65	9.08	21.05	4.73	0.18	0.85
17	Chan	1094.12	1139.77	4613.99	969.89	45.65	9.23	21.25	4.76	0.18	0.86
18	Chan	1139.77	1185.42	4541.34	963.33	45.96	9.08	21.10	4.71	0.18	0.84

Plan: Grand Rvr 2017 Grand River Upper RS: 213856.9 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
19	ROB	1185.42	1440.00	3504.30	2046.31	220.48	7.01	9.43	1.71	0.08	0.14
20	ROB	1440.00	2038.36	0.00	1496.38	387.40	0.00	3.90	0.00	0.03	0.00
21	ROB	2038.36	2636.72	0.00	3417.99	598.36	0.00	5.71	0.00	0.05	0.00
22	ROB	2636.72	3235.08	0.00	3068.07	598.41	0.00	5.13	0.00	0.04	0.00
23	ROB	3235.08	3833.44	0.00	2479.69	598.38	0.00	4.14	0.00	0.04	0.00
24	ROB	3833.44	4431.80	0.00	2800.23	598.37	0.00	4.68	0.00	0.04	0.00
25	ROB	4431.80	5030.15	0.00	3407.08	598.42	0.00	5.69	0.00	0.05	0.00
26	ROB	5030.15	5628.51	0.00	2607.95	598.38	0.00	4.36	0.00	0.04	0.00
27	ROB	5628.51	6226.87	0.00	838.04	598.40	0.00	1.40	0.00	0.01	0.00
28	ROB	6226.87	6825.23	0.00	1827.47	598.50	0.00	3.05	0.00	0.03	0.00
29	ROB	6825.23	7423.59	0.00	3094.10	481.03	0.00	6.44	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213851.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	227.90	303.87	0.00	1.17	22.65	0.00	0.05	0.00	0.00	0.00
2	LOB	303.87	379.83	0.00	12.93	75.97	0.00	0.17	0.00	0.00	0.00
3	LOB	379.83	455.80	0.00	26.02	75.97	0.00	0.34	0.00	0.00	0.00
4	LOB	455.80	531.77	0.00	60.00	75.97	0.00	0.79	0.00	0.01	0.00
5	LOB	531.77	607.73	0.00	53.81	60.54	0.00	0.89	0.00	0.01	0.00
6	LOB	607.73	683.70							0.00	0.00
7	LOB	683.70	697.75	16.62	32.45	17.98	0.03	2.31	0.51	0.01	0.01
8	LOB	697.75	728.94	682.36	450.96	42.00	1.36	14.46	1.51	0.07	0.11
9	Chan	728.94	774.59	4498.57	1021.27	46.09	9.00	22.37	4.40	0.15	0.67
10	Chan	774.59	820.24	4606.08	1031.84	45.65	9.21	22.60	4.46	0.16	0.70
11	Chan	820.24	865.88	4619.50	1033.65	45.65	9.24	22.64	4.47	0.16	0.70
12	Chan	865.88	911.53	4622.25	1034.01	45.65	9.24	22.65	4.47	0.16	0.70
13	Chan	911.53	957.18	4626.01	1034.52	45.65	9.25	22.66	4.47	0.16	0.70
14	Chan	957.18	1002.83	4640.38	1036.45	45.65	9.28	22.71	4.48	0.16	0.70
15	Chan	1002.83	1048.48	4650.03	1037.74	45.65	9.30	22.73	4.48	0.16	0.70
16	Chan	1048.48	1094.12	4655.87	1038.52	45.65	9.31	22.75	4.48	0.16	0.71
17	Chan	1094.12	1139.77	4659.09	1038.95	45.65	9.32	22.76	4.48	0.16	0.71
18	Chan	1139.77	1185.42	4541.13	1036.05	47.11	9.08	22.70	4.38	0.15	0.67
19	ROB	1185.42	1440.00	3182.12	2034.50	214.66	6.36	9.64	1.56	0.07	0.10
20	ROB	1440.00	2038.36	0.00	1475.62	373.59	0.00	3.99	0.00	0.03	0.00
21	ROB	2038.36	2636.72	0.00	3384.97	598.36	0.00	5.66	0.00	0.04	0.00
22	ROB	2636.72	3235.08	0.00	3035.06	598.41	0.00	5.07	0.00	0.04	0.00
23	ROB	3235.08	3833.44	0.00	2446.67	598.38	0.00	4.09	0.00	0.03	0.00
24	ROB	3833.44	4431.80	0.00	2767.22	598.37	0.00	4.62	0.00	0.03	0.00
25	ROB	4431.80	5030.15	0.00	3374.06	598.42	0.00	5.64	0.00	0.04	0.00
26	ROB	5030.15	5628.51	0.00	2574.93	598.38	0.00	4.30	0.00	0.03	0.00
27	ROB	5628.51	6226.87	0.00	805.03	598.40	0.00	1.35	0.00	0.01	0.00
28	ROB	6226.87	6825.23	0.00	1794.46	598.50	0.00	3.00	0.00	0.02	0.00
29	ROB	6825.23	7423.59	0.00	3067.59	480.48	0.00	6.39	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213666.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	719.05	720.28	6.43	19.22	20.54	0.01	15.76	0.33	0.01	0.00
2	Chan	720.28	768.01	4834.39	1089.97	49.09	9.67	22.84	4.44	0.16	0.69
3	Chan	768.01	815.74	4781.42	1070.75	47.73	9.56	22.43	4.47	0.16	0.70
4	Chan	815.74	863.47	4720.94	1062.59	47.73	9.44	22.26	4.44	0.16	0.69
5	Chan	863.47	911.20	4837.02	1078.18	47.73	9.67	22.59	4.49	0.16	0.71
6	Chan	911.20	958.94	4869.45	1082.51	47.73	9.74	22.68	4.50	0.16	0.71
7	Chan	958.94	1006.67	4751.56	1066.78	47.74	9.50	22.35	4.45	0.16	0.70
8	Chan	1006.67	1054.40	4530.46	1036.68	47.74	9.06	21.72	4.37	0.15	0.66
9	Chan	1054.40	1102.13	4595.53	1045.56	47.73	9.19	21.91	4.40	0.15	0.67
10	Chan	1102.13	1149.86	4747.49	1066.20	47.74	9.49	22.34	4.45	0.16	0.70
11	Chan	1149.86	1197.59	4805.66	1076.63	48.03	9.61	22.56	4.46	0.16	0.70

Plan: Grand Rvr 2017 Grand River Upper RS: 213666.4 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
12	ROB	1197.59	1451.81	2519.67	1831.56	228.46	5.04	8.07	1.38	0.06	0.08
13	ROB	1451.81	2052.05	0.00	829.76	239.66	0.00	3.53	0.00	0.02	0.00
14	ROB	2052.05	2652.28	0.00	2310.41	600.25	0.00	3.85	0.00	0.03	0.00
15	ROB	2652.28	3252.52	0.00	2894.95	600.26	0.00	4.82	0.00	0.03	0.00
16	ROB	3252.52	3852.75	0.00	2350.75	600.40	0.00	3.92	0.00	0.03	0.00
17	ROB	3852.75	4452.99	0.00	3279.59	600.25	0.00	5.46	0.00	0.04	0.00
18	ROB	4452.99	5053.23	0.00	3572.00	600.24	0.00	5.95	0.00	0.04	0.00
19	ROB	5053.23	5653.46	0.00	2927.74	600.27	0.00	4.88	0.00	0.03	0.00
20	ROB	5653.46	6253.70	0.00	869.38	600.27	0.00	1.45	0.00	0.01	0.00
21	ROB	6253.70	6853.93	0.00	1849.25	600.38	0.00	3.08	0.00	0.02	0.00
22	ROB	6853.93	7454.17	0.00	3131.42	484.27	0.00	6.47	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213522.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	853.38	853.39	0.00	0.10	20.35	0.00	10.17	0.01	0.00	0.00
2	Chan	853.39	900.02	4744.53	1030.11	47.61	9.49	22.09	4.61	0.17	0.78
3	Chan	900.02	946.65	4981.02	1051.97	46.64	9.96	22.56	4.73	0.18	0.83
4	Chan	946.65	993.29	5030.25	1058.17	46.64	10.06	22.69	4.75	0.18	0.84
5	Chan	993.29	1039.92	4921.98	1044.46	46.64	9.84	22.40	4.71	0.17	0.82
6	Chan	1039.92	1086.55	4742.38	1021.37	46.64	9.48	21.90	4.64	0.17	0.79
7	Chan	1086.55	1133.18	4862.27	1036.86	46.64	9.72	22.23	4.69	0.17	0.81
8	Chan	1133.18	1179.81	5015.96	1056.32	46.63	10.03	22.65	4.75	0.18	0.84
9	Chan	1179.81	1226.45	4927.05	1045.05	46.63	9.85	22.41	4.71	0.17	0.82
10	Chan	1226.45	1273.08	4895.86	1041.18	46.65	9.79	22.33	4.70	0.17	0.82
11	Chan	1273.08	1319.71	4923.31	1047.17	46.92	9.85	22.46	4.70	0.17	0.82
12	ROB	1319.71	1593.75	955.39	895.64	269.05	1.91	3.39	1.07	0.03	0.03
13	ROB	1593.75	2194.39	0.00	1336.98	410.96	0.00	3.29	0.00	0.03	0.00
14	ROB	2194.39	2795.02	0.00	1587.35	600.71	0.00	2.64	0.00	0.02	0.00
15	ROB	2795.02	3395.66	0.00	2833.02	600.67	0.00	4.72	0.00	0.04	0.00
16	ROB	3395.66	3996.29	0.00	2237.59	600.90	0.00	3.73	0.00	0.03	0.00
17	ROB	3996.29	4596.93	0.00	3359.76	600.65	0.00	5.59	0.00	0.04	0.00
18	ROB	4596.93	5197.56	0.00	3509.89	600.64	0.00	5.84	0.00	0.05	0.00
19	ROB	5197.56	5798.20	0.00	2981.64	600.67	0.00	4.96	0.00	0.04	0.00
20	ROB	5798.20	6398.83	0.00	872.40	600.67	0.00	1.45	0.00	0.01	0.00
21	ROB	6398.83	6999.47	0.00	1913.72	600.79	0.00	3.19	0.00	0.02	0.00
22	ROB	6999.47	7600.10	0.00	3159.74	487.26	0.00	6.49	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213489.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	966.00	973.01	0.00	0.10	20.21	0.00	10.14	0.01	0.00	0.00
2	Chan	973.01	1019.96	4871.86	1038.87	48.28	9.74	22.13	4.69	0.18	0.82
3	Chan	1019.96	1066.91	4893.92	1030.24	46.96	9.79	21.94	4.75	0.18	0.85
4	Chan	1066.91	1113.86	5037.78	1048.34	46.97	10.08	22.33	4.81	0.18	0.87
5	Chan	1113.86	1160.81	4814.07	1020.23	46.98	9.63	21.73	4.72	0.18	0.83
6	Chan	1160.81	1207.76	4792.79	1017.34	46.96	9.59	21.67	4.71	0.18	0.83
7	Chan	1207.76	1254.70	4803.02	1018.64	46.96	9.61	21.70	4.72	0.18	0.83
8	Chan	1254.70	1301.65	4829.12	1021.98	46.96	9.66	21.77	4.73	0.18	0.84
9	Chan	1301.65	1348.60	4889.42	1029.61	46.96	9.78	21.93	4.75	0.18	0.85
10	Chan	1348.60	1395.55	4933.94	1035.93	47.04	9.87	22.06	4.76	0.18	0.85
11	Chan	1395.55	1442.50	4773.89	1015.42	47.01	9.55	21.63	4.70	0.18	0.83
12	ROB	1442.50	1724.00	1360.19	1227.42	272.08	2.72	4.61	1.11	0.04	0.04
13	ROB	1724.00	2326.07	0.00	1461.67	452.72	0.00	3.23	0.00	0.03	0.00
14	ROB	2326.07	2928.13	0.00	1418.35	602.08	0.00	2.36	0.00	0.02	0.00
15	ROB	2928.13	3530.20	0.00	2848.06	602.11	0.00	4.73	0.00	0.04	0.00
16	ROB	3530.20	4132.26	0.00	2385.76	602.37	0.00	3.96	0.00	0.03	0.00
17	ROB	4132.26	4734.33	0.00	3568.89	602.07	0.00	5.93	0.00	0.05	0.00
18	ROB	4734.33	5336.40	0.00	3247.62	602.09	0.00	5.39	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213489.9 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
19	ROB	5336.40	5938.46	0.00	3059.32	602.09	0.00	5.08	0.00	0.04	0.00
20	ROB	5938.46	6540.53	0.00	1025.48	602.10	0.00	1.70	0.00	0.01	0.00
21	ROB	6540.53	7142.59	0.00	2077.98	602.24	0.00	3.45	0.00	0.03	0.00
22	ROB	7142.59	7744.66	0.00	3198.93	497.18	0.00	6.44	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213220.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1014.10	1014.11	0.00	0.10	20.68	0.00	10.34	0.01	0.00	0.00
2	Chan	1014.11	1058.48	4730.11	965.45	44.67	9.46	21.76	4.90	0.19	0.94
3	Chan	1058.48	1102.84	4806.09	972.09	44.37	9.61	21.91	4.94	0.19	0.96
4	Chan	1102.84	1147.21	4853.14	977.79	44.37	9.71	22.04	4.96	0.19	0.97
5	Chan	1147.21	1191.57	4876.89	980.65	44.37	9.75	22.10	4.97	0.20	0.97
6	Chan	1191.57	1235.94	4889.40	982.16	44.37	9.78	22.14	4.98	0.20	0.97
7	Chan	1235.94	1280.30	4895.02	982.84	44.37	9.79	22.15	4.98	0.20	0.98
8	Chan	1280.30	1324.67	4888.55	982.06	44.36	9.78	22.14	4.98	0.20	0.97
9	Chan	1324.67	1369.03	4876.63	980.62	44.37	9.75	22.10	4.97	0.20	0.97
10	Chan	1369.03	1413.40	4846.71	977.01	44.37	9.69	22.02	4.96	0.19	0.97
11	Chan	1413.40	1457.76	4693.84	958.68	44.40	9.39	21.61	4.90	0.19	0.93
12	ROB	1457.76	1695.25	1643.64	1151.81	214.39	3.29	5.44	1.43	0.05	0.07
13	ROB	1695.25	2304.51	0.00	915.89	453.95	0.00	2.02	0.00	0.02	0.00
14	ROB	2304.51	2913.76	0.00	1427.18	609.32	0.00	2.34	0.00	0.02	0.00
15	ROB	2913.76	3523.02	0.00	2847.79	609.30	0.00	4.67	0.00	0.04	0.00
16	ROB	3523.02	4132.27	0.00	3176.02	609.31	0.00	5.21	0.00	0.05	0.00
17	ROB	4132.27	4741.53	0.00	3729.10	609.30	0.00	6.12	0.00	0.05	0.00
18	ROB	4741.53	5350.79	0.00	3240.09	609.34	0.00	5.32	0.00	0.05	0.00
19	ROB	5350.79	5960.04	0.00	3052.62	609.28	0.00	5.01	0.00	0.04	0.00
20	ROB	5960.04	6569.30	0.00	1127.26	558.09	0.00	2.02	0.00	0.02	0.00
21	ROB	6569.30	7178.55	0.00	1995.01	500.24	0.00	3.99	0.00	0.04	0.00
22	ROB	7178.55	7787.81	0.00	3252.86	502.87	0.00	6.47	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213213.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1014.10	1014.11	0.00	0.10	20.64	0.00	10.35	0.01	0.00	0.00
2	Chan	1014.11	1058.48	4391.36	1000.84	45.39	8.78	22.56	4.39	0.15	0.67
3	Chan	1058.48	1102.84	4643.59	1025.58	44.37	9.29	23.12	4.53	0.16	0.72
4	Chan	1102.84	1147.21	4875.12	1055.96	44.37	9.75	23.80	4.62	0.16	0.76
5	Chan	1147.21	1191.57	4987.88	1070.51	44.37	9.98	24.13	4.66	0.17	0.78
6	Chan	1191.57	1235.94	5037.72	1076.91	44.37	10.08	24.27	4.68	0.17	0.79
7	Chan	1235.94	1280.30	5075.45	1081.74	44.37	10.15	24.38	4.69	0.17	0.79
8	Chan	1280.30	1324.67	5091.66	1083.82	44.37	10.18	24.43	4.70	0.17	0.79
9	Chan	1324.67	1369.03	5094.05	1084.12	44.37	10.19	24.44	4.70	0.17	0.79
10	Chan	1369.03	1413.40	5050.12	1078.50	44.37	10.10	24.31	4.68	0.17	0.79
11	Chan	1413.40	1457.76	4310.52	1000.66	46.65	8.62	22.56	4.31	0.15	0.64
12	ROB	1457.76	1695.25	1442.53	1142.90	213.72	2.89	5.42	1.26	0.04	0.05
13	ROB	1695.25	2304.51	0.00	896.82	450.83	0.00	1.99	0.00	0.01	0.00
14	ROB	2304.51	2913.76	0.00	1401.49	609.32	0.00	2.30	0.00	0.02	0.00
15	ROB	2913.76	3523.02	0.00	2822.09	609.30	0.00	4.63	0.00	0.03	0.00
16	ROB	3523.02	4132.27	0.00	3150.32	609.31	0.00	5.17	0.00	0.04	0.00
17	ROB	4132.27	4741.53	0.00	3703.40	609.30	0.00	6.08	0.00	0.04	0.00
18	ROB	4741.53	5350.79	0.00	3214.40	609.34	0.00	5.28	0.00	0.04	0.00
19	ROB	5350.79	5960.04	0.00	3026.92	609.28	0.00	4.97	0.00	0.03	0.00
20	ROB	5960.04	6569.30	0.00	1103.82	553.77	0.00	1.99	0.00	0.01	0.00
21	ROB	6569.30	7178.55	0.00	1974.72	467.34	0.00	4.23	0.00	0.03	0.00
22	ROB	7178.55	7787.81	0.00	3231.69	501.81	0.00	6.44	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213163.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1002.66	1002.67	0.00	0.10	21.03	0.00	10.55	0.01	0.00	0.00
2	Chan	1002.67	1048.92	5012.67	1078.02	47.11	10.03	23.31	4.65	0.17	0.79
3	Chan	1048.92	1095.16	5175.03	1091.03	46.27	10.35	23.59	4.74	0.17	0.83
4	Chan	1095.16	1141.41	4977.02	1065.77	46.27	9.95	23.05	4.67	0.17	0.79
5	Chan	1141.41	1187.65	4685.69	1027.69	46.25	9.37	22.22	4.56	0.16	0.75
6	Chan	1187.65	1233.90	4863.91	1051.00	46.25	9.73	22.73	4.63	0.17	0.78
7	Chan	1233.90	1280.15	4992.53	1067.53	46.25	9.99	23.08	4.68	0.17	0.80
8	Chan	1280.15	1326.39	4923.70	1058.68	46.25	9.85	22.89	4.65	0.17	0.79
9	Chan	1326.39	1372.64	4840.42	1047.89	46.25	9.68	22.66	4.62	0.17	0.77
10	Chan	1372.64	1418.88	4984.06	1066.56	46.26	9.97	23.06	4.67	0.17	0.79
11	Chan	1418.88	1465.13	4851.29	1049.91	46.31	9.70	22.70	4.62	0.17	0.77
12	ROB	1465.13	1502.45	693.68	522.95	49.58	1.39	14.04	1.33	0.08	0.10
13	ROB	1502.45	2132.03	0.00	1478.11	509.80	0.00	2.91	0.00	0.02	0.00
14	ROB	2132.03	2761.61	0.00	909.49	581.91	0.00	1.56	0.00	0.01	0.00
15	ROB	2761.61	3391.18	0.00	2156.62	569.76	0.00	3.79	0.00	0.03	0.00
16	ROB	3391.18	4020.76	0.00	3255.33	629.61	0.00	5.17	0.00	0.04	0.00
17	ROB	4020.76	4650.34	0.00	3695.47	629.58	0.00	5.87	0.00	0.04	0.00
18	ROB	4650.34	5279.92	0.00	3562.39	629.75	0.00	5.66	0.00	0.04	0.00
19	ROB	5279.92	5909.50	0.00	3032.78	629.60	0.00	4.82	0.00	0.04	0.00
20	ROB	5909.50	6539.07	0.00	1430.75	618.77	0.00	2.31	0.00	0.02	0.00
21	ROB	6539.07	7168.65	0.00	1783.12	449.29	0.00	3.97	0.00	0.03	0.00
22	ROB	7168.65	7798.23	0.00	3443.29	522.27	0.00	6.60	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 213093.7 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1006.97	1006.98	0.00	0.09	20.42	0.00	10.21	0.01	0.00	0.00
2	Chan	1006.98	1053.08	4986.18	1025.15	46.72	9.97	22.24	4.86	0.19	0.91
3	Chan	1053.08	1099.18	4796.91	997.07	46.19	9.59	21.63	4.81	0.18	0.89
4	Chan	1099.18	1145.29	4809.08	997.96	46.12	9.62	21.65	4.82	0.18	0.89
5	Chan	1145.29	1191.39	4969.43	1017.75	46.11	9.94	22.08	4.88	0.19	0.92
6	Chan	1191.39	1237.49	4851.69	1003.23	46.11	9.70	21.76	4.84	0.19	0.90
7	Chan	1237.49	1283.59	5074.16	1030.50	46.10	10.15	22.35	4.92	0.19	0.94
8	Chan	1283.59	1329.69	4912.25	1010.71	46.11	9.82	21.92	4.86	0.19	0.91
9	Chan	1329.69	1375.80	4860.78	1004.26	46.10	9.72	21.78	4.84	0.19	0.90
10	Chan	1375.80	1421.90	4962.05	1016.84	46.11	9.92	22.06	4.88	0.19	0.92
11	Chan	1421.90	1468.00	5000.85	1022.59	46.22	10.00	22.18	4.89	0.19	0.92
12	ROB	1468.00	1513.54	776.62	582.39	58.76	1.55	12.79	1.33	0.08	0.11
13	ROB	1513.54	2143.31	0.00	1007.88	458.48	0.00	2.20	0.00	0.02	0.00
14	ROB	2143.31	2773.08	0.00	218.40	324.79	0.00	0.67	0.00	0.01	0.00
15	ROB	2773.08	3402.84	0.00	1607.60	547.74	0.00	2.94	0.00	0.03	0.00
16	ROB	3402.84	4032.61	0.00	2747.96	629.81	0.00	4.36	0.00	0.04	0.00
17	ROB	4032.61	4662.38	0.00	3168.67	629.77	0.00	5.03	0.00	0.04	0.00
18	ROB	4662.38	5292.15	0.00	2691.34	629.83	0.00	4.27	0.00	0.04	0.00
19	ROB	5292.15	5921.92	0.00	2637.56	629.81	0.00	4.19	0.00	0.04	0.00
20	ROB	5921.92	6551.68	0.00	1077.27	564.78	0.00	1.91	0.00	0.02	0.00
21	ROB	6551.68	7181.45	0.00	1536.41	336.67	0.00	4.57	0.00	0.04	0.00
22	ROB	7181.45	7811.22	0.00	3104.14	498.74	0.00	6.23	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 212980.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1037.52	1065.95	754.03	454.44	51.11	1.51	16.05	1.66	0.08	0.13
2	Chan	1065.95	1108.98	4841.82	958.85	43.42	9.68	22.28	5.05	0.20	1.02
3	Chan	1108.98	1152.01	4858.62	957.52	43.04	9.72	22.25	5.07	0.20	1.03
4	Chan	1152.01	1195.05	4880.58	960.03	43.03	9.76	22.31	5.08	0.20	1.03
5	Chan	1195.05	1238.08	4767.44	946.60	43.03	9.53	22.00	5.04	0.20	1.01
6	Chan	1238.08	1281.11	4840.35	955.27	43.03	9.68	22.20	5.07	0.20	1.03
7	Chan	1281.11	1324.14	4970.79	970.63	43.03	9.94	22.56	5.12	0.21	1.05

Plan: Grand Rvr 2017 Grand River Upper RS: 212980.5 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
8	Chan	1324.14	1367.17	4850.13	956.53	43.05	9.70	22.23	5.07	0.20	1.03
9	Chan	1367.17	1410.21	4892.10	961.43	43.04	9.78	22.34	5.09	0.20	1.04
10	Chan	1410.21	1453.24	4921.35	964.84	43.03	9.84	22.42	5.10	0.20	1.04
11	Chan	1453.24	1496.27	4830.73	954.91	43.12	9.66	22.19	5.06	0.20	1.02
12	ROB	1496.27	1528.02	592.05	423.47	36.45	1.18	13.34	1.40	0.11	0.15
13	ROB	1528.02	2160.88	0.00	792.81	461.64	0.00	1.73	0.00	0.02	0.00
14	ROB	2160.88	2793.74							0.00	0.00
15	ROB	2793.74	3426.60	0.00	1532.98	609.19	0.00	2.52	0.00	0.02	0.00
16	ROB	3426.60	4059.46	0.00	2907.62	632.90	0.00	4.59	0.00	0.04	0.00
17	ROB	4059.46	4692.32	0.00	3154.21	632.86	0.00	4.98	0.00	0.05	0.00
18	ROB	4692.32	5325.17	0.00	2694.28	632.92	0.00	4.26	0.00	0.04	0.00
19	ROB	5325.17	5958.03	0.00	2788.09	632.90	0.00	4.41	0.00	0.04	0.00
20	ROB	5958.03	6590.89	0.00	1194.75	592.90	0.00	2.02	0.00	0.02	0.00
21	ROB	6590.89	7223.75	0.00	1622.71	367.05	0.00	4.42	0.00	0.04	0.00
22	ROB	7223.75	7856.61	0.00	3052.72	502.15	0.00	6.09	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 212611.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	902.95	1008.07	1279.50	1033.47	108.52	2.56	9.83	1.24	0.07	0.09
2	Chan	1008.07	1051.44	4724.16	997.73	43.53	9.45	23.00	4.73	0.18	0.83
3	Chan	1051.44	1094.81	4649.35	987.05	43.40	9.30	22.76	4.71	0.17	0.82
4	Chan	1094.81	1138.19	4626.53	983.90	43.37	9.25	22.69	4.70	0.17	0.81
5	Chan	1138.19	1181.56	4658.58	987.98	43.37	9.32	22.78	4.72	0.17	0.82
6	Chan	1181.56	1224.93	4630.60	984.44	43.38	9.26	22.70	4.70	0.17	0.82
7	Chan	1224.93	1268.30	4824.20	1008.95	43.38	9.65	23.26	4.78	0.18	0.85
8	Chan	1268.30	1311.67	4987.25	1029.24	43.37	9.97	23.73	4.85	0.18	0.88
9	Chan	1311.67	1355.05	5072.38	1039.74	43.37	10.14	23.97	4.88	0.18	0.89
10	Chan	1355.05	1398.42	5127.25	1046.51	43.38	10.25	24.13	4.90	0.18	0.90
11	Chan	1398.42	1441.79	4793.01	1006.39	43.52	9.59	23.20	4.76	0.18	0.84
12	ROB	1441.79	1559.56	627.20	609.25	123.44	1.25	5.17	1.03	0.04	0.04
13	ROB	1559.56	2191.28	0.00	673.52	409.59	0.00	1.65	0.00	0.01	0.00
14	ROB	2191.28	2823.01	0.00	194.90	378.38	0.00	0.52	0.00	0.00	0.00
15	ROB	2823.01	3454.73	0.00	615.45	631.73	0.00	0.97	0.00	0.01	0.00
16	ROB	3454.73	4086.46	0.00	2712.42	631.76	0.00	4.29	0.00	0.03	0.00
17	ROB	4086.46	4718.18	0.00	3139.07	631.72	0.00	4.97	0.00	0.04	0.00
18	ROB	4718.18	5349.90	0.00	2583.07	631.77	0.00	4.09	0.00	0.03	0.00
19	ROB	5349.90	5981.63	0.00	3105.82	631.73	0.00	4.92	0.00	0.04	0.00
20	ROB	5981.63	6613.35	0.00	1297.07	631.76	0.00	2.05	0.00	0.02	0.00
21	ROB	6613.35	7245.08	0.00	1832.55	428.20	0.00	4.28	0.00	0.03	0.00
22	ROB	7245.08	7876.80	0.00	3062.15	506.27	0.00	6.05	0.00	0.05	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 212446.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1084.01	1233.27	1019.06	590.57	51.57	2.04	16.37	1.73	0.09	0.15
2	Chan	1233.27	1275.93	4624.44	977.75	42.76	9.25	22.92	4.73	0.17	0.83
3	Chan	1275.93	1318.59	4824.71	1002.05	42.66	9.65	23.49	4.81	0.18	0.86
4	Chan	1318.59	1361.26	4693.50	985.89	42.69	9.39	23.11	4.76	0.18	0.84
5	Chan	1361.26	1403.92	4864.41	1007.05	42.67	9.73	23.61	4.83	0.18	0.87
6	Chan	1403.92	1446.58	4618.13	977.19	42.78	9.24	22.91	4.73	0.17	0.83
7	Chan	1446.58	1489.24	4898.41	1011.20	42.66	9.80	23.70	4.84	0.18	0.88
8	Chan	1489.24	1531.90	4828.16	1002.60	42.68	9.66	23.50	4.82	0.18	0.86
9	Chan	1531.90	1574.57	4947.96	1017.41	42.67	9.90	23.85	4.86	0.18	0.89
10	Chan	1574.57	1617.23	5211.57	1049.55	42.67	10.42	24.60	4.97	0.19	0.93
11	Chan	1617.23	1659.89	4941.33	1017.64	42.78	9.88	23.85	4.86	0.18	0.88
12	ROB	1659.89	1680.85	528.30	333.38	36.91	1.06	16.09	1.58	0.07	0.11

Plan: Grand Rvr 2017 Grand River Upper RS: 212431.8BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1084.01	1233.27	1157.70	518.98	85.57	2.32	14.39	2.23	0.23	0.51
2	Chan	1233.27	1275.93	5497.79	901.35	85.42	11.00	21.13	6.10	0.39	2.40
3	Chan	1275.93	1318.59	3464.37	767.75	114.35	6.93	21.12	4.51	0.25	1.13
4	Chan	1318.59	1361.26	5591.31	910.24	85.36	11.18	21.34	6.14	0.40	2.45
5	Chan	1361.26	1403.92	5801.57	930.53	85.33	11.60	21.81	6.23	0.41	2.54
6	Chan	1403.92	1446.58	3314.14	744.40	113.13	6.63	20.48	4.45	0.25	1.09
7	Chan	1446.58	1489.24	5867.30	936.81	85.32	11.73	21.96	6.26	0.41	2.57
8	Chan	1489.24	1531.90	3469.32	768.05	114.21	6.94	21.13	4.52	0.25	1.13
9	Chan	1531.90	1574.57	5866.79	936.80	85.33	11.73	21.96	6.26	0.41	2.57
10	Chan	1574.57	1617.23	4638.93	861.72	98.49	9.28	22.51	5.38	0.33	1.76
11	Chan	1617.23	1659.89	4626.78	877.40	103.44	9.25	21.54	5.27	0.32	1.67
12	ROB	1659.89	1680.85	704.00	288.88	55.13	1.41	14.13	2.44	0.20	0.48

Plan: Grand Rvr 2017 Grand River Upper RS: 212431.8BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1180.12	1243.16	1112.76	465.24	77.95	2.23	14.47	2.39	0.26	0.61
2	Chan	1243.16	1285.91	5456.71	897.33	85.53	10.91	20.99	6.08	0.45	2.74
3	Chan	1285.91	1328.66	3403.87	754.57	112.57	6.81	20.71	4.51	0.29	1.30
4	Chan	1328.66	1371.41	5595.01	910.81	85.51	11.19	21.31	6.14	0.46	2.81
5	Chan	1371.41	1414.16	5690.29	920.09	85.51	11.38	21.52	6.18	0.46	2.86
6	Chan	1414.16	1456.91	3314.47	741.84	112.28	6.63	20.36	4.47	0.28	1.27
7	Chan	1456.91	1499.66	5724.82	923.40	85.50	11.45	21.60	6.20	0.46	2.87
8	Chan	1499.66	1542.41	3382.15	752.60	112.92	6.76	20.66	4.49	0.29	1.29
9	Chan	1542.41	1585.16	5968.26	946.83	85.52	11.94	22.15	6.30	0.48	3.00
10	Chan	1585.16	1627.91	4530.45	846.62	97.76	9.06	21.89	5.35	0.37	1.99
11	Chan	1627.91	1670.66	4576.23	864.11	101.35	9.15	21.34	5.30	0.37	1.94
12	ROB	1670.66	1698.21	1244.98	428.12	69.56	2.49	15.54	2.91	0.26	0.77

Plan: Grand Rvr 2017 Grand River Upper RS: 212414.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1180.12	1243.16	975.18	518.16	47.55	1.95	16.11	1.88	0.10	0.19
2	Chan	1243.16	1285.91	4644.31	959.93	42.78	9.29	22.45	4.84	0.21	1.02
3	Chan	1285.91	1328.66	4702.13	967.04	42.78	9.40	22.62	4.86	0.21	1.04
4	Chan	1328.66	1371.41	4748.93	972.63	42.76	9.50	22.75	4.88	0.21	1.05
5	Chan	1371.41	1414.16	4832.38	982.86	42.76	9.66	22.99	4.92	0.22	1.06
6	Chan	1414.16	1456.91	4607.84	955.51	42.80	9.22	22.35	4.82	0.21	1.01
7	Chan	1456.91	1499.66	4842.01	983.96	42.75	9.68	23.02	4.92	0.22	1.07
8	Chan	1499.66	1542.41	4701.19	966.99	42.79	9.40	22.62	4.86	0.21	1.03
9	Chan	1542.41	1585.16	5085.90	1013.55	42.77	10.17	23.71	5.02	0.22	1.12
10	Chan	1585.16	1627.91	5013.58	1005.37	42.82	10.03	23.52	4.99	0.22	1.10
11	Chan	1627.91	1670.66	4892.30	992.56	43.02	9.78	23.22	4.93	0.22	1.07
12	ROB	1670.66	1698.21	954.25	479.41	44.09	1.91	17.40	1.99	0.10	0.20

Plan: Grand Rvr 2017 Grand River Upper RS: 212334.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1178.55	1220.57	621.25	436.30	42.02	1.24	12.22	1.42	0.09	0.13
2	Chan	1220.57	1263.45	4628.89	981.73	43.04	9.26	22.90	4.72	0.20	0.94
3	Chan	1263.45	1306.32	4712.23	990.77	42.88	9.42	23.11	4.76	0.20	0.96
4	Chan	1306.32	1349.20	4755.52	996.22	42.88	9.51	23.23	4.77	0.20	0.97
5	Chan	1349.20	1392.08	4810.13	1003.07	42.88	9.62	23.39	4.80	0.20	0.98
6	Chan	1392.08	1434.96	4707.28	990.17	42.88	9.41	23.09	4.75	0.20	0.96
7	Chan	1434.96	1477.83	4683.88	987.19	42.88	9.37	23.02	4.74	0.20	0.96
8	Chan	1477.83	1520.71	4776.38	998.90	42.88	9.55	23.30	4.78	0.20	0.97
9	Chan	1520.71	1563.59	4940.94	1019.34	42.88	9.88	23.77	4.85	0.21	1.01
10	Chan	1563.59	1606.46	4955.37	1021.13	42.88	9.91	23.82	4.85	0.21	1.01
11	Chan	1606.46	1649.34	4853.38	1009.65	43.00	9.71	23.55	4.81	0.21	0.99

Plan: Grand Rvr 2017 Grand River Upper RS: 212334.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
12	ROB	1649.34	1766.53	1554.78	942.50	108.71	3.11	9.06	1.65	0.08	0.13

Plan: Grand Rvr 2017 Grand River Upper RS: 212103.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	406.00	541.33	0.00	7.27	30.75	0.00	0.24	0.00	0.00	0.00
2	LOB	541.33	676.67	0.00	43.84	135.33	0.00	0.32	0.00	0.00	0.00
3	LOB	676.67	812.00	0.00	120.94	135.34	0.00	0.89	0.00	0.01	0.00
4	LOB	812.00	947.33	0.00	286.03	135.34	0.00	2.11	0.00	0.02	0.00
5	LOB	947.33	1082.67	0.00	497.57	135.39	0.00	3.68	0.00	0.03	0.00
6	LOB	1082.67	1218.00	0.00	83.87	59.03	0.00	1.42	0.00	0.01	0.00
7	LOB	1218.00	1385.49	332.63	426.31	75.39	0.67	6.12	0.78	0.05	0.04
8	Chan	1385.49	1427.95	4820.27	1013.39	42.64	9.64	23.87	4.76	0.20	0.95
9	Chan	1427.95	1470.41	5007.85	1035.13	42.46	10.02	24.38	4.84	0.21	0.99
10	Chan	1470.41	1512.87	4945.46	1027.37	42.46	9.89	24.20	4.81	0.20	0.98
11	Chan	1512.87	1555.33	4903.09	1022.08	42.46	9.81	24.07	4.80	0.20	0.97
12	Chan	1555.33	1597.79	4908.23	1022.72	42.46	9.82	24.09	4.80	0.20	0.97
13	Chan	1597.79	1640.24	4937.60	1026.39	42.46	9.88	24.17	4.81	0.20	0.98
14	Chan	1640.24	1682.70	4941.96	1026.94	42.46	9.88	24.19	4.81	0.20	0.98
15	Chan	1682.70	1725.16	5075.04	1043.53	42.47	10.15	24.58	4.86	0.21	1.01
16	Chan	1725.16	1767.62	4872.63	1018.44	42.48	9.75	23.99	4.78	0.20	0.97
17	Chan	1767.62	1810.08	4459.52	965.71	42.48	8.92	22.74	4.62	0.19	0.88
18	ROB	1810.08	1850.73	795.72	455.30	46.84	1.59	11.37	1.75	0.08	0.14

Plan: Grand Rvr 2017 Grand River Upper RS: 211964.7 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1441.81	1463.39	479.60	453.74	40.85	0.96	21.04	1.06	0.06	0.07
2	Chan	1463.39	1511.91	4543.27	1165.47	48.54	9.09	24.02	3.90	0.13	0.52
3	Chan	1511.91	1560.42	5135.29	1255.50	48.65	10.27	25.88	4.09	0.14	0.59
4	Chan	1560.42	1608.94	4776.21	1201.33	48.57	9.55	24.76	3.98	0.14	0.55
5	Chan	1608.94	1657.45	4942.88	1228.13	48.75	9.89	25.31	4.02	0.14	0.57
6	Chan	1657.45	1705.97	5164.34	1260.85	48.75	10.33	25.99	4.10	0.14	0.59
7	Chan	1705.97	1754.48	4839.16	1210.52	48.55	9.68	24.95	4.00	0.14	0.56
8	Chan	1754.48	1803.00	4767.07	1199.42	48.52	9.53	24.72	3.97	0.14	0.55
9	Chan	1803.00	1851.51	4646.13	1181.09	48.52	9.29	24.34	3.93	0.14	0.53
10	Chan	1851.51	1900.03	4990.41	1233.01	48.54	9.98	25.41	4.05	0.14	0.57
11	Chan	1900.03	1948.54	4831.13	1209.55	48.57	9.66	24.93	3.99	0.14	0.56
12	ROB	1948.54	2032.60	884.51	657.37	73.52	1.77	11.37	1.35	0.05	0.07

Plan: Grand Rvr 2017 Grand River Upper RS: 211918.1BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1441.81	1463.39	252.09	210.17	48.14	0.50	9.78	1.20	0.23	0.27
2	Chan	1463.39	1511.91	5856.26	933.83	97.56	11.71	19.25	6.27	0.50	3.12
3	Chan	1511.91	1560.42	2702.59	605.06	105.16	5.41	15.31	4.47	0.30	1.34
4	Chan	1560.42	1608.94	6318.45	978.65	97.87	12.64	20.17	6.46	0.52	3.35
5	Chan	1608.94	1657.45	3745.51	708.94	95.78	7.49	17.55	5.28	0.38	2.03
6	Chan	1657.45	1705.97	5333.84	929.21	110.85	10.67	19.51	5.74	0.44	2.50
7	Chan	1705.97	1754.48	6156.90	965.00	98.24	12.31	19.89	6.38	0.51	3.26
8	Chan	1754.48	1803.00	2963.65	635.64	103.59	5.93	16.09	4.66	0.32	1.49
9	Chan	1803.00	1851.51	6597.14	1002.92	97.53	13.19	20.67	6.58	0.53	3.51
10	Chan	1851.51	1900.03	2630.08	592.41	103.90	5.26	14.99	4.44	0.30	1.32
11	Chan	1900.03	1948.54	6522.68	996.37	97.60	13.05	20.54	6.55	0.53	3.47
12	ROB	1948.54	2032.60	920.81	325.38	63.55	1.84	11.20	2.83	0.27	0.75

Plan: Grand Rvr 2017 Grand River Upper RS: 211918.1BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1482.65	1494.43	129.96	120.53	31.63	0.26	10.31	1.08	0.15	0.16
2	Chan	1494.43	1544.35	5591.45	959.59	100.75	11.18	19.22	5.83	0.37	2.17
3	Chan	1544.35	1594.26	2901.57	660.85	106.08	5.80	16.15	4.39	0.24	1.07
4	Chan	1594.26	1644.18	6285.07	1030.86	101.13	12.57	20.65	6.10	0.40	2.43
5	Chan	1644.18	1694.10	4617.98	873.31	106.07	9.24	18.96	5.29	0.32	1.71
6	Chan	1694.10	1744.02	4635.72	865.22	103.03	9.27	19.33	5.36	0.33	1.76
7	Chan	1744.02	1793.93	6657.43	1066.29	100.94	13.31	21.36	6.24	0.41	2.58
8	Chan	1793.93	1843.85	3067.23	687.64	107.80	6.13	16.81	4.46	0.25	1.11
9	Chan	1843.85	1893.77	6769.88	1074.63	100.37	13.54	21.53	6.30	0.42	2.64
10	Chan	1893.77	1943.68	2583.56	617.75	106.67	5.17	15.10	4.18	0.23	0.95
11	Chan	1943.68	1993.60	6112.35	1010.94	100.42	12.22	20.25	6.05	0.39	2.38
12	ROB	1993.60	2016.81	647.82	267.98	53.64	1.30	11.55	2.42	0.20	0.47

Plan: Grand Rvr 2017 Grand River Upper RS: 211868.1 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1482.65	1494.43	271.38	263.87	33.70	0.54	22.42	1.03	0.04	0.04
2	Chan	1494.43	1544.35	4567.14	1189.78	49.94	9.13	23.84	3.84	0.11	0.44
3	Chan	1544.35	1594.26	4801.92	1226.02	49.93	9.60	24.56	3.92	0.12	0.46
4	Chan	1594.26	1644.18	5079.78	1268.55	49.97	10.16	25.41	4.00	0.12	0.48
5	Chan	1644.18	1694.10	4947.06	1248.21	49.94	9.89	25.01	3.96	0.12	0.47
6	Chan	1694.10	1744.02	5050.92	1263.88	49.94	10.10	25.32	4.00	0.12	0.48
7	Chan	1744.02	1793.93	5124.94	1274.88	49.93	10.25	25.54	4.02	0.12	0.49
8	Chan	1793.93	1843.85	4950.84	1248.64	49.92	9.90	25.01	3.97	0.12	0.47
9	Chan	1843.85	1893.77	4859.03	1234.69	49.92	9.72	24.73	3.94	0.12	0.46
10	Chan	1893.77	1943.68	4871.06	1237.02	49.97	9.74	24.78	3.94	0.12	0.46
11	Chan	1943.68	1993.60	4721.31	1213.84	49.95	9.44	24.32	3.89	0.12	0.45
12	ROB	1993.60	2016.81	754.63	510.59	44.04	1.51	22.00	1.48	0.06	0.08

Plan: Grand Rvr 2017 Grand River Upper RS: 211664.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1886.36	2164.09	377.90	570.34	215.06	0.76	2.72	0.66	0.02	0.01
2	Chan	2164.09	2204.00	4149.83	972.42	40.15	8.30	24.36	4.27	0.14	0.60
3	Chan	2204.00	2243.91	4828.39	1062.81	39.95	9.66	26.63	4.54	0.15	0.70
4	Chan	2243.91	2283.83	5489.75	1148.36	39.99	10.98	28.77	4.78	0.17	0.80
5	Chan	2283.83	2323.74	5921.48	1201.44	39.97	11.84	30.10	4.93	0.17	0.86
6	Chan	2323.74	2363.65	5391.92	1135.48	39.94	10.78	28.45	4.75	0.16	0.78
7	Chan	2363.65	2403.56	5129.22	1101.68	39.92	10.26	27.60	4.66	0.16	0.74
8	Chan	2403.56	2443.47	4743.79	1051.66	39.96	9.49	26.35	4.51	0.15	0.69
9	Chan	2443.47	2483.39	4384.63	1002.74	39.92	8.77	25.12	4.37	0.15	0.64
10	Chan	2483.39	2523.30	4401.30	1005.01	39.92	8.80	25.18	4.38	0.15	0.64
11	Chan	2523.30	2563.21	4198.67	979.82	40.21	8.40	24.55	4.29	0.14	0.60
12	ROB	2563.21	2589.94	874.06	515.95	43.96	1.75	19.30	1.69	0.07	0.12
13	ROB	2589.94	2770.94	109.07	266.00	181.07	0.22	1.47	0.41	0.01	0.00
14	ROB	2770.94	3386.55	0.00	775.09	455.47	0.00	1.70	0.00	0.01	0.00
15	ROB	3386.55	4002.15	0.00	605.36	472.38	0.00	1.28	0.00	0.01	0.00
16	ROB	4002.15	4617.76	0.00	2.85	25.27	0.00	0.11	0.00	0.00	0.00
17	ROB	4617.76	5233.36	0.00	219.99	106.75	0.00	2.06	0.00	0.01	0.00
18	ROB	5233.36	5848.97	0.00	2363.62	615.67	0.00	3.84	0.00	0.02	0.00
19	ROB	5848.97	6464.58	0.00	3413.28	615.63	0.00	5.54	0.00	0.03	0.00
20	ROB	6464.58	7080.18	0.00	2426.77	615.61	0.00	3.94	0.00	0.02	0.00
21	ROB	7080.18	7695.79	0.00	879.55	351.30	0.00	2.50	0.00	0.01	0.00
22	ROB	7695.79	8311.40	0.00	2254.47	504.23	0.00	4.47	0.00	0.03	0.00
23	ROB	8311.40	8927.00	0.00	3027.47	484.83	0.00	6.25	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 211561.3 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1968.20	2188.66	300.60	470.37	50.30	0.60	10.69	0.64	0.05	0.04
2	Chan	2188.66	2227.77	4473.31	1010.00	39.80	8.95	25.82	4.43	0.15	0.66
3	Chan	2227.77	2266.88	5313.06	1112.78	39.17	10.63	28.45	4.77	0.17	0.80
4	Chan	2266.88	2306.00	5875.32	1181.63	39.14	11.75	30.21	4.97	0.18	0.88
5	Chan	2306.00	2345.11	5673.37	1157.79	39.20	11.35	29.60	4.90	0.17	0.85
6	Chan	2345.11	2384.22	4613.95	1023.71	39.29	9.23	26.17	4.51	0.15	0.69
7	Chan	2384.22	2423.33	4366.44	988.56	39.11	8.73	25.27	4.42	0.15	0.65
8	Chan	2423.33	2462.44	4400.32	993.16	39.11	8.80	25.39	4.43	0.15	0.66
9	Chan	2462.44	2501.56	4496.48	1006.13	39.11	8.99	25.72	4.47	0.15	0.67
10	Chan	2501.56	2540.67	4590.51	1018.70	39.11	9.18	26.05	4.51	0.15	0.69
11	Chan	2540.67	2579.78	4197.04	968.78	39.46	8.39	24.77	4.33	0.14	0.62
12	ROB	2579.78	2622.75	1269.22	782.22	59.85	2.54	18.20	1.62	0.08	0.12
13	ROB	2622.75	2777.00	430.38	571.14	155.43	0.86	3.70	0.75	0.02	0.02
14	ROB	2777.00	3391.36	0.00	1752.13	614.44	0.00	2.85	0.00	0.02	0.00
15	ROB	3391.36	4005.71	0.00	736.35	604.40	0.00	1.22	0.00	0.01	0.00
16	ROB	4005.71	4620.07							0.00	0.00
17	ROB	4620.07	5234.42	0.00	48.63	79.60	0.00	0.61	0.00	0.00	0.00
18	ROB	5234.42	5848.78	0.00	1699.65	510.90	0.00	3.33	0.00	0.02	0.00
19	ROB	5848.78	6463.14	0.00	3443.14	614.37	0.00	5.60	0.00	0.03	0.00
20	ROB	6463.14	7077.49	0.00	2429.06	614.36	0.00	3.95	0.00	0.02	0.00
21	ROB	7077.49	7691.85	0.00	1008.05	396.49	0.00	2.54	0.00	0.01	0.00
22	ROB	7691.85	8306.20	0.00	2576.61	561.47	0.00	4.59	0.00	0.03	0.00
23	ROB	8306.20	8920.56	0.00	3057.89	464.67	0.00	6.59	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 211348.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	819.54	946.22	693.17	882.66	86.36	1.39	10.71	0.79	0.08	0.06
2	Chan	946.22	979.96	3899.15	808.89	33.75	7.80	23.97	4.82	0.18	0.87
3	Chan	979.96	1013.70	4122.32	836.39	33.75	8.24	24.79	4.93	0.19	0.92
4	Chan	1013.70	1047.44	4550.52	889.71	33.96	9.10	26.37	5.11	0.20	1.00
5	Chan	1047.44	1081.18	5376.69	982.26	33.87	10.75	29.11	5.47	0.22	1.19
6	Chan	1081.18	1114.92	5391.52	982.82	33.78	10.78	29.13	5.49	0.22	1.20
7	Chan	1114.92	1148.66	5323.35	975.65	33.80	10.65	28.92	5.46	0.22	1.18
8	Chan	1148.66	1182.40	4241.48	854.80	34.15	8.48	25.33	4.96	0.19	0.93
9	Chan	1182.40	1216.14	4117.63	837.12	33.88	8.24	24.81	4.92	0.19	0.91
10	Chan	1216.14	1249.88	4128.02	837.60	33.80	8.26	24.83	4.93	0.19	0.92
11	Chan	1249.88	1283.62	4287.94	858.12	33.92	8.58	25.43	5.00	0.19	0.95
12	ROB	1283.62	1386.09	3868.22	1983.03	121.23	7.74	19.35	1.95	0.12	0.24

Plan: Grand Rvr 2017 Grand River Upper RS: 211242.4BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	819.54	946.22	888.58	877.51	86.14	1.78	10.67	1.01	0.13	0.13
2	Chan	946.22	979.96	4669.92	806.78	33.75	9.34	23.91	5.79	0.30	1.74
3	Chan	979.96	1013.70	4025.49	817.54	43.59	8.05	24.23	4.92	0.24	1.16
4	Chan	1013.70	1047.44	1916.28	618.55	66.08	3.83	23.47	3.10	0.12	0.36
5	Chan	1047.44	1081.18	6444.49	980.15	33.87	12.89	29.05	6.57	0.36	2.39
6	Chan	1081.18	1114.92	6462.27	980.71	33.78	12.92	29.07	6.59	0.36	2.40
7	Chan	1114.92	1148.66	6380.40	973.54	33.80	12.76	28.85	6.55	0.36	2.37
8	Chan	1148.66	1182.40	2445.95	646.97	51.27	4.89	23.82	3.78	0.16	0.60
9	Chan	1182.40	1216.14	3045.13	768.60	56.78	6.09	23.37	3.96	0.17	0.67
10	Chan	1216.14	1249.88	4944.77	835.49	33.80	9.89	24.76	5.92	0.31	1.84
11	Chan	1249.88	1283.62	5136.84	856.01	33.92	10.27	25.37	6.00	0.32	1.90
12	ROB	1283.62	1386.09	3639.88	1791.33	149.97	7.28	18.89	2.03	0.15	0.30

Plan: Grand Rvr 2017 Grand River Upper RS: 211242.4BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	883.87	995.68	891.03	821.25	69.19	1.78	12.68	1.08	0.14	0.15
2	Chan	995.68	1029.67	5452.89	849.21	34.15	10.91	24.98	6.42	0.29	1.86
3	Chan	1029.67	1063.66	3306.42	769.36	56.50	6.61	23.56	4.30	0.16	0.68
4	Chan	1063.66	1097.65	2795.48	672.92	52.00	5.59	24.40	4.15	0.15	0.62
5	Chan	1097.65	1131.64	6916.78	978.04	34.03	13.83	28.77	7.07	0.33	2.36
6	Chan	1131.64	1165.64	6877.23	975.11	34.06	13.75	28.69	7.05	0.33	2.35
7	Chan	1165.64	1199.63	6495.72	941.59	34.00	12.99	27.70	6.90	0.32	2.22
8	Chan	1199.63	1233.62	2062.37	619.52	66.74	4.12	23.61	3.33	0.11	0.36
9	Chan	1233.62	1267.61	4301.94	812.49	43.63	8.60	23.90	5.29	0.22	1.15
10	Chan	1267.61	1301.60	5270.01	830.56	34.00	10.54	24.43	6.35	0.28	1.80
11	Chan	1301.60	1335.59	5275.48	832.10	34.11	10.55	24.48	6.34	0.28	1.80
12	ROB	1335.59	1438.77	354.66	1825.58	153.05	0.71	19.14	0.19	0.14	0.03

Plan: Grand Rvr 2017 Grand River Upper RS: 211144.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	883.87	995.68	696.23	824.00	69.43	1.39	12.67	0.84	0.08	0.07
2	Chan	995.68	1029.67	4561.18	850.65	34.15	9.12	25.03	5.36	0.17	0.94
3	Chan	1029.67	1063.66	4531.43	846.02	34.02	9.06	24.89	5.36	0.17	0.93
4	Chan	1063.66	1097.65	4696.71	872.19	34.79	9.39	25.66	5.38	0.18	0.95
5	Chan	1097.65	1131.64	5783.53	979.48	34.03	11.57	28.82	5.90	0.20	1.19
6	Chan	1131.64	1165.64	5750.51	976.55	34.06	11.50	28.73	5.89	0.20	1.18
7	Chan	1165.64	1199.63	5431.98	943.03	34.00	10.86	27.74	5.76	0.19	1.12
8	Chan	1199.63	1233.62	5031.88	903.33	34.25	10.06	26.58	5.57	0.19	1.03
9	Chan	1233.62	1267.61	4308.98	820.90	34.02	8.62	24.15	5.25	0.17	0.89
10	Chan	1267.61	1301.60	4408.49	832.00	34.00	8.82	24.48	5.30	0.17	0.91
11	Chan	1301.60	1335.59	4413.04	833.55	34.11	8.83	24.52	5.29	0.17	0.91
12	ROB	1335.59	1438.77	386.06	2026.44	123.19	0.77	19.64	0.19	0.12	0.02

Plan: Grand Rvr 2017 Grand River Upper RS: 210918.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	406.46	487.76	0.00	4.90	23.71	0.00	0.21	0.00	0.00	0.00
2	LOB	487.76	569.05	0.00	60.72	81.30	0.00	0.75	0.00	0.00	0.00
3	LOB	569.05	650.34	0.00	82.09	81.29	0.00	1.01	0.00	0.00	0.00
4	LOB	650.34	757.99	0.00	65.51	101.80	0.00	0.64	0.00	0.00	0.00
5	LOB	757.99	797.04	256.09	444.05	44.68	0.51	11.42	0.58	0.04	0.03
6	Chan	797.04	835.66	4329.70	1006.37	39.69	8.66	26.06	4.30	0.11	0.48
7	Chan	835.66	874.29	4822.51	1062.10	38.64	9.65	27.50	4.54	0.12	0.55
8	Chan	874.29	912.91	5066.39	1093.93	38.63	10.13	28.32	4.63	0.12	0.58
9	Chan	912.91	951.54	5250.82	1117.69	38.63	10.50	28.94	4.70	0.13	0.60
10	Chan	951.54	990.16	5049.60	1091.95	38.65	10.10	28.27	4.62	0.12	0.58
11	Chan	990.16	1028.78	4719.94	1048.45	38.63	9.44	27.15	4.50	0.12	0.54
12	Chan	1028.78	1067.41	4557.73	1026.63	38.63	9.12	26.58	4.44	0.12	0.52
13	Chan	1067.41	1106.03	4604.54	1032.92	38.63	9.21	26.74	4.46	0.12	0.52
14	Chan	1106.03	1144.66	4723.53	1048.86	38.63	9.45	27.16	4.50	0.12	0.54
15	Chan	1144.66	1183.28	4183.92	980.44	39.14	8.37	25.38	4.27	0.11	0.47
16	ROB	1183.28	1238.32	1361.32	1163.48	75.47	2.72	21.14	1.17	0.07	0.08
17	ROB	1238.32	1539.34	1073.92	1418.06	305.56	2.15	4.71	0.76	0.02	0.02
18	ROB	1539.34	2188.57	0.00	1913.36	626.77	0.00	3.05	0.00	0.01	0.00
19	ROB	2188.57	2837.80	0.00	414.91	346.36	0.00	1.20	0.00	0.01	0.00
20	ROB	2837.80	3487.02	0.00	0.44	4.88	0.00	0.09	0.00	0.00	0.00
21	ROB	3487.02	4136.25	0.00	189.46	115.64	0.00	1.64	0.00	0.01	0.00
22	ROB	4136.25	4785.48	0.00	3882.76	649.27	0.00	5.98	0.00	0.03	0.00
23	ROB	4785.48	5434.71	0.00	4264.58	649.25	0.00	6.57	0.00	0.03	0.00
24	ROB	5434.71	6083.94	0.00	4183.92	649.29	0.00	6.44	0.00	0.03	0.00
25	ROB	6083.94	6733.16	0.00	3533.92	649.24	0.00	5.44	0.00	0.02	0.00
26	ROB	6733.16	7382.39	0.00	1585.50	465.64	0.00	3.41	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 210676.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	478.32	558.04	0.00	7.00	57.03	0.00	0.12	0.00	0.00	0.00
2	LOB	558.04	637.76	0.00	11.90	79.72	0.00	0.15	0.00	0.00	0.00
3	LOB	637.76	721.19	0.12	3.49	83.43	0.00	0.04	0.03	0.00	0.00
4	LOB	721.19	804.62	260.31	468.53	88.46	0.52	5.62	0.56	0.02	0.01
5	Chan	804.62	848.45	4850.40	1128.30	44.41	9.70	25.74	4.30	0.11	0.48
6	Chan	848.45	892.28	5701.99	1237.10	43.86	11.40	28.23	4.61	0.12	0.57
7	Chan	892.28	936.11	5962.32	1270.33	43.83	11.92	28.98	4.69	0.13	0.60
8	Chan	936.11	979.94	5766.36	1245.17	43.84	11.53	28.41	4.63	0.12	0.58
9	Chan	979.94	1023.77	5503.64	1210.82	43.84	11.01	27.63	4.55	0.12	0.55
10	Chan	1023.77	1067.60	5232.83	1174.86	43.85	10.47	26.80	4.45	0.12	0.52
11	Chan	1067.60	1111.43	4736.39	1106.73	43.86	9.47	25.25	4.28	0.11	0.47
12	Chan	1111.43	1155.26	4528.36	1077.14	43.84	9.06	24.58	4.20	0.11	0.45
13	Chan	1155.26	1199.09	3249.38	1013.77	43.95	6.50	23.13	3.21	0.10	0.32
14	Chan	1199.09	1242.92	2913.69	1023.15	46.20	5.83	23.34	2.85	0.10	0.28
15	ROB	1242.92	1245.02	0.09	1.26	23.77	0.00	0.60	0.07	0.00	0.00
16	ROB	1245.02	1547.97	1294.13	1457.43	306.31	2.59	4.81	0.89	0.02	0.02
17	ROB	1547.97	2132.16	0.00	1163.28	500.83	0.00	2.32	0.00	0.01	0.00
18	ROB	2132.16	2716.35	0.00	0.89	35.20	0.00	0.03	0.00	0.00	0.00
19	ROB	2716.35	3300.54							0.00	0.00
20	ROB	3300.54	3884.73							0.00	0.00
21	ROB	3884.73	4468.92	0.00	2119.23	489.57	0.00	4.33	0.00	0.02	0.00
22	ROB	4468.92	5053.11	0.00	3357.58	584.20	0.00	5.75	0.00	0.03	0.00
23	ROB	5053.11	5637.30	0.00	4230.42	584.20	0.00	7.24	0.00	0.03	0.00
24	ROB	5637.30	6221.49	0.00	4090.91	584.20	0.00	7.00	0.00	0.03	0.00
25	ROB	6221.49	6805.68	0.00	3531.67	584.23	0.00	6.05	0.00	0.03	0.00
26	ROB	6805.68	7389.87	0.00	597.89	283.72	0.00	2.11	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209996.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	998.90	1007.89	93.32	105.27	23.65	0.19	11.75	0.89	0.03	0.02
2	Chan	1007.89	1052.67	6097.27	1205.12	47.77	12.19	26.91	5.06	0.16	0.78
3	Chan	1052.67	1097.45	7065.50	1283.23	44.81	14.13	28.66	5.51	0.18	0.97
4	Chan	1097.45	1142.22	7514.93	1331.32	44.78	15.03	29.73	5.64	0.18	1.03
5	Chan	1142.22	1187.00	7572.04	1337.87	44.82	15.14	29.88	5.66	0.18	1.04
6	Chan	1187.00	1231.78	6574.59	1231.75	45.06	13.15	27.51	5.34	0.17	0.90
7	Chan	1231.78	1276.56	1685.44	808.83	46.70	3.37	18.06	2.08	0.11	0.22
8	Chan	1276.56	1321.34	448.57	563.74	44.79	0.90	12.59	0.80	0.08	0.06
9	Chan	1321.34	1366.11	2511.59	872.79	46.68	5.02	19.49	2.88	0.11	0.33
10	Chan	1366.11	1410.89	5072.96	1051.75	44.79	10.15	23.49	4.82	0.14	0.70
11	Chan	1410.89	1455.67	5278.05	1102.35	47.47	10.56	24.62	4.79	0.14	0.68
12	ROB	1455.67	1458.38	12.53	29.68	21.76	0.03	10.95	0.42	0.01	0.00
13	ROB	1458.38	1731.55	73.20	121.07	51.82	0.15	2.91	0.60	0.01	0.01
14	ROB	1731.55	2311.76	0.00	212.41	153.84	0.00	1.41	0.00	0.01	0.00
15	ROB	2311.76	2891.97							0.00	0.00
16	ROB	2891.97	3472.17							0.00	0.00
17	ROB	3472.17	4052.38							0.00	0.00
18	ROB	4052.38	4632.59	0.00	769.02	322.71	0.00	2.38	0.00	0.01	0.00
19	ROB	4632.59	5212.80	0.00	2825.02	580.22	0.00	4.87	0.00	0.03	0.00
20	ROB	5212.80	5793.01	0.00	3949.81	580.22	0.00	6.81	0.00	0.04	0.00
21	ROB	5793.01	6373.21	0.00	4395.79	580.21	0.00	7.58	0.00	0.05	0.00
22	ROB	6373.21	6953.42	0.00	2852.76	580.24	0.00	4.92	0.00	0.03	0.00
23	ROB	6953.42	7533.63	0.00	278.82	195.63	0.00	1.43	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209711.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	760.00	886.67	0.00	36.43	82.19	0.00	0.44	0.00	0.00	0.00
2	LOB	886.67	1013.33	0.00	134.19	126.67	0.00	1.06	0.00	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209711.4 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
3	LOB	1013.33	1140.00	0.00	141.46	126.68	0.00	1.12	0.00	0.00	0.00
4	LOB	1140.00	1331.55	1526.52	2252.29	208.56	3.05	11.76	0.68	0.04	0.02
5	Chan	1331.55	1383.90	4539.86	1266.57	52.39	9.08	24.20	3.58	0.08	0.28
6	Chan	1383.90	1436.24	5959.86	1495.41	52.76	11.92	28.57	3.99	0.09	0.37
7	Chan	1436.24	1488.59	7708.48	1742.15	52.54	15.42	33.28	4.42	0.11	0.48
8	Chan	1488.59	1540.93	6808.92	1616.87	52.52	13.62	30.89	4.21	0.10	0.43
9	Chan	1540.93	1593.28	5245.96	1382.68	52.52	10.49	26.41	3.79	0.09	0.33
10	Chan	1593.28	1645.62	5146.40	1365.16	52.36	10.29	26.08	3.77	0.09	0.32
11	Chan	1645.62	1697.97	3177.54	1233.09	53.81	6.36	23.56	2.58	0.08	0.19
12	Chan	1697.97	1750.31	1064.37	1229.16	53.52	2.13	23.48	0.87	0.08	0.07
13	Chan	1750.31	1802.66	3833.29	1268.77	52.40	7.67	24.24	3.02	0.08	0.24
14	Chan	1802.66	1855.00	4691.77	1291.67	52.38	9.38	24.68	3.63	0.08	0.29
15	ROB	1855.00	1870.20	230.71	339.29	36.46	0.46	22.32	0.68	0.03	0.02
16	ROB	1870.20	2110.00	66.32	341.20	239.95	0.13	1.42	0.19	0.00	0.00
17	ROB	2110.00	2694.64	0.00	803.17	340.88	0.00	2.36	0.00	0.01	0.00
18	ROB	2694.64	3279.28							0.00	0.00
19	ROB	3279.28	3863.91							0.00	0.00
20	ROB	3863.91	4448.55							0.00	0.00
21	ROB	4448.55	5033.19	0.00	670.56	290.09	0.00	2.31	0.00	0.01	0.00
22	ROB	5033.19	5617.83	0.00	3143.39	584.78	0.00	5.38	0.00	0.02	0.00
23	ROB	5617.83	6202.47	0.00	3371.12	584.65	0.00	5.77	0.00	0.02	0.00
24	ROB	6202.47	6787.10	0.00	4115.90	584.66	0.00	7.04	0.00	0.02	0.00
25	ROB	6787.10	7371.74	0.00	1655.92	485.93	0.00	3.41	0.00	0.01	0.00
26	ROB	7371.74	7956.38	0.00	258.60	208.07	0.00	1.24	0.00	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209683.8BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1140.00	1331.55	1640.45	1784.61	273.57	3.33	14.91	0.92	0.00	0.00
2	Chan	1331.55	1383.90	4678.30	1053.18	118.02	9.49	21.65	4.44	0.00	0.00
3	Chan	1383.90	1436.24	5712.61	1206.61	122.88	11.59	25.40	4.73	0.00	0.00
4	Chan	1436.24	1488.59	3022.38	683.88	77.22	6.13	29.50	4.42	0.00	0.00
5	Chan	1488.59	1540.93	9229.76	1510.20	104.87	18.73	28.85	6.11	0.00	0.00
6	Chan	1540.93	1593.28	3947.18	991.70	131.02	8.01	23.15	3.98	0.00	0.00
7	Chan	1593.28	1645.62	6596.87	1233.83	104.70	13.39	23.57	5.35	0.00	0.00
8	Chan	1645.62	1697.97	3944.82	1076.29	106.15	8.01	20.56	3.67	0.00	0.00
9	Chan	1697.97	1750.31	714.26	812.37	129.22	1.45	17.92	0.88	0.00	0.00
10	Chan	1750.31	1802.66	4267.06	1053.90	104.74	8.66	20.13	4.05	0.00	0.00
11	Chan	1802.66	1855.00	5030.96	1048.76	104.72	10.21	20.04	4.80	0.00	0.00
12	ROB	1855.00	1870.20	488.41	263.22	46.61	0.99	17.32	1.86	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209683.8BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1192.69	1326.12	576.11	763.58	175.67	1.17	9.30	0.75	0.00	0.00
2	Chan	1326.12	1382.00	4239.70	1022.59	120.80	8.60	20.56	4.15	0.00	0.00
3	Chan	1382.00	1437.87	5436.32	1222.48	130.00	11.03	22.22	4.45	0.00	0.00
4	Chan	1437.87	1493.75	4509.41	1013.21	107.62	9.15	24.64	4.45	0.00	0.00
5	Chan	1493.75	1549.62	4475.09	977.84	99.60	9.08	26.70	4.58	0.00	0.00
6	Chan	1549.62	1605.50	7902.68	1441.43	111.98	16.04	25.80	5.48	0.00	0.00
7	Chan	1605.50	1661.38	4293.50	1084.58	137.32	8.71	23.39	3.96	0.00	0.00
8	Chan	1661.38	1717.25	6539.56	1318.86	111.96	13.27	23.60	4.96	0.00	0.00
9	Chan	1717.25	1773.13	832.64	816.69	117.22	1.69	16.52	1.02	0.00	0.00
10	Chan	1773.13	1829.00	4894.77	1090.66	129.47	9.93	19.72	4.49	0.00	0.00
11	Chan	1829.00	1884.88	5246.31	1126.52	111.78	10.65	20.16	4.66	0.00	0.00
12	ROB	1884.88	1894.81	326.96	181.58	37.53	0.66	18.29	1.80	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209656.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	795.13	927.65	0.00	48.36	88.97	0.00	0.54	0.00	0.00	0.00
2	LOB	927.65	1060.17	0.00	167.80	132.52	0.00	1.27	0.00	0.01	0.00
3	LOB	1060.17	1192.69	0.00	132.50	132.53	0.00	1.00	0.00	0.00	0.00
4	LOB	1192.69	1326.12	583.67	1025.85	140.35	1.17	8.21	0.57	0.03	0.02
5	Chan	1326.12	1382.00	4406.10	1295.33	57.34	8.81	23.18	3.40	0.09	0.31
6	Chan	1382.00	1437.87	4885.63	1366.03	56.09	9.77	24.45	3.58	0.10	0.35
7	Chan	1437.87	1493.75	6028.57	1548.21	55.96	12.06	27.71	3.89	0.11	0.44
8	Chan	1493.75	1549.62	6691.27	1647.22	55.88	13.38	29.48	4.06	0.12	0.48
9	Chan	1549.62	1605.50	5991.86	1544.10	56.10	11.98	27.63	3.88	0.11	0.43
10	Chan	1605.50	1661.38	5525.22	1469.34	55.96	11.05	26.30	3.76	0.11	0.40
11	Chan	1661.38	1717.25	5218.03	1456.87	56.08	10.44	26.07	3.58	0.10	0.38
12	Chan	1717.25	1773.13	1003.61	1147.29	57.70	2.01	20.53	0.87	0.08	0.07
13	Chan	1773.13	1829.00	4579.53	1346.16	55.97	9.16	24.09	3.40	0.10	0.33
14	Chan	1829.00	1884.88	4865.33	1360.80	55.90	9.73	24.35	3.58	0.10	0.35
15	ROB	1884.88	1894.81	221.20	226.69	32.20	0.44	22.83	0.98	0.03	0.03

Plan: Grand Rvr 2017 Grand River Upper RS: 209422.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	837.23	976.76	0.00	23.32	48.61	0.00	0.48	0.00	0.00	0.00
2	LOB	976.76	1116.30	0.00	209.63	139.54	0.00	1.50	0.00	0.01	0.00
3	LOB	1116.30	1255.84	0.00	210.27	139.55	0.00	1.51	0.00	0.01	0.00
4	LOB	1255.84	1455.07	269.92	584.95	204.52	0.54	2.94	0.46	0.01	0.01
5	Chan	1455.07	1502.12	4218.11	1112.38	47.84	8.44	23.64	3.79	0.11	0.43
6	Chan	1502.12	1549.18	4526.26	1152.92	47.07	9.05	24.50	3.93	0.12	0.46
7	Chan	1549.18	1596.23	4908.53	1210.42	47.07	9.82	25.72	4.06	0.12	0.50
8	Chan	1596.23	1643.28	5338.90	1273.03	47.07	10.68	27.06	4.19	0.13	0.55
9	Chan	1643.28	1690.34	5494.09	1294.92	47.05	10.99	27.52	4.24	0.13	0.56
10	Chan	1690.34	1737.39	5379.72	1278.67	47.05	10.76	27.18	4.21	0.13	0.55
11	Chan	1737.39	1784.44	5266.30	1262.43	47.05	10.53	26.83	4.17	0.13	0.54
12	Chan	1784.44	1831.49	5149.68	1245.58	47.05	10.30	26.47	4.13	0.13	0.53
13	Chan	1831.49	1878.55	5005.99	1224.69	47.06	10.01	26.03	4.09	0.13	0.51
14	Chan	1878.55	1925.60	4429.38	1160.90	49.47	8.86	24.67	3.82	0.11	0.43
15	ROB	1925.60	1927.97	13.12	25.26	21.50	0.03	10.68	0.52	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 209175.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	866.08	1010.43	0.00	287.86	114.14	0.00	2.52	0.00	0.02	0.00
2	LOB	1010.43	1154.77	0.00	611.15	144.46	0.00	4.23	0.00	0.04	0.00
3	LOB	1154.77	1299.12	0.00	159.83	144.37	0.00	1.11	0.00	0.01	0.00
4	LOB	1299.12	1495.72	2088.89	2139.73	199.38	4.18	10.88	0.98	0.09	0.09
5	Chan	1495.72	1528.92	4232.58	820.38	33.85	8.47	24.71	5.16	0.20	1.06
6	Chan	1528.92	1562.13	4750.53	872.56	33.21	9.50	26.28	5.44	0.22	1.21
7	Chan	1562.13	1595.33	4969.15	896.47	33.21	9.94	27.00	5.54	0.23	1.26
8	Chan	1595.33	1628.54	5231.24	924.56	33.21	10.46	27.84	5.66	0.23	1.33
9	Chan	1628.54	1661.74	5340.64	936.29	33.23	10.68	28.20	5.70	0.24	1.36
10	Chan	1661.74	1694.94	4921.40	891.50	33.23	9.84	26.85	5.52	0.23	1.25
11	Chan	1694.94	1728.15	4794.23	877.30	33.20	9.59	26.42	5.46	0.22	1.22
12	Chan	1728.15	1761.35	4832.35	881.49	33.21	9.66	26.55	5.48	0.22	1.23
13	Chan	1761.35	1794.56	4706.22	867.76	33.22	9.41	26.13	5.42	0.22	1.20
14	Chan	1794.56	1827.76	4131.78	816.61	34.69	8.26	24.59	5.06	0.20	1.00
15	ROB	1827.76	1828.19	0.99	4.50	21.23	0.00	10.62	0.22	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 208859.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	828.47	927.70	1348.86	1191.14	94.08	2.70	13.10	1.13	0.16	0.18
2	Chan	927.70	957.01	4101.35	681.82	29.61	8.20	23.26	6.02	0.28	1.70

Plan: Grand Rvr 2017 Grand River Upper RS: 208859.8 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
3	Chan	957.01	986.32	4876.82	753.97	29.36	9.75	25.72	6.47	0.32	2.04
4	Chan	986.32	1015.63	4863.55	752.24	29.32	9.73	25.66	6.47	0.32	2.04
5	Chan	1015.63	1044.95	4757.72	742.69	29.35	9.52	25.34	6.41	0.31	1.99
6	Chan	1044.95	1074.26	5268.27	789.84	29.38	10.54	26.95	6.67	0.33	2.20
7	Chan	1074.26	1103.57	5447.64	805.21	29.32	10.90	27.47	6.77	0.34	2.28
8	Chan	1103.57	1132.88	5161.96	779.93	29.35	10.32	26.61	6.62	0.33	2.16
9	Chan	1132.88	1162.20	4739.79	741.03	29.35	9.48	25.28	6.40	0.31	1.98
10	Chan	1162.20	1191.51	4891.43	755.90	29.42	9.78	25.79	6.47	0.32	2.04
11	Chan	1191.51	1220.82	4025.88	674.11	29.59	8.05	23.00	5.97	0.28	1.67
12	ROB	1220.82	1280.74	516.73	566.12	61.79	1.03	9.76	0.91	0.11	0.10

Plan: Grand Rvr 2017 Grand River Upper RS: 208814.8BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	828.47	927.70	1525.72	1124.56	142.55	3.05	13.17	1.36	0.22	0.30
2	Chan	927.70	957.01	3458.62	651.98	52.74	6.92	22.80	5.30	0.35	1.84
3	Chan	957.01	986.32	3960.86	703.23	51.99	7.92	25.33	5.63	0.38	2.14
4	Chan	986.32	1015.63	6460.16	749.96	29.32	12.92	25.59	8.61	0.72	6.19
5	Chan	1015.63	1044.95	2795.59	662.93	75.66	5.59	24.55	4.22	0.25	1.04
6	Chan	1044.95	1074.26	6999.42	787.56	29.38	14.00	26.87	8.89	0.75	6.69
7	Chan	1074.26	1103.57	7238.44	802.93	29.32	14.48	27.39	9.02	0.77	6.94
8	Chan	1103.57	1132.88	2914.57	692.87	79.37	5.83	25.62	4.21	0.25	1.03
9	Chan	1132.88	1162.20	6295.29	738.75	29.35	12.59	25.20	8.52	0.71	6.03
10	Chan	1162.20	1191.51	2831.76	674.37	77.45	5.66	24.79	4.20	0.24	1.03
11	Chan	1191.51	1220.82	5344.36	671.83	29.59	10.69	22.92	7.95	0.64	5.07
12	ROB	1220.82	1280.74	175.21	168.53	28.14	0.35	18.56	1.04	0.17	0.17

Plan: Grand Rvr 2017 Grand River Upper RS: 208814.8BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	711.35	778.33	189.99	295.14	90.42	0.38	6.64	0.64	0.09	0.06
2	LOB	778.33	845.32	1609.69	1114.97	101.70	3.22	17.18	1.44	0.30	0.43
3	Chan	845.32	874.49	5359.77	686.32	29.56	10.72	23.53	7.81	0.63	4.95
4	Chan	874.49	903.66	2722.84	665.54	75.59	5.45	24.75	4.09	0.24	0.98
5	Chan	903.66	932.82	6375.82	757.66	29.17	12.75	25.97	8.42	0.71	5.97
6	Chan	932.82	961.99	2760.17	677.26	77.36	5.52	25.22	4.08	0.24	0.97
7	Chan	961.99	991.16	6975.05	800.91	29.29	13.95	27.46	8.71	0.75	6.51
8	Chan	991.16	1020.33	6424.27	761.78	29.23	12.85	26.12	8.43	0.71	6.00
9	Chan	1020.33	1049.50	2766.54	677.24	77.09	5.53	25.18	4.09	0.24	0.98
10	Chan	1049.50	1078.67	6574.44	771.91	29.19	13.15	26.46	8.52	0.72	6.15
11	Chan	1078.67	1107.84	2720.18	659.88	74.10	5.44	24.39	4.12	0.24	1.00
12	Chan	1107.84	1137.01	5174.72	678.09	30.23	10.35	23.25	7.63	0.61	4.68
13	ROB	1137.01	1192.04	346.52	296.89	40.81	0.69	18.10	1.17	0.20	0.23

Plan: Grand Rvr 2017 Grand River Upper RS: 208777.1 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	711.35	778.33	242.25	365.90	55.48	0.48	6.80	0.66	0.08	0.05
2	LOB	778.33	845.32	1462.48	1164.90	67.64	2.92	17.39	1.26	0.21	0.26
3	Chan	845.32	874.49	4144.14	687.51	29.56	8.29	23.57	6.03	0.28	1.71
4	Chan	874.49	903.66	4764.03	743.92	29.21	9.53	25.50	6.40	0.31	1.99
5	Chan	903.66	932.82	4928.41	758.84	29.17	9.86	26.02	6.49	0.32	2.06
6	Chan	932.82	961.99	4935.24	759.74	29.20	9.87	26.05	6.50	0.32	2.06
7	Chan	961.99	991.16	5390.85	802.10	29.29	10.78	27.50	6.72	0.33	2.24
8	Chan	991.16	1020.33	4965.79	762.96	29.23	9.93	26.16	6.51	0.32	2.07
9	Chan	1020.33	1049.50	4925.52	758.81	29.19	9.85	26.01	6.49	0.32	2.05
10	Chan	1049.50	1078.67	5081.70	773.09	29.19	10.16	26.50	6.57	0.32	2.12
11	Chan	1078.67	1107.84	4651.58	733.62	29.23	9.30	25.15	6.34	0.31	1.94
12	Chan	1107.84	1137.01	4001.20	679.27	30.23	8.00	23.29	5.89	0.27	1.61

Plan: Grand Rvr 2017 Grand River Upper RS: 208777.1 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
13	ROB	1137.01	1192.04	506.84	527.81	53.01	1.01	11.18	0.96	0.12	0.12

Plan: Grand Rvr 2017 Grand River Upper RS: 208327.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	996.37	996.94	1.44	5.77	21.14	0.00	10.57	0.25	0.00	0.00
2	Chan	996.94	1032.08	4468.04	928.38	39.84	8.94	26.42	4.81	0.18	0.87
3	Chan	1032.08	1067.22	5074.35	953.07	35.15	10.15	27.12	5.32	0.21	1.12
4	Chan	1067.22	1102.36	5007.79	945.50	35.14	10.02	26.91	5.30	0.21	1.10
5	Chan	1102.36	1137.50	5014.98	946.33	35.14	10.03	26.93	5.30	0.21	1.10
6	Chan	1137.50	1172.64	5192.23	966.32	35.15	10.38	27.50	5.37	0.21	1.14
7	Chan	1172.64	1207.78	5194.86	966.56	35.14	10.39	27.51	5.37	0.21	1.14
8	Chan	1207.78	1242.92	5021.36	947.07	35.14	10.04	26.95	5.30	0.21	1.11
9	Chan	1242.92	1278.06	4896.21	932.80	35.14	9.79	26.55	5.25	0.21	1.08
10	Chan	1278.06	1313.20	4747.26	916.01	35.17	9.49	26.07	5.18	0.20	1.04
11	Chan	1313.20	1348.34	4003.73	829.32	35.42	8.01	23.60	4.83	0.18	0.88
12	ROB	1348.34	1456.92	1377.75	1490.16	112.83	2.76	13.72	0.92	0.10	0.09
13	ROB	1456.92	2033.27	0.00	3199.28	576.45	0.00	5.55	0.00	0.04	0.00
14	ROB	2033.27	2609.61	0.00	2185.69	502.15	0.00	4.35	0.00	0.03	0.00
15	ROB	2609.61	3185.96							0.00	0.00
16	ROB	3185.96	3762.31							0.00	0.00
17	ROB	3762.31	4338.66	0.00	462.86	368.92	0.00	1.25	0.00	0.01	0.00
18	ROB	4338.66	4915.00	0.00	2830.67	576.39	0.00	4.91	0.00	0.04	0.00
19	ROB	4915.00	5491.35	0.00	4852.47	576.35	0.00	8.42	0.00	0.07	0.00
20	ROB	5491.35	6067.70	0.00	1840.13	576.50	0.00	3.19	0.00	0.02	0.00
21	ROB	6067.70	6644.04	0.00	489.25	576.35	0.00	0.85	0.00	0.01	0.00
22	ROB	6644.04	7220.39	0.00	127.05	193.10	0.00	0.66	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 207340.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2451.12	2451.13	0.00	0.11	22.96	0.00	11.48	0.01	0.00	0.00
2	Chan	2451.13	2487.90	4443.67	957.52	37.55	8.89	26.04	4.64	0.16	0.75
3	Chan	2487.90	2524.66	4992.45	1019.94	36.93	9.98	27.74	4.89	0.18	0.86
4	Chan	2524.66	2561.43	4649.33	975.70	36.78	9.30	26.54	4.77	0.17	0.81
5	Chan	2561.43	2598.20	4702.52	982.37	36.78	9.41	26.72	4.79	0.17	0.82
6	Chan	2598.20	2634.97	4611.17	970.96	36.78	9.22	26.41	4.75	0.17	0.80
7	Chan	2634.97	2671.73	4917.81	1009.32	36.79	9.84	27.45	4.87	0.17	0.85
8	Chan	2671.73	2708.50	5394.00	1067.66	36.86	10.79	29.04	5.05	0.18	0.93
9	Chan	2708.50	2745.27	4776.96	993.05	36.90	9.55	27.01	4.81	0.17	0.83
10	Chan	2745.27	2782.03	4389.57	942.64	36.78	8.78	25.64	4.66	0.16	0.76
11	Chan	2782.03	2818.80	4172.58	917.74	37.11	8.35	24.96	4.55	0.16	0.72
12	ROB	2818.80	2970.00	2949.96	2909.36	165.78	5.90	19.30	1.01	0.11	0.11
13	ROB	2970.00	3507.74	0.00	1313.66	294.17	0.00	4.47	0.00	0.03	0.00
14	ROB	3507.74	4045.48	0.00	3046.77	537.80	0.00	5.67	0.00	0.04	0.00
15	ROB	4045.48	4583.22	0.00	178.64	116.14	0.00	1.54	0.00	0.01	0.00
16	ROB	4583.22	5120.96							0.00	0.00
17	ROB	5120.96	5658.71	0.00	2684.55	510.24	0.00	5.26	0.00	0.03	0.00
18	ROB	5658.71	6196.45	0.00	3080.86	537.77	0.00	5.73	0.00	0.04	0.00
19	ROB	6196.45	6734.19	0.00	3352.75	537.75	0.00	6.23	0.00	0.04	0.00
20	ROB	6734.19	7271.93	0.00	1083.89	537.86	0.00	2.02	0.00	0.01	0.00
21	ROB	7271.93	7809.67	0.00	822.40	537.75	0.00	1.53	0.00	0.01	0.00
22	ROB	7809.67	8347.41	0.00	125.28	121.43	0.00	1.03	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 207332.5BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2451.12	2451.13	0.00	0.10	22.59	0.00	11.58	0.02	0.00	0.00
2	Chan	2451.13	2487.90	6283.88	954.20	37.55	12.57	25.95	6.59	0.40	2.62

Plan: Grand Rvr 2017 Grand River Upper RS: 207332.5BR U Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
3	Chan	2487.90	2524.66	2889.82	776.72	71.98	5.78	26.57	3.72	0.17	0.63
4	Chan	2524.66	2561.43	5689.24	970.17	45.44	11.38	26.39	5.86	0.33	1.96
5	Chan	2561.43	2598.20	6650.89	979.05	36.78	13.30	26.63	6.79	0.42	2.83
6	Chan	2598.20	2634.97	2590.96	759.56	80.18	5.18	25.13	3.41	0.15	0.51
7	Chan	2634.97	2671.73	6956.45	1005.99	36.79	13.91	27.36	6.92	0.43	2.96
8	Chan	2671.73	2708.50	3872.47	849.05	57.97	7.74	28.23	4.56	0.23	1.05
9	Chan	2708.50	2745.27	2650.74	642.96	51.08	5.30	25.64	4.12	0.20	0.81
10	Chan	2745.27	2782.03	6206.80	939.31	36.78	12.41	25.55	6.61	0.40	2.65
11	Chan	2782.03	2818.80	2437.32	721.45	77.27	4.87	23.81	3.38	0.15	0.49
12	ROB	2818.80	2970.00	3771.45	2745.76	197.36	7.54	19.01	1.37	0.22	0.30

Plan: Grand Rvr 2017 Grand River Upper RS: 207332.5BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2451.12	2451.13	0.00	0.10	22.59	0.00	11.58	0.02	0.00	0.00
2	Chan	2451.13	2487.90	6283.80	954.08	37.55	12.57	25.95	6.59	0.40	2.62
3	Chan	2487.90	2524.66	2889.85	776.63	71.98	5.78	26.56	3.72	0.17	0.63
4	Chan	2524.66	2561.43	5689.19	970.06	45.44	11.38	26.38	5.86	0.33	1.96
5	Chan	2561.43	2598.20	6650.85	978.93	36.78	13.30	26.63	6.79	0.42	2.84
6	Chan	2598.20	2634.97	2591.07	759.47	80.18	5.18	25.13	3.41	0.15	0.51
7	Chan	2634.97	2671.73	6956.43	1005.88	36.79	13.91	27.36	6.92	0.43	2.96
8	Chan	2671.73	2708.50	3872.71	848.95	57.97	7.75	28.23	4.56	0.23	1.05
9	Chan	2708.50	2745.27	2650.82	642.88	51.08	5.30	25.64	4.12	0.20	0.81
10	Chan	2745.27	2782.03	6206.71	939.20	36.78	12.41	25.54	6.61	0.40	2.65
11	Chan	2782.03	2818.80	2437.40	721.35	77.26	4.87	23.81	3.38	0.15	0.49
12	ROB	2818.80	2970.00	3771.17	2745.32	197.35	7.54	19.00	1.37	0.22	0.30

Plan: Grand Rvr 2017 Grand River Upper RS: 207324.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2451.12	2451.13	0.00	0.11	22.93	0.00	11.46	0.01	0.00	0.00
2	Chan	2451.13	2487.90	4443.57	956.16	37.55	8.89	26.01	4.65	0.16	0.76
3	Chan	2487.90	2524.66	4993.07	1018.58	36.93	9.99	27.70	4.90	0.18	0.87
4	Chan	2524.66	2561.43	4649.43	974.33	36.78	9.30	26.50	4.77	0.17	0.81
5	Chan	2561.43	2598.20	4702.70	981.01	36.78	9.41	26.68	4.79	0.17	0.82
6	Chan	2598.20	2634.97	4611.22	969.60	36.78	9.22	26.37	4.76	0.17	0.80
7	Chan	2634.97	2671.73	4918.31	1007.95	36.79	9.84	27.41	4.88	0.18	0.86
8	Chan	2671.73	2708.50	5395.20	1066.30	36.86	10.79	29.00	5.06	0.19	0.94
9	Chan	2708.50	2745.27	4777.26	991.68	36.90	9.55	26.97	4.82	0.17	0.83
10	Chan	2745.27	2782.03	4389.31	941.27	36.78	8.78	25.60	4.66	0.16	0.76
11	Chan	2782.03	2818.80	4172.05	916.37	37.11	8.34	24.92	4.55	0.16	0.72
12	ROB	2818.80	2970.00	2947.90	2903.76	165.74	5.90	19.26	1.02	0.11	0.11
13	ROB	2970.00	3507.74	0.00	1302.76	293.53	0.00	4.44	0.00	0.03	0.00
14	ROB	3507.74	4045.48	0.00	3026.82	537.80	0.00	5.63	0.00	0.04	0.00
15	ROB	4045.48	4583.22	0.00	174.35	114.98	0.00	1.52	0.00	0.01	0.00
16	ROB	4583.22	5120.96							0.00	0.00
17	ROB	5120.96	5658.71	0.00	2665.66	507.99	0.00	5.25	0.00	0.03	0.00
18	ROB	5658.71	6196.45	0.00	3060.91	537.77	0.00	5.69	0.00	0.04	0.00
19	ROB	6196.45	6734.19	0.00	3332.79	537.75	0.00	6.20	0.00	0.04	0.00
20	ROB	6734.19	7271.93	0.00	1063.93	537.86	0.00	1.98	0.00	0.01	0.00
21	ROB	7271.93	7809.67	0.00	802.44	537.75	0.00	1.49	0.00	0.01	0.00
22	ROB	7809.67	8347.41	0.00	120.79	120.40	0.00	1.00	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 206988.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2549.82	2551.91	4.05	11.41	23.50	0.01	5.46	0.36	0.00	0.00
2	Chan	2551.91	2586.10	4302.67	875.24	34.91	8.61	25.60	4.92	0.18	0.90
3	Chan	2586.10	2620.28	4786.92	926.26	34.28	9.57	27.09	5.17	0.20	1.02

Plan: Grand Rvr 2017 Grand River Upper RS: 206988.0 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
4	Chan	2620.28	2654.47	4730.32	918.76	34.19	9.46	26.87	5.15	0.20	1.01
5	Chan	2654.47	2688.66	4758.47	922.09	34.20	9.52	26.97	5.16	0.20	1.02
6	Chan	2688.66	2722.85	4975.39	947.17	34.20	9.95	27.71	5.25	0.20	1.06
7	Chan	2722.85	2757.03	5343.91	989.11	34.24	10.69	28.93	5.40	0.21	1.14
8	Chan	2757.03	2791.22	4942.09	943.93	34.25	9.88	27.61	5.24	0.20	1.06
9	Chan	2791.22	2825.41	4586.90	901.93	34.19	9.17	26.38	5.09	0.19	0.98
10	Chan	2825.41	2859.59	4426.74	882.97	34.20	8.85	25.83	5.01	0.19	0.95
11	Chan	2859.59	2893.78	4152.30	853.65	34.60	8.30	24.97	4.86	0.18	0.88
12	ROB	2893.78	3125.87	2990.24	2686.53	162.01	5.98	18.50	1.11	0.12	0.14
13	ROB	3125.87	3355.00	0.00	308.43	120.91	0.00	2.55	0.00	0.02	0.00
14	ROB	3355.00	3893.72	0.00	3144.75	538.74	0.00	5.84	0.00	0.04	0.00
15	ROB	3893.72	4432.45	0.00	710.84	272.88	0.00	2.61	0.00	0.02	0.00
16	ROB	4432.45	4971.17							0.00	0.00
17	ROB	4971.17	5509.89	0.00	1845.70	492.77	0.00	3.75	0.00	0.03	0.00
18	ROB	5509.89	6048.62	0.00	2973.29	538.86	0.00	5.52	0.00	0.04	0.00
19	ROB	6048.62	6587.34	0.00	3114.17	538.74	0.00	5.78	0.00	0.04	0.00
20	ROB	6587.34	7126.06	0.00	905.85	533.96	0.00	1.70	0.00	0.01	0.00
21	ROB	7126.06	7664.79	0.00	817.73	538.73	0.00	1.52	0.00	0.01	0.00
22	ROB	7664.79	8203.51	0.00	200.02	154.97	0.00	1.29	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 206651.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2634.09	2652.70	332.41	206.05	42.40	0.66	11.07	1.61	0.04	0.06
2	Chan	2652.70	2684.31	4103.57	802.67	32.41	8.21	25.40	5.11	0.20	1.02
3	Chan	2684.31	2715.91	4577.43	848.86	31.64	9.15	26.86	5.39	0.22	1.16
4	Chan	2715.91	2747.52	4744.03	867.05	31.62	9.49	27.43	5.47	0.22	1.21
5	Chan	2747.52	2779.13	4964.77	891.06	31.62	9.93	28.19	5.57	0.23	1.26
6	Chan	2779.13	2810.74	5170.26	913.21	31.64	10.34	28.89	5.66	0.23	1.32
7	Chan	2810.74	2842.34	4846.67	878.42	31.63	9.69	27.79	5.52	0.22	1.23
8	Chan	2842.34	2873.95	4620.74	853.38	31.61	9.24	27.00	5.41	0.22	1.18
9	Chan	2873.95	2905.56	4537.34	844.10	31.61	9.07	26.71	5.38	0.21	1.16
10	Chan	2905.56	2937.16	4403.90	829.14	31.61	8.81	26.23	5.31	0.21	1.12
11	Chan	2937.16	2968.77	3949.95	781.86	32.13	7.90	24.74	5.05	0.20	0.99
12	ROB	2968.77	3191.28	3748.94	3025.28	222.97	7.50	14.23	1.24	0.11	0.14
13	ROB	3191.28	3550.00	0.00	1316.66	313.53	0.00	4.20	0.00	0.03	0.00
14	ROB	3550.00	4051.07	0.00	2566.36	501.23	0.00	5.12	0.00	0.04	0.00
15	ROB	4051.07	4552.14	0.00	119.23	118.34	0.00	1.01	0.00	0.01	0.00
16	ROB	4552.14	5053.20	0.00	226.32	251.94	0.00	0.90	0.00	0.01	0.00
17	ROB	5053.20	5554.27	0.00	2240.09	501.57	0.00	4.47	0.00	0.04	0.00
18	ROB	5554.27	6055.34	0.00	2716.38	501.08	0.00	5.42	0.00	0.04	0.00
19	ROB	6055.34	6556.41	0.00	2362.79	501.10	0.00	4.72	0.00	0.04	0.00
20	ROB	6556.41	7057.47	0.00	472.29	389.86	0.00	1.21	0.00	0.01	0.00
21	ROB	7057.47	7558.54	0.00	819.97	501.09	0.00	1.64	0.00	0.01	0.00
22	ROB	7558.54	8059.61	0.00	227.78	165.76	0.00	1.37	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 206315.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2736.00	2753.48	582.31	255.93	33.51	1.16	14.80	2.28	0.06	0.13
2	Chan	2753.48	2782.51	3654.76	739.46	30.15	7.31	25.47	4.94	0.19	0.92
3	Chan	2782.51	2811.53	4284.74	801.74	29.07	8.57	27.62	5.34	0.21	1.12
4	Chan	2811.53	2840.56	4608.25	837.07	29.03	9.22	28.84	5.51	0.22	1.21
5	Chan	2840.56	2869.59	4564.85	832.38	29.04	9.13	28.68	5.48	0.22	1.20
6	Chan	2869.59	2898.62	4364.35	810.18	29.03	8.73	27.91	5.39	0.21	1.15
7	Chan	2898.62	2927.64	4292.21	802.06	29.03	8.58	27.63	5.35	0.21	1.13
8	Chan	2927.64	2956.67	4235.81	795.72	29.03	8.47	27.41	5.32	0.21	1.11
9	Chan	2956.67	2985.70	4168.15	788.08	29.03	8.34	27.15	5.29	0.21	1.10
10	Chan	2985.70	3014.72	4047.83	774.56	29.05	8.10	26.68	5.23	0.20	1.06

Plan: Grand Rvr 2017 Grand River Upper RS: 206315.8 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
11	Chan	3014.72	3043.75	3418.03	705.97	29.69	6.84	24.32	4.84	0.18	0.88
12	ROB	3043.75	3270.53	5741.18	3498.36	233.18	11.48	15.43	1.64	0.11	0.19
13	ROB	3270.53	3720.15	2037.55	2436.72	449.91	4.08	5.42	0.84	0.04	0.03
14	ROB	3720.15	4186.32	0.00	1586.99	452.28	0.00	3.51	0.00	0.03	0.00
15	ROB	4186.32	4652.50	0.00	381.48	224.51	0.00	1.70	0.00	0.01	0.00
16	ROB	4652.50	5118.67	0.00	1452.17	466.30	0.00	3.12	0.00	0.02	0.00
17	ROB	5118.67	5584.84	0.00	2127.52	467.26	0.00	4.56	0.00	0.03	0.00
18	ROB	5584.84	6051.02	0.00	2591.10	466.20	0.00	5.56	0.00	0.04	0.00
19	ROB	6051.02	6517.19	0.00	1621.39	466.23	0.00	3.48	0.00	0.03	0.00
20	ROB	6517.19	6983.36	0.00	364.90	331.45	0.00	1.10	0.00	0.01	0.00
21	ROB	6983.36	7449.54	0.00	824.63	466.23	0.00	1.77	0.00	0.01	0.00
22	ROB	7449.54	7915.71	0.00	323.44	240.55	0.00	1.34	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 205904.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2415.70	2717.67	0.00	3.80	59.44	0.00	0.06	0.00	0.00	0.00
2	LOB	2717.67	3019.63	0.00	33.44	82.10	0.00	0.41	0.00	0.00	0.00
3	LOB	3019.63	3097.50	586.00	369.19	90.50	1.17	4.74	1.59	0.05	0.08
4	Chan	3097.50	3125.66	3470.99	706.91	29.07	6.94	25.10	4.91	0.29	1.42
5	Chan	3125.66	3153.83	4140.33	776.30	28.20	8.28	27.56	5.33	0.33	1.75
6	Chan	3153.83	3181.99	4503.37	816.40	28.19	9.01	28.99	5.52	0.35	1.90
7	Chan	3181.99	3210.15	4650.07	831.98	28.17	9.30	29.54	5.59	0.35	1.97
8	Chan	3210.15	3238.32	4515.02	817.42	28.17	9.03	29.02	5.52	0.35	1.91
9	Chan	3238.32	3266.48	4406.37	805.49	28.16	8.81	28.60	5.47	0.34	1.86
10	Chan	3266.48	3294.64	4326.84	796.73	28.16	8.65	28.29	5.43	0.34	1.83
11	Chan	3294.64	3322.80	4237.99	786.89	28.17	8.48	27.94	5.39	0.33	1.79
12	Chan	3322.80	3350.97	4082.16	769.73	28.20	8.16	27.33	5.30	0.33	1.72
13	Chan	3350.97	3379.13	3309.19	685.12	28.87	6.62	24.33	4.83	0.28	1.37
14	ROB	3379.13	3603.45	5374.66	3236.23	228.86	10.75	14.43	1.66	0.17	0.28
15	ROB	3603.45	4277.14	2397.02	2656.24	673.98	4.79	3.94	0.90	0.05	0.04
16	ROB	4277.14	4740.32	0.00	723.51	341.82	0.00	2.12	0.00	0.03	0.00
17	ROB	4740.32	5203.50	0.00	976.66	463.27	0.00	2.11	0.00	0.03	0.00
18	ROB	5203.50	5666.68	0.00	1456.85	463.19	0.00	3.15	0.00	0.04	0.00
19	ROB	5666.68	6129.86	0.00	1162.63	463.89	0.00	2.51	0.00	0.03	0.00
20	ROB	6129.86	6593.04	0.00	607.90	463.19	0.00	1.31	0.00	0.02	0.00
21	ROB	6593.04	7056.22	0.00	877.10	463.39	0.00	1.89	0.00	0.02	0.00
22	ROB	7056.22	7519.40	0.00	1502.24	463.27	0.00	3.24	0.00	0.04	0.00
23	ROB	7519.40	7982.58	0.00	646.86	267.50	0.00	2.42	0.00	0.03	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 205492.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	3229.44	3441.52	570.52	428.28	129.45	1.14	3.55	1.33	0.04	0.06
2	Chan	3441.52	3468.82	3439.88	670.60	28.04	6.88	24.57	5.13	0.32	1.63
3	Chan	3468.82	3496.12	4209.99	749.37	27.34	8.42	27.45	5.62	0.37	2.05
4	Chan	3496.12	3523.42	4559.23	786.07	27.34	9.12	28.79	5.80	0.38	2.22
5	Chan	3523.42	3550.72	4855.72	816.01	27.31	9.71	29.89	5.95	0.40	2.37
6	Chan	3550.72	3578.02	4884.16	818.83	27.30	9.77	29.99	5.96	0.40	2.38
7	Chan	3578.02	3605.31	4763.65	806.62	27.30	9.53	29.55	5.91	0.39	2.32
8	Chan	3605.31	3632.61	4656.66	795.71	27.30	9.31	29.15	5.85	0.39	2.27
9	Chan	3632.61	3659.91	4536.68	783.36	27.30	9.07	28.70	5.79	0.38	2.21
10	Chan	3659.91	3687.21	4347.45	764.33	27.37	8.69	28.00	5.69	0.37	2.12
11	Chan	3687.21	3714.51	3379.63	664.16	28.11	6.76	24.33	5.09	0.31	1.60
12	ROB	3714.51	4217.44	5320.72	3703.94	506.05	10.64	7.36	1.44	0.10	0.14
13	ROB	4217.44	4560.14	475.73	688.45	342.75	0.95	2.01	0.69	0.03	0.02
14	ROB	4560.14	4996.30	0.00	1363.70	436.91	0.00	3.13	0.00	0.04	0.00
15	ROB	4996.30	5432.47	0.00	727.63	436.21	0.00	1.67	0.00	0.02	0.00
16	ROB	5432.47	5868.63	0.00	802.38	436.18	0.00	1.84	0.00	0.02	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 205492.2 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
17	ROB	5868.63	6304.80	0.00	82.94	131.89	0.00	0.63	0.00	0.01	0.00
18	ROB	6304.80	6740.96	0.00	5.01	16.98	0.00	0.30	0.00	0.00	0.00
19	ROB	6740.96	7177.12	0.00	1487.38	436.88	0.00	3.41	0.00	0.05	0.00
20	ROB	7177.12	7613.29	0.00	2007.54	436.39	0.00	4.60	0.00	0.06	0.00
21	ROB	7613.29	8049.45	0.00	861.12	255.40	0.00	3.37	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 205080.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	3552.26	3785.54	602.41	484.23	67.81	1.20	7.75	1.24	0.10	0.13
2	Chan	3785.54	3811.98	3313.00	634.43	27.06	6.63	24.00	5.22	0.33	1.74
3	Chan	3811.98	3838.41	4166.07	721.88	26.50	8.33	27.31	5.77	0.39	2.23
4	Chan	3838.41	3864.85	4504.69	756.14	26.46	9.01	28.60	5.96	0.41	2.42
5	Chan	3864.85	3891.28	4862.31	791.65	26.47	9.72	29.95	6.14	0.42	2.61
6	Chan	3891.28	3917.72	5043.21	808.87	26.44	10.09	30.60	6.23	0.43	2.71
7	Chan	3917.72	3944.16	5018.10	806.43	26.44	10.04	30.50	6.22	0.43	2.70
8	Chan	3944.16	3970.59	4915.24	796.52	26.44	9.83	30.13	6.17	0.43	2.64
9	Chan	3970.59	3997.03	4756.17	780.98	26.44	9.51	29.54	6.09	0.42	2.55
10	Chan	3997.03	4023.46	4540.72	760.58	26.53	9.08	28.77	5.97	0.41	2.43
11	Chan	4023.46	4049.90	3390.43	647.14	27.46	6.78	24.48	5.24	0.33	1.75
12	ROB	4049.90	4549.15	4887.66	3135.26	341.21	9.78	9.25	1.56	0.13	0.20
13	ROB	4549.15	4945.50	0.00	979.01	271.22	0.00	3.62	0.00	0.05	0.00
14	ROB	4945.50	5341.85	0.00	1263.62	397.33	0.00	3.19	0.00	0.05	0.00
15	ROB	5341.85	5738.20	0.00	463.73	396.37	0.00	1.17	0.00	0.02	0.00
16	ROB	5738.20	6134.56	0.00	181.13	263.37	0.00	0.69	0.00	0.01	0.00
17	ROB	6134.56	6530.91							0.00	0.00
18	ROB	6530.91	6927.26	0.00	62.67	42.47	0.00	1.48	0.00	0.02	0.00
19	ROB	6927.26	7323.61	0.00	2107.67	398.41	0.00	5.32	0.00	0.08	0.00
20	ROB	7323.61	7719.96	0.00	2365.06	396.36	0.00	5.97	0.00	0.08	0.00
21	ROB	7719.96	8116.31	0.00	979.18	229.07	0.00	4.28	0.00	0.06	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 204668.7 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	3870.52	4129.56	530.78	564.62	67.99	1.06	8.76	0.94	0.12	0.12
2	Chan	4129.56	4155.13	3152.34	599.15	26.08	6.30	23.43	5.26	0.34	1.80
3	Chan	4155.13	4180.70	4041.44	691.30	25.69	8.08	27.03	5.85	0.40	2.34
4	Chan	4180.70	4206.28	4439.76	730.25	25.59	8.88	28.56	6.08	0.42	2.58
5	Chan	4206.28	4231.85	4729.28	758.78	25.62	9.46	29.67	6.23	0.44	2.74
6	Chan	4231.85	4257.42	5054.44	789.25	25.58	10.11	30.86	6.40	0.46	2.94
7	Chan	4257.42	4282.99	5156.80	798.67	25.57	10.31	31.23	6.46	0.46	3.00
8	Chan	4282.99	4308.56	5138.26	797.00	25.58	10.28	31.17	6.45	0.46	2.98
9	Chan	4308.56	4334.14	4959.68	780.35	25.58	9.92	30.52	6.36	0.45	2.88
10	Chan	4334.14	4359.71	4721.71	757.86	25.60	9.44	29.64	6.23	0.44	2.74
11	Chan	4359.71	4385.28	3397.97	636.12	27.07	6.80	24.88	5.34	0.35	1.87
12	ROB	4385.28	4827.05	4677.55	2830.15	275.01	9.36	10.36	1.65	0.15	0.25
13	ROB	4827.05	5199.95	0.00	689.19	115.48	0.00	6.04	0.00	0.09	0.00
14	ROB	5199.95	5572.86	0.00	1877.67	374.65	0.00	5.04	0.00	0.07	0.00
15	ROB	5572.86	5945.76	0.00	249.52	257.96	0.00	0.97	0.00	0.01	0.00
16	ROB	5945.76	6318.66							0.00	0.00
17	ROB	6318.66	6691.57							0.00	0.00
18	ROB	6691.57	7064.47	0.00	40.85	27.69	0.00	1.48	0.00	0.02	0.00
19	ROB	7064.47	7437.37	0.00	2561.12	350.62	0.00	7.39	0.00	0.11	0.00
20	ROB	7437.37	7810.28	0.00	2749.82	372.91	0.00	7.37	0.00	0.11	0.00
21	ROB	7810.28	8183.18	0.00	1143.87	218.20	0.00	5.25	0.00	0.08	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 204250.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	4185.54	4410.07	985.66	1026.59	135.17	1.97	7.72	0.96	0.13	0.13
2	Chan	4410.07	4435.96	3482.84	609.38	26.50	6.97	23.54	5.72	0.40	2.29
3	Chan	4435.96	4461.84	4393.80	694.84	25.96	8.79	26.84	6.32	0.47	2.95
4	Chan	4461.84	4487.73	4710.93	723.72	25.89	9.42	27.96	6.51	0.49	3.18
5	Chan	4487.73	4513.61	4928.44	743.77	25.91	9.86	28.73	6.63	0.50	3.32
6	Chan	4513.61	4539.50	5188.18	766.88	25.89	10.38	29.63	6.77	0.52	3.50
7	Chan	4539.50	4565.38	5307.55	777.34	25.89	10.62	30.03	6.83	0.52	3.58
8	Chan	4565.38	4591.27	5297.97	776.49	25.89	10.60	30.00	6.82	0.52	3.57
9	Chan	4591.27	4617.15	5121.49	761.07	25.90	10.24	29.40	6.73	0.51	3.45
10	Chan	4617.15	4643.04	4912.04	742.50	25.93	9.82	28.68	6.62	0.50	3.31
11	Chan	4643.04	4668.92	3632.84	630.78	27.12	7.27	24.37	5.76	0.41	2.34
12	ROB	4668.92	5077.65	2038.27	1662.39	200.50	4.08	8.35	1.23	0.14	0.18
13	ROB	5077.65	5402.13	0.00	251.18	70.04	0.00	3.60	0.00	0.06	0.00
14	ROB	5402.13	5726.62	0.00	285.55	74.41	0.00	3.86	0.00	0.07	0.00
15	ROB	5726.62	6051.10	0.00	10.67	40.21	0.00	0.27	0.00	0.00	0.00
16	ROB	6051.10	6375.58	0.00	314.11	279.83	0.00	1.12	0.00	0.02	0.00
17	ROB	6375.58	6700.07	0.00	14.96	38.51	0.00	0.39	0.00	0.01	0.00
18	ROB	6700.07	7024.55							0.00	0.00
19	ROB	7024.55	7349.03	0.00	11.83	61.44	0.00	0.19	0.00	0.00	0.00
20	ROB	7349.03	7673.52	0.00	1761.72	325.00	0.00	5.43	0.00	0.09	0.00
21	ROB	7673.52	7998.00	0.00	67.18	33.35	0.00	2.03	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 203832.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	4452.03	4690.58	2015.49	1604.18	147.34	4.03	11.07	1.26	0.20	0.25
2	Chan	4690.58	4716.78	3665.54	621.60	26.98	7.33	23.73	5.90	0.43	2.51
3	Chan	4716.78	4742.98	4556.08	700.54	26.25	9.11	26.74	6.50	0.49	3.21
4	Chan	4742.98	4769.17	4762.56	718.87	26.20	9.53	27.44	6.63	0.51	3.36
5	Chan	4769.17	4795.37	4888.63	730.30	26.21	9.78	27.88	6.69	0.52	3.45
6	Chan	4795.37	4821.57	5062.60	745.77	26.20	10.13	28.47	6.79	0.53	3.57
7	Chan	4821.57	4847.77	5194.20	757.29	26.20	10.39	28.91	6.86	0.53	3.67
8	Chan	4847.77	4873.97	5194.77	757.32	26.20	10.39	28.91	6.86	0.53	3.67
9	Chan	4873.97	4900.16	5038.07	743.79	26.22	10.08	28.39	6.77	0.52	3.55
10	Chan	4900.16	4926.36	4858.41	728.64	26.30	9.72	27.81	6.67	0.51	3.42
11	Chan	4926.36	4952.56	3697.67	627.12	27.22	7.40	23.94	5.90	0.43	2.51
12	ROB	4952.56	5300.00	1065.99	947.13	103.11	2.13	9.37	1.13	0.17	0.19
13	ROB	5300.00	5579.20							0.00	0.00
14	ROB	5579.20	5858.41							0.00	0.00
15	ROB	5858.41	6137.61	0.00	19.76	37.27	0.00	0.53	0.00	0.01	0.00
16	ROB	6137.61	6416.81	0.00	941.66	279.24	0.00	3.37	0.00	0.06	0.00
17	ROB	6416.81	6696.02	0.00	406.20	159.11	0.00	2.55	0.00	0.05	0.00
18	ROB	6696.02	6975.22							0.00	0.00
19	ROB	6975.22	7254.42							0.00	0.00
20	ROB	7254.42	7533.63	0.00	1497.87	179.17	0.00	8.45	0.00	0.15	0.00
21	ROB	7533.63	7812.83	0.00	11.46	8.12	0.00	1.51	0.00	0.03	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 203398.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	4020.00	4522.50	0.00	219.99	321.74	0.00	0.68	0.00	0.01	0.00
2	LOB	4522.50	4635.02	0.00	10.09	82.60	0.00	0.12	0.00	0.00	0.00
3	LOB	4635.02	4800.74	2712.21	1396.39	148.64	5.42	9.52	1.94	0.15	0.30
4	Chan	4800.74	4828.57	3730.24	664.37	28.52	7.46	23.87	5.61	0.38	2.16
5	Chan	4828.57	4856.40	4424.59	729.14	27.86	8.85	26.20	6.07	0.43	2.62
6	Chan	4856.40	4884.22	4685.12	754.33	27.83	9.37	27.11	6.21	0.45	2.78
7	Chan	4884.22	4912.05	4693.85	755.18	27.83	9.39	27.14	6.22	0.45	2.78
8	Chan	4912.05	4939.88	4859.54	771.11	27.84	9.72	27.71	6.30	0.46	2.88
9	Chan	4939.88	4967.71	5019.63	786.20	27.83	10.04	28.25	6.38	0.47	2.98

Plan: Grand Rvr 2017 Grand River Upper RS: 203398.8 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
10	Chan	4967.71	4995.54	5109.40	794.57	27.83	10.22	28.55	6.43	0.47	3.03
11	Chan	4995.54	5023.36	5059.73	790.05	27.84	10.12	28.39	6.40	0.47	3.00
12	Chan	5023.36	5051.19	4815.34	766.92	27.84	9.63	27.56	6.28	0.45	2.85
13	Chan	5051.19	5079.02	3812.33	675.87	28.81	7.62	24.29	5.64	0.39	2.18
14	ROB	5079.02	5432.50	1078.02	993.41	137.08	2.16	7.35	1.09	0.12	0.13
15	ROB	5432.50	5679.86							0.00	0.00
16	ROB	5679.86	5927.21							0.00	0.00
17	ROB	5927.21	6174.57	0.00	3.12	16.76	0.00	0.19	0.00	0.00	0.00
18	ROB	6174.57	6421.93	0.00	663.24	247.39	0.00	2.68	0.00	0.04	0.00
19	ROB	6421.93	6669.28	0.00	589.84	164.34	0.00	3.59	0.00	0.06	0.00
20	ROB	6669.28	6916.64							0.00	0.00
21	ROB	6916.64	7164.00							0.00	0.00
22	ROB	7164.00	7411.35	0.00	1111.08	171.35	0.00	6.54	0.00	0.11	0.00
23	ROB	7411.35	7658.71	0.00	2.03	3.70	0.00	0.58	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 202965.1 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	3110.00	3628.33	0.00	22.52	109.00	0.00	0.21	0.00	0.00	0.00
2	LOB	3628.33	4146.67	0.00	351.40	289.14	0.00	1.22	0.00	0.02	0.00
3	LOB	4146.67	4665.00	0.00	1002.93	372.15	0.00	2.70	0.00	0.04	0.00
4	LOB	4665.00	4743.60	0.00	108.72	66.54	0.00	1.64	0.00	0.03	0.00
5	LOB	4743.60	4910.90	1773.95	1173.34	148.11	3.55	8.03	1.51	0.13	0.19
6	Chan	4910.90	4940.36	3949.05	710.55	30.14	7.90	24.12	5.56	0.37	2.08
7	Chan	4940.36	4969.82	4483.75	759.94	29.47	8.97	25.80	5.90	0.41	2.42
8	Chan	4969.82	4999.27	4742.69	785.91	29.47	9.49	26.68	6.03	0.42	2.56
9	Chan	4999.27	5028.73	4761.61	787.76	29.46	9.52	26.74	6.04	0.42	2.57
10	Chan	5028.73	5058.19	4780.48	789.78	29.48	9.56	26.81	6.05	0.43	2.58
11	Chan	5058.19	5087.65	5005.06	811.66	29.46	10.01	27.55	6.17	0.44	2.70
12	Chan	5087.65	5117.11	5143.52	825.05	29.46	10.29	28.01	6.23	0.44	2.77
13	Chan	5117.11	5146.56	5176.84	828.22	29.46	10.35	28.12	6.25	0.45	2.79
14	Chan	5146.56	5176.02	4977.50	809.20	29.48	9.95	27.47	6.15	0.44	2.68
15	Chan	5176.02	5205.48	4032.64	721.28	30.33	8.07	24.49	5.59	0.38	2.11
16	ROB	5205.48	5385.24	1172.91	1110.67	161.01	2.35	6.99	1.06	0.11	0.12
17	ROB	5385.24	5565.00							0.00	0.00
18	ROB	5565.00	5807.45							0.00	0.00
19	ROB	5807.45	6049.90							0.00	0.00
20	ROB	6049.90	6292.35	0.00	52.43	63.88	0.00	0.82	0.00	0.01	0.00
21	ROB	6292.35	6534.80	0.00	1162.94	242.71	0.00	4.80	0.00	0.08	0.00
22	ROB	6534.80	6777.24	0.00	86.09	48.12	0.00	1.79	0.00	0.03	0.00
23	ROB	6777.24	7019.69							0.00	0.00
24	ROB	7019.69	7262.14	0.00	694.41	141.56	0.00	4.92	0.00	0.08	0.00
25	ROB	7262.14	7504.59	0.00	79.31	28.21	0.00	2.86	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 202531.5 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	3365.25	3846.00	0.00	156.49	290.89	0.00	0.54	0.00	0.01	0.00
2	LOB	3846.00	4326.75	0.00	1493.17	369.05	0.00	4.05	0.00	0.06	0.00
3	LOB	4326.75	4807.50	0.00	1780.69	450.49	0.00	3.96	0.00	0.06	0.00
4	LOB	4807.50	4863.75	0.00	81.48	34.61	0.00	2.38	0.00	0.04	0.00
5	LOB	4863.75	5021.06	1143.49	946.72	135.75	2.29	7.12	1.21	0.11	0.13
6	Chan	5021.06	5052.15	4163.56	760.32	31.82	8.33	24.46	5.48	0.36	1.98
7	Chan	5052.15	5083.23	4547.94	794.40	31.10	9.10	25.55	5.72	0.39	2.21
8	Chan	5083.23	5114.32	4743.82	814.75	31.10	9.49	26.21	5.82	0.40	2.31
9	Chan	5114.32	5145.41	4843.94	824.97	31.09	9.69	26.54	5.87	0.40	2.36
10	Chan	5145.41	5176.50	4674.69	807.78	31.12	9.35	25.98	5.79	0.39	2.27
11	Chan	5176.50	5207.58	4945.08	835.32	31.10	9.89	26.87	5.92	0.41	2.41
12	Chan	5207.58	5238.67	5097.36	850.56	31.09	10.19	27.36	5.99	0.41	2.48

Plan: Grand Rvr 2017 Grand River Upper RS: 202531.5 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
13	Chan	5238.67	5269.76	5204.97	861.28	31.09	10.41	27.70	6.04	0.42	2.53
14	Chan	5269.76	5300.84	5116.13	852.57	31.10	10.23	27.43	6.00	0.41	2.49
15	Chan	5300.84	5331.93	4205.91	765.61	31.89	8.41	24.63	5.49	0.36	2.00
16	ROB	5331.93	5514.72	1313.12	1264.97	174.68	2.63	7.35	1.04	0.11	0.11
17	ROB	5514.72	5697.50							0.00	0.00
18	ROB	5697.50	5904.12							0.00	0.00
19	ROB	5904.12	6110.75							0.00	0.00
20	ROB	6110.75	6317.37	0.00	41.20	43.17	0.00	0.96	0.00	0.01	0.00
21	ROB	6317.37	6523.99	0.00	1321.88	207.25	0.00	6.40	0.00	0.10	0.00
22	ROB	6523.99	6730.61	0.00	75.55	36.34	0.00	2.09	0.00	0.03	0.00
23	ROB	6730.61	6937.24	0.00	168.06	163.25	0.00	1.03	0.00	0.02	0.00
24	ROB	6937.24	7143.86	0.00	543.85	206.74	0.00	2.63	0.00	0.04	0.00
25	ROB	7143.86	7350.48	0.00	34.69	24.58	0.00	1.42	0.00	0.02	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 202097.9 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1511.38	2015.17	0.00	176.70	223.65	0.00	0.79	0.00	0.01	0.00
2	LOB	2015.17	2518.97	0.00	1287.70	503.82	0.00	2.56	0.00	0.04	0.00
3	LOB	2518.97	3022.76	0.00	697.56	503.80	0.00	1.38	0.00	0.02	0.00
4	LOB	3022.76	3526.55	0.00	646.68	503.79	0.00	1.28	0.00	0.02	0.00
5	LOB	3526.55	4030.34	0.00	507.85	443.38	0.00	1.15	0.00	0.02	0.00
6	LOB	4030.34	4534.14	0.00	3392.46	492.98	0.00	6.89	0.00	0.10	0.00
7	LOB	4534.14	5037.93	0.00	2595.24	416.92	0.00	6.23	0.00	0.09	0.00
8	LOB	5037.93	5131.22	958.82	853.22	76.01	1.92	11.78	1.12	0.16	0.18
9	Chan	5131.22	5163.94	4357.69	812.71	33.51	8.72	24.84	5.36	0.34	1.85
10	Chan	5163.94	5196.65	4611.06	833.07	32.75	9.22	25.46	5.54	0.36	2.00
11	Chan	5196.65	5229.37	4697.46	842.19	32.73	9.39	25.74	5.58	0.37	2.04
12	Chan	5229.37	5262.09	4866.02	860.13	32.72	9.73	26.29	5.66	0.37	2.11
13	Chan	5262.09	5294.81	4627.59	834.99	32.76	9.26	25.52	5.54	0.36	2.01
14	Chan	5294.81	5327.52	4788.49	852.14	32.74	9.58	26.05	5.62	0.37	2.08
15	Chan	5327.52	5360.24	5012.42	875.56	32.72	10.02	26.76	5.72	0.38	2.18
16	Chan	5360.24	5392.96	5142.86	889.16	32.72	10.29	27.18	5.78	0.39	2.23
17	Chan	5392.96	5425.67	5166.28	891.64	32.72	10.33	27.25	5.79	0.39	2.24
18	Chan	5425.67	5458.39	4348.29	811.51	33.49	8.70	24.80	5.36	0.34	1.84
19	ROB	5458.39	5674.13	1423.03	1398.37	175.62	2.85	8.11	1.02	0.11	0.12
20	ROB	5674.13	5889.87							0.00	0.00
21	ROB	5889.87	6053.18							0.00	0.00
22	ROB	6053.18	6216.49							0.00	0.00
23	ROB	6216.49	6379.80	0.00	329.03	90.36	0.00	3.66	0.00	0.05	0.00
24	ROB	6379.80	6543.12	0.00	1228.89	148.65	0.00	8.34	0.00	0.12	0.00
25	ROB	6543.12	6706.43	0.00	148.04	115.77	0.00	1.28	0.00	0.02	0.00
26	ROB	6706.43	6869.74	0.00	758.30	163.36	0.00	4.64	0.00	0.07	0.00
27	ROB	6869.74	7033.05	0.00	393.52	163.33	0.00	2.41	0.00	0.03	0.00
28	ROB	7033.05	7196.36	0.00	46.37	69.66	0.00	0.67	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 201740.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1557.98	2077.31	0.00	95.02	116.20	0.00	0.82	0.00	0.01	0.00
2	LOB	2077.31	2596.64	0.00	1111.95	519.34	0.00	2.14	0.00	0.03	0.00
3	LOB	2596.64	3115.97	0.00	838.86	519.33	0.00	1.62	0.00	0.02	0.00
4	LOB	3115.97	3635.30	0.00	889.01	519.33	0.00	1.71	0.00	0.02	0.00
5	LOB	3635.30	4154.62	0.00	610.89	496.66	0.00	1.23	0.00	0.01	0.00
6	LOB	4154.62	4673.95	0.00	2638.17	506.03	0.00	5.22	0.00	0.06	0.00
7	LOB	4673.95	5241.25	4264.21	3556.86	499.73	8.53	7.18	1.20	0.08	0.10
8	Chan	5241.25	5274.49	3893.43	805.83	33.83	7.79	24.25	4.83	0.28	1.36
9	Chan	5274.49	5307.72	4161.36	832.93	33.25	8.32	25.06	5.00	0.30	1.48
10	Chan	5307.72	5340.96	4389.40	859.97	33.25	8.78	25.87	5.10	0.31	1.56

Plan: Grand Rvr 2017 Grand River Upper RS: 201740.0 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
11	Chan	5340.96	5374.19	4389.16	860.00	33.25	8.78	25.88	5.10	0.31	1.56
12	Chan	5374.19	5407.43	4465.02	868.95	33.26	8.93	26.14	5.14	0.31	1.59
13	Chan	5407.43	5440.67	4668.58	892.32	33.24	9.34	26.85	5.23	0.32	1.66
14	Chan	5440.67	5473.90	4773.36	904.28	33.24	9.55	27.21	5.28	0.32	1.70
15	Chan	5473.90	5507.14	4745.65	901.09	33.24	9.49	27.11	5.27	0.32	1.69
16	Chan	5507.14	5540.37	4652.64	890.71	33.26	9.31	26.80	5.22	0.32	1.65
17	Chan	5540.37	5573.61	3872.97	802.52	33.75	7.75	24.15	4.83	0.28	1.36
18	ROB	5573.61	5709.77	1531.31	1476.63	138.53	3.06	10.84	1.04	0.13	0.13
19	ROB	5709.77	5845.93	192.92	307.67	128.32	0.39	2.40	0.63	0.03	0.02
20	ROB	5845.93	5982.09							0.00	0.00
21	ROB	5982.09	6118.25							0.00	0.00
22	ROB	6118.25	6273.33							0.00	0.00
23	ROB	6273.33	6428.40	0.00	485.69	108.94	0.00	4.48	0.00	0.05	0.00
24	ROB	6428.40	6583.48	0.00	486.90	155.34	0.00	3.14	0.00	0.04	0.00
25	ROB	6583.48	6738.55	0.00	666.47	155.23	0.00	4.30	0.00	0.05	0.00
26	ROB	6738.55	6893.63	0.00	140.88	105.48	0.00	1.34	0.00	0.02	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 201382.2 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1596.21	2128.28	0.00	79.64	79.71	0.00	1.00	0.00	0.01	0.00
2	LOB	2128.28	2660.35	0.00	892.77	532.07	0.00	1.68	0.00	0.02	0.00
3	LOB	2660.35	3192.42	0.00	991.64	532.07	0.00	1.86	0.00	0.02	0.00
4	LOB	3192.42	3724.49	0.00	1109.07	532.08	0.00	2.08	0.00	0.02	0.00
5	LOB	3724.49	4256.56	0.00	728.89	532.19	0.00	1.37	0.00	0.01	0.00
6	LOB	4256.56	4788.63	0.00	1735.99	483.32	0.00	3.60	0.00	0.04	0.00
7	LOB	4788.63	5351.29	4683.84	4341.42	541.34	9.37	8.09	1.08	0.09	0.09
8	Chan	5351.29	5385.04	3620.91	797.92	34.16	7.24	23.64	4.54	0.25	1.14
9	Chan	5385.04	5418.80	4013.78	844.95	33.78	8.03	25.03	4.75	0.27	1.27
10	Chan	5418.80	5452.55	4250.51	874.31	33.76	8.50	25.90	4.86	0.28	1.35
11	Chan	5452.55	5486.31	4333.74	884.62	33.77	8.67	26.21	4.90	0.28	1.38
12	Chan	5486.31	5520.06	4520.84	907.27	33.76	9.04	26.88	4.98	0.29	1.43
13	Chan	5520.06	5553.81	4561.83	912.20	33.76	9.12	27.03	5.00	0.29	1.45
14	Chan	5553.81	5587.57	4520.84	907.22	33.75	9.04	26.88	4.98	0.29	1.44
15	Chan	5587.57	5621.32	4561.42	912.10	33.76	9.12	27.02	5.00	0.29	1.45
16	Chan	5621.32	5655.08	4437.40	897.33	33.77	8.87	26.58	4.95	0.28	1.41
17	Chan	5655.08	5688.83	3691.61	807.60	34.20	7.38	23.93	4.57	0.25	1.16
18	ROB	5688.83	5815.46	1671.15	1600.82	128.31	3.34	12.64	1.04	0.13	0.14
19	ROB	5815.46	5942.10	963.88	1024.67	126.70	1.93	8.09	0.94	0.09	0.08
20	ROB	5942.10	6068.73	168.25	348.70	117.37	0.34	2.97	0.48	0.03	0.02
21	ROB	6068.73	6195.36							0.00	0.00
22	ROB	6195.36	6312.97							0.00	0.00
23	ROB	6312.97	6430.58	0.00	249.15	83.03	0.00	3.01	0.00	0.03	0.00
24	ROB	6430.58	6548.20	0.00	573.48	117.67	0.00	4.88	0.00	0.05	0.00
25	ROB	6548.20	6665.81	0.00	490.89	117.80	0.00	4.17	0.00	0.04	0.00
26	ROB	6665.81	6783.42	0.00	2.15	5.77	0.00	0.38	0.00	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 201024.4 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1632.59	2176.78	0.00	75.84	73.66	0.00	1.03	0.00	0.01	0.00
2	LOB	2176.78	2720.98	0.00	664.53	544.20	0.00	1.22	0.00	0.01	0.00
3	LOB	2720.98	3265.17	0.00	1163.54	544.20	0.00	2.14	0.00	0.02	0.00
4	LOB	3265.17	3809.37	0.00	1333.17	544.21	0.00	2.45	0.00	0.02	0.00
5	LOB	3809.37	4353.56	0.00	833.34	544.20	0.00	1.53	0.00	0.01	0.00
6	LOB	4353.56	4897.76	0.00	938.47	443.68	0.00	2.12	0.00	0.02	0.00
7	LOB	4897.76	5461.32	5280.63	5233.81	545.53	10.56	9.71	1.01	0.09	0.09
8	Chan	5461.32	5495.59	3386.82	796.47	34.58	6.77	23.24	4.25	0.22	0.94
9	Chan	5495.59	5529.87	3930.35	868.13	34.31	7.86	25.33	4.53	0.24	1.10

Plan: Grand Rvr 2017 Grand River Upper RS: 201024.4 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
10	Chan	5529.87	5564.14	4186.84	901.41	34.28	8.37	26.30	4.64	0.25	1.17
11	Chan	5564.14	5598.41	4356.87	923.24	34.28	8.71	26.94	4.72	0.26	1.22
12	Chan	5598.41	5632.69	4299.01	915.83	34.28	8.60	26.72	4.69	0.26	1.20
13	Chan	5632.69	5666.96	4272.25	912.36	34.27	8.54	26.62	4.68	0.26	1.20
14	Chan	5666.96	5701.23	4362.81	923.91	34.27	8.73	26.96	4.72	0.26	1.22
15	Chan	5701.23	5735.50	4379.24	925.99	34.27	8.76	27.02	4.73	0.26	1.23
16	Chan	5735.50	5769.78	4307.97	917.22	34.30	8.62	26.76	4.70	0.26	1.20
17	Chan	5769.78	5804.05	3508.76	814.75	34.70	7.02	23.77	4.31	0.23	0.97
18	ROB	5804.05	5903.87	1568.16	1508.01	101.11	3.14	15.11	1.04	0.14	0.15
19	ROB	5903.87	6003.69	1558.18	1495.01	99.90	3.12	14.98	1.04	0.14	0.15
20	ROB	6003.69	6103.52	594.22	839.94	100.36	1.19	8.41	0.71	0.08	0.06
21	ROB	6103.52	6203.34	7.89	35.28	23.74	0.02	1.50	0.22	0.01	0.00
22	ROB	6203.34	6303.16							0.00	0.00
23	ROB	6303.16	6393.20	0.00	158.67	42.97	0.00	3.75	0.00	0.04	0.00
24	ROB	6393.20	6483.24	0.00	639.58	90.07	0.00	7.10	0.00	0.07	0.00
25	ROB	6483.24	6573.29	0.00	324.17	83.35	0.00	3.91	0.00	0.04	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 200751.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	1746.19	2328.25	0.00	21.56	146.62	0.00	0.15	0.00	0.00	0.00
2	LOB	2328.25	2910.32	0.00	443.72	582.07	0.00	0.76	0.00	0.01	0.00
3	LOB	2910.32	3492.38	0.00	1596.84	582.07	0.00	2.74	0.00	0.03	0.00
4	LOB	3492.38	4074.44	0.00	1493.25	582.07	0.00	2.57	0.00	0.03	0.00
5	LOB	4074.44	4656.51	0.00	1448.21	582.09	0.00	2.49	0.00	0.03	0.00
6	LOB	4656.51	5238.57	0.00	289.94	212.27	0.00	1.37	0.00	0.01	0.00
7	LOB	5238.57	5357.81							0.00	0.00
8	LOB	5357.81	5619.17	1724.91	1807.72	235.01	3.45	7.76	0.95	0.08	0.07
9	Chan	5619.17	5656.06	3818.02	864.94	37.03	7.64	23.45	4.41	0.24	1.04
10	Chan	5656.06	5692.95	4148.88	907.81	36.90	8.30	24.61	4.57	0.25	1.14
11	Chan	5692.95	5729.83	4351.20	934.15	36.90	8.70	25.32	4.66	0.26	1.19
12	Chan	5729.83	5766.72	4423.37	943.39	36.90	8.85	25.57	4.69	0.26	1.21
13	Chan	5766.72	5803.61	4371.29	936.63	36.89	8.74	25.39	4.67	0.26	1.20
14	Chan	5803.61	5840.50	4440.00	945.89	36.93	8.88	25.64	4.69	0.26	1.22
15	Chan	5840.50	5877.39	4831.96	995.31	36.95	9.66	26.98	4.85	0.27	1.32
16	Chan	5877.39	5914.27	4751.64	984.76	36.89	9.50	26.70	4.83	0.27	1.30
17	Chan	5914.27	5951.16	4577.05	962.93	36.90	9.15	26.10	4.75	0.26	1.26
18	Chan	5951.16	5988.05	4052.46	897.87	37.18	8.10	24.34	4.51	0.24	1.10
19	ROB	5988.05	6093.53	1962.91	1591.36	106.51	3.93	15.09	1.23	0.15	0.19
20	ROB	6093.53	6199.02	1896.12	1552.78	105.51	3.79	14.72	1.22	0.15	0.18
21	ROB	6199.02	6304.50	650.20	791.34	97.42	1.30	8.22	0.82	0.08	0.07
22	ROB	6304.50	6403.06							0.00	0.00
23	ROB	6403.06	6501.63							0.00	0.00
24	ROB	6501.63	6600.19	0.00	59.05	25.95	0.00	2.31	0.00	0.02	0.00
25	ROB	6600.19	6698.76	0.00	680.52	98.75	0.00	6.90	0.00	0.07	0.00
26	ROB	6698.76	6797.32	0.00	429.72	98.86	0.00	4.36	0.00	0.04	0.00
27	ROB	6797.32	6895.89	0.00	0.83	2.42	0.00	0.36	0.00	0.00	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 200477.6 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2209.60	2762.00	0.00	32.01	124.05	0.00	0.26	0.00	0.00	0.00
2	LOB	2762.00	3314.40	0.00	1316.15	552.41	0.00	2.38	0.00	0.02	0.00
3	LOB	3314.40	3866.80	0.00	1733.43	552.40	0.00	3.14	0.00	0.03	0.00
4	LOB	3866.80	4419.20	0.00	1733.43	552.40	0.00	3.14	0.00	0.03	0.00
5	LOB	4419.20	4971.60	0.00	1553.72	432.81	0.00	3.60	0.00	0.03	0.00
6	LOB	4971.60	5524.00							0.00	0.00
7	LOB	5524.00	5777.02	1774.97	2080.31	199.07	3.55	10.59	0.85	0.09	0.08
8	Chan	5777.02	5816.52	4084.64	958.17	39.63	8.17	24.26	4.26	0.22	0.93

Plan: Grand Rvr 2017 Grand River Upper RS: 200477.6 Profile: 1% (Continued)

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
9	Chan	5816.52	5856.03	4246.86	979.58	39.51	8.49	24.80	4.34	0.22	0.97
10	Chan	5856.03	5895.53	4338.68	992.24	39.51	8.68	25.12	4.37	0.23	0.99
11	Chan	5895.53	5935.03	4447.48	1007.09	39.51	8.89	25.49	4.42	0.23	1.01
12	Chan	5935.03	5974.54	4426.90	1004.47	39.53	8.85	25.43	4.41	0.23	1.01
13	Chan	5974.54	6014.04	4225.50	976.65	39.51	8.45	24.72	4.33	0.22	0.96
14	Chan	6014.04	6053.54	4133.71	963.80	39.50	8.27	24.40	4.29	0.22	0.94
15	Chan	6053.54	6093.04	4176.48	970.78	39.61	8.35	24.57	4.30	0.22	0.95
16	Chan	6093.04	6132.55	4658.97	1036.66	39.61	9.32	26.24	4.49	0.24	1.06
17	Chan	6132.55	6172.05	4445.62	1010.92	39.91	8.89	25.59	4.40	0.23	1.00
18	ROB	6172.05	6283.87	2231.73	1690.90	113.03	4.46	15.12	1.32	0.13	0.18
19	ROB	6283.87	6395.70	2097.07	1622.00	111.83	4.19	14.50	1.29	0.13	0.17
20	ROB	6395.70	6507.52	711.40	780.59	90.94	1.42	8.72	0.91	0.08	0.07
21	ROB	6507.52	6611.52							0.00	0.00
22	ROB	6611.52	6715.52							0.00	0.00
23	ROB	6715.52	6819.52	0.00	42.93	22.13	0.00	1.97	0.00	0.02	0.00
24	ROB	6819.52	6923.52	0.00	707.43	104.25	0.00	6.80	0.00	0.06	0.00
25	ROB	6923.52	7027.52	0.00	485.76	104.27	0.00	4.67	0.00	0.04	0.00
26	ROB	7027.52	7131.52	0.00	3.75	4.67	0.00	0.86	0.00	0.01	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 200443.2BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	5524.00	5777.02	2068.10	1984.61	250.61	4.14	10.44	1.04	0.11	0.12
2	Chan	5777.02	5816.52	4739.44	957.87	39.63	9.48	24.25	4.95	0.35	1.73
3	Chan	5816.52	5856.03	4927.73	979.27	39.51	9.86	24.79	5.03	0.36	1.81
4	Chan	5856.03	5895.53	2566.51	907.61	86.92	5.13	24.86	2.83	0.15	0.43
5	Chan	5895.53	5935.03	5160.58	1006.79	39.51	10.32	25.49	5.13	0.37	1.89
6	Chan	5935.03	5974.54	2632.48	920.36	86.65	5.26	25.21	2.86	0.15	0.44
7	Chan	5974.54	6014.04	4902.93	976.34	39.51	9.81	24.72	5.02	0.36	1.80
8	Chan	6014.04	6053.54	4796.39	963.50	39.50	9.59	24.39	4.98	0.35	1.76
9	Chan	6053.54	6093.04	2467.40	886.22	86.87	4.93	24.28	2.78	0.15	0.41
10	Chan	6093.04	6132.55	5406.06	1036.36	39.61	10.81	26.23	5.22	0.38	1.98
11	Chan	6132.55	6172.05	5158.44	1010.61	39.91	10.32	25.58	5.10	0.37	1.87
12	ROB	6172.05	6283.87	2275.70	1626.17	148.66	4.55	14.94	1.40	0.16	0.22
13	ROB	6283.87	6395.70	2114.72	1570.81	152.18	4.23	14.45	1.35	0.15	0.20
14	ROB	6395.70	6507.52	783.53	737.58	101.95	1.57	8.52	1.06	0.10	0.11

Plan: Grand Rvr 2017 Grand River Upper RS: 200443.2BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	5528.00	5810.01	2061.70	1939.50	215.28	4.12	12.09	1.06	0.13	0.14
2	Chan	5810.01	5849.50	4680.69	955.01	39.61	9.36	24.18	4.90	0.34	1.68
3	Chan	5849.50	5888.99	4858.59	975.49	39.49	9.72	24.70	4.98	0.35	1.75
4	Chan	5888.99	5928.48	2543.64	904.61	86.33	5.09	24.79	2.81	0.15	0.42
5	Chan	5928.48	5967.97	5166.08	1012.17	39.50	10.33	25.63	5.10	0.37	1.86
6	Chan	5967.97	6007.46	2635.67	929.98	87.71	5.27	25.49	2.83	0.15	0.43
7	Chan	6007.46	6046.95	4962.91	988.27	39.52	9.93	25.03	5.02	0.36	1.79
8	Chan	6046.95	6086.44	4845.81	973.96	39.49	9.69	24.66	4.98	0.35	1.75
9	Chan	6086.44	6125.93	2482.53	891.27	86.28	4.97	24.42	2.79	0.15	0.41
10	Chan	6125.93	6165.42	5350.00	1034.71	39.60	10.70	26.20	5.17	0.37	1.93
11	Chan	6165.42	6204.91	5110.08	1009.44	39.88	10.22	25.56	5.06	0.36	1.83
12	ROB	6204.91	6295.23	1762.80	1326.44	128.36	3.53	15.19	1.33	0.15	0.20
13	ROB	6295.23	6385.56	1759.37	1274.87	116.59	3.52	14.60	1.38	0.16	0.22
14	ROB	6385.56	6475.88	1589.49	1195.31	115.57	3.18	13.69	1.33	0.15	0.20
15	ROB	6475.88	6566.20	190.64	225.83	43.16	0.38	5.40	0.84	0.07	0.06

Plan: Grand Rvr 2017 Grand River Upper RS: 200408.8 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2211.20	2764.00	0.00	19.32	68.30	0.00	0.28	0.00	0.00	0.00
2	LOB	2764.00	3316.80	0.00	1254.01	552.81	0.00	2.27	0.00	0.02	0.00
3	LOB	3316.80	3869.60	0.00	1726.79	552.80	0.00	3.12	0.00	0.03	0.00
4	LOB	3869.60	4422.40	0.00	1726.79	552.80	0.00	3.12	0.00	0.03	0.00
5	LOB	4422.40	4975.20	0.00	1312.27	400.76	0.00	3.28	0.00	0.03	0.00
6	LOB	4975.20	5528.00							0.00	0.00
7	LOB	5528.00	5810.01	1867.57	2023.75	169.51	3.74	12.15	0.92	0.11	0.10
8	Chan	5810.01	5849.50	4023.53	955.20	39.61	8.05	24.19	4.21	0.21	0.90
9	Chan	5849.50	5888.99	4176.42	975.69	39.49	8.35	24.71	4.28	0.22	0.93
10	Chan	5888.99	5928.48	4265.40	988.13	39.49	8.53	25.02	4.32	0.22	0.95
11	Chan	5928.48	5967.97	4440.69	1012.37	39.50	8.88	25.64	4.39	0.23	0.99
12	Chan	5967.97	6007.46	4466.56	1015.89	39.50	8.93	25.73	4.40	0.23	1.00
13	Chan	6007.46	6046.95	4266.08	988.46	39.52	8.53	25.03	4.32	0.22	0.95
14	Chan	6046.95	6086.44	4165.44	974.15	39.49	8.33	24.67	4.28	0.22	0.93
15	Chan	6086.44	6125.93	4165.75	974.62	39.54	8.33	24.68	4.27	0.22	0.93
16	Chan	6125.93	6165.42	4598.75	1034.91	39.60	9.20	26.21	4.44	0.23	1.02
17	Chan	6165.42	6204.91	4392.55	1009.63	39.88	8.79	25.57	4.35	0.22	0.97
18	ROB	6204.91	6295.23	1824.61	1392.92	91.48	3.65	15.42	1.31	0.13	0.18
19	ROB	6295.23	6385.56	1687.92	1322.62	90.33	3.38	14.64	1.28	0.13	0.16
20	ROB	6385.56	6475.88	1513.42	1240.69	90.68	3.03	13.74	1.22	0.12	0.15
21	ROB	6475.88	6566.20	145.31	226.03	43.18	0.29	5.40	0.64	0.05	0.03
22	ROB	6566.20	6671.24							0.00	0.00
23	ROB	6671.24	6776.28	0.00	10.84	9.96	0.00	1.12	0.00	0.01	0.00
24	ROB	6776.28	6881.32	0.00	789.10	105.60	0.00	7.51	0.00	0.07	0.00
25	ROB	6881.32	6986.36	0.00	653.82	105.23	0.00	6.22	0.00	0.05	0.00
26	ROB	6986.36	7091.40	0.00	72.97	28.96	0.00	2.55	0.00	0.02	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 200340.0 Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	2240.00	2800.00	0.00	7.76	36.80	0.00	0.21	0.00	0.00	0.00
2	LOB	2800.00	3360.00	0.00	1303.50	560.01	0.00	2.33	0.00	0.02	0.00
3	LOB	3360.00	3920.00	0.00	1745.18	560.00	0.00	3.12	0.00	0.03	0.00
4	LOB	3920.00	4480.00	0.00	1745.18	560.00	0.00	3.12	0.00	0.03	0.00
5	LOB	4480.00	5040.00	0.00	924.59	311.45	0.00	2.98	0.00	0.03	0.00
6	LOB	5040.00	5600.00							0.00	0.00
7	LOB	5600.00	5843.01	1837.14	1981.54	162.82	3.67	12.44	0.93	0.11	0.10
8	Chan	5843.01	5882.49	3971.91	952.32	39.59	7.94	24.12	4.17	0.21	0.87
9	Chan	5882.49	5921.96	4118.76	972.22	39.48	8.24	24.63	4.24	0.21	0.91
10	Chan	5921.96	5961.44	4206.91	984.71	39.48	8.41	24.95	4.27	0.22	0.93
11	Chan	5961.44	6000.91	4444.67	1017.83	39.49	8.89	25.78	4.37	0.22	0.98
12	Chan	6000.91	6040.39	4521.41	1028.25	39.48	9.04	26.05	4.40	0.23	0.99
13	Chan	6040.39	6079.86	4310.82	999.83	39.54	8.62	25.33	4.31	0.22	0.95
14	Chan	6079.86	6119.34	4207.97	984.81	39.48	8.42	24.95	4.27	0.22	0.93
15	Chan	6119.34	6158.81	4157.24	977.75	39.49	8.31	24.77	4.25	0.21	0.91
16	Chan	6158.81	6198.29	4548.08	1033.03	39.59	9.10	26.17	4.40	0.23	1.00
17	Chan	6198.29	6237.76	4354.19	1009.27	39.88	8.71	25.57	4.31	0.22	0.95
18	ROB	6237.76	6347.24	2236.63	1685.07	110.60	4.47	15.39	1.33	0.13	0.18
19	ROB	6347.24	6456.72	2082.37	1607.93	109.51	4.16	14.69	1.30	0.13	0.17
20	ROB	6456.72	6566.20	1001.91	979.42	95.01	2.00	10.55	1.02	0.09	0.09
21	ROB	6566.20	6656.23							0.00	0.00
22	ROB	6656.23	6746.27	0.00	14.85	10.83	0.00	1.42	0.00	0.01	0.00
23	ROB	6746.27	6836.30	0.00	775.96	90.76	0.00	8.62	0.00	0.07	0.00
24	ROB	6836.30	6926.34	0.00	803.41	90.34	0.00	8.92	0.00	0.08	0.00
25	ROB	6926.34	7016.37	0.00	262.98	71.55	0.00	3.69	0.00	0.03	0.00

Plan: Grand Rvr 2017 Grand River Upper RS: 200305.2BR U Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	5600.00	5843.01	2006.68	1899.62	206.63	4.01	12.40	1.06	0.13	0.14
2	Chan	5843.01	5882.49	4625.33	951.88	39.59	9.25	24.11	4.86	0.34	1.64
3	Chan	5882.49	5921.96	4796.42	971.78	39.48	9.59	24.62	4.94	0.35	1.71
4	Chan	5921.96	5961.44	2522.88	901.78	85.85	5.05	24.72	2.80	0.15	0.41
5	Chan	5961.44	6000.91	5176.13	1017.39	39.49	10.35	25.77	5.09	0.36	1.84
6	Chan	6000.91	6040.39	2644.11	940.17	88.80	5.29	25.78	2.81	0.15	0.42
7	Chan	6040.39	6079.86	5020.18	999.39	39.54	10.04	25.32	5.02	0.36	1.79
8	Chan	6079.86	6119.34	4900.35	984.37	39.48	9.80	24.94	4.98	0.35	1.75
9	Chan	6119.34	6158.81	2491.96	894.92	85.79	4.98	24.54	2.78	0.15	0.41
10	Chan	6158.81	6198.29	5296.61	1032.59	39.59	10.59	26.16	5.13	0.37	1.88
11	Chan	6198.29	6237.76	5070.72	1008.83	39.88	10.14	25.56	5.03	0.36	1.79
12	ROB	6237.76	6347.24	1900.07	1567.27	175.59	3.80	15.15	1.21	0.13	0.15
13	ROB	6347.24	6456.72	2243.65	1560.15	135.29	4.49	14.65	1.44	0.16	0.23
14	ROB	6456.72	6566.20	1304.89	978.38	94.99	2.61	10.54	1.33	0.14	0.19

Plan: Grand Rvr 2017 Grand River Upper RS: 200305.2BR D Profile: 1%

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	5600.00	5876.00	2406.90	1862.50	201.80	4.81	12.51	1.29	0.13	0.16
2	Chan	5876.00	5915.46	4517.49	949.29	39.58	9.03	24.06	4.76	0.33	1.55
3	Chan	5915.46	5954.92	2410.96	886.41	85.53	4.82	24.31	2.72	0.14	0.38
4	Chan	5954.92	5994.39	4779.97	981.07	39.48	9.56	24.86	4.87	0.34	1.64
5	Chan	5994.39	6033.85	5126.50	1023.21	39.49	10.25	25.93	5.01	0.35	1.76
6	Chan	6033.85	6073.31	2619.33	951.07	90.07	5.24	26.08	2.75	0.14	0.39
7	Chan	6073.31	6112.77	5013.81	1010.65	39.59	10.03	25.61	4.96	0.35	1.72
8	Chan	6112.77	6152.23	4894.36	994.92	39.47	9.79	25.21	4.92	0.34	1.68
9	Chan	6152.23	6191.70	2453.28	897.52	85.96	4.91	24.62	2.73	0.14	0.39
10	Chan	6191.70	6231.16	5180.18	1030.63	39.59	10.36	26.12	5.03	0.35	1.78
11	Chan	6231.16	6270.62	4975.12	1009.13	39.90	9.95	25.57	4.93	0.34	1.69
12	ROB	6270.62	6370.96	2018.58	1494.40	141.50	4.04	15.35	1.35	0.14	0.19
13	ROB	6370.96	6471.31	2059.12	1447.15	126.74	4.12	14.87	1.42	0.16	0.22
14	ROB	6471.31	6571.65	1544.40	1223.07	128.13	3.09	12.56	1.26	0.13	0.16
15	ROB	6571.65	6658.11	0.00	27.12	11.23	0.00	2.71	0.00	0.03	0.00

Plate 1

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Embankment_Plate 1 Flood Protection System.mxd Date: 8/31/2017 11:06:09 AM User: MCL

PLAINFIELD TOWNSHIP
CITY OF GRAND RAPIDS
US-131
MONROE AVE.
N. PARK
I-96
CITY OF WALKER
CITY OF GRAND RAPIDS
3 MILE RD.
I-96
US-131
MONROE AVE.
CITY OF WALKER
CITY OF GRAND RAPIDS
RR
ANN ST.
KNAPP ST.
INDIAN MILL CREEK
PALMER STREET PUMP STATION
ANN ST.
INDIAN MILL CREEK PUMP STATION
RICHMOND ST.
RR
ALPINE AVE.
US-131
CALEDONIA STREET PUMP STATION
LEONARD ST.
LEONARD ST.
RR
GRAND RIVER
GARFIELD AVE.
WALKER AVE.
6TH ST.
6TH ST.
FRONT & SCRIBNER PUMP STATION
6TH ST. DAM
I-196
I-196
BRIDGE ST.
MICHIGAN ST.
RR
US-131
LAKE MI DR.
PEARL ST.
JOHN BALL PARK
FULTON ST.
FULTON ST.
US 131
BUTTERWORTH ST.
WEALTHY ST.
WEALTHY STREET PUMP STATION
WEALTHY ST.
MARKET AVENUE PUMP STATION
I-196
GRAND RIVER
MARKET ST.
RR
GR WWTP
GR WRRF
PLASTER CREEK
GRAND RAPIDS
WYOMING

NORTH
0 500 1,000 FEET

LEGEND

- Storm Water Pump Station
- HEC RAS Stations
- Municipal_Boundaries
- 1 Typical Embankment Station

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

City of Grand Rapids

Kent County, Michigan

Grand River Flood Protection System

PLATE NO. 1

PROJECT NO. G120330LMP

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Manager:
Reviewer:
Designer:
Drawn By:

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fishbeck, thompson, carr & huber, inc.

engineers
scientists
architects
constructors

fTC&h

Grand River Flood Protection System
44 CFR 65.10 (b)(1)
Freeboard Evaluation

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

fishbeck
Engineers | Architects | Scientists | Constructors

44 CFR 65.10(b) (1) (i) Tab

(1) *Freeboard.* (i) Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

P.E. Signature: Peter W. Soltys

Non Applicable: See Below

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

Reaches E1, E2, E3, E4, W1, W2, W3, and W4 are Freeboard Deficient Reaches in accordance with FEMA's *Analysis and Mapping Procedures for Non-Accredited Levee Systems* dated July 2013 with the top of flood protection elevation above the Base Flood Elevation.

Reach E5 meets the freeboard requirements of 44 CFR 65.10(b) (1) (i).

44 CFR 65.10(b) (1) (ii) Tab

(ii) Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and magnitude of debris, sediment, and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.

P.E. Signature: _____

Non Applicable: Peter W. Soltys

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

44 CFR 65.10(b) (1) (iii) Tab

(iii) For coastal levees, the freeboard must be established at one foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site.

P.E. Signature: _____

Non Applicable: Peter W. Soltys

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

44 CFR 65.10 (b) (1) (iv)

(iv) Occasionally, exceptions to the minimum coastal levee freeboard requirement described in paragraph (b)(1)(iii) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood loading conditions. Particular emphasis must be placed on the effects of wave attack and overtopping on the stability of the levee. Under no circumstances, however, will a freeboard of less than two feet above the 100-year stillwater surge elevation be accepted.

P.E. Signature: _____

Non Applicable: Peter W. Soltys

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

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Engineers | Architects | Scientists | Constructors

1515 Arboretum Drive, SE
Grand Rapids, Michigan 49546

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Grand River Flood Protection System
44 CFR 65.10 (b)(1)
Freeboard Evaluation

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

January 31, 2020
Project No. 120330LMP

Final

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Appendix 1 100-Year Water Surface Profile HEC-RAS Results

List of Abbreviations/Acronyms

BFE	Base Flood Elevation
FIRM	Flood Insurance Rate Map
GRFPS	Grand River Flood Protection System
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
USACE	U.S. Army Corps of Engineers
WRRF	Water Resource Recovery Facility

Introduction

This report provides the results of a freeboard evaluation of the Grand Rapids flood protection system (GRFPS) based on crest elevation surveys conducted by Fishbeck. The Federal Emergency Management Agency (FEMA) and the Cities of Grand Rapids and Walker agreed to the division of the GRFPS into the reaches shown in Figure 1 for purposes of evaluation per the requirements of 44 CFR 65.10. In terms of the freeboard requirements of 44 CFR 65.10 (b)(1)(i), only the reach along the east bank of the Grand River at the Water Resource Recovery Facility (WRRF) identified as Reach E5 meets the sound reach freeboard requirements. However, all of the other reaches discussed below provide protection from the 100-year flood elevation with varying levels of freeboard. For these reaches, Grand Rapids and Walker are seeking Freeboard Deficient Reach certification.

Description

The reaches of the Grand River Flood Protection System (GRFPS), shown in Figure 1, are along the Grand River and Indian Mill Creek in Grand Rapids, Michigan and consist of the following:

- Reach E1 – Knapp Street downstream to Leonard Street.
  - 5,260 feet of natural ground topped by former railroad embankment.
  - 630 feet of natural ground.
- Reach E2 – Leonard Street downstream to Interstate Route 196 (I-196)
  - 3,520 feet of earth embankment inland from river edge retaining wall.
  - 560 feet of floodwall and concrete bridge abutments.
  - 750 feet of natural ground
- Reach E3 – Gillett Pedestrian Bridge downstream to US 131.
  - 1,215 feet of floodwall and concrete bridge abutments between Fulton and Bridge Streets
  - 1,280 feet of natural ground much of which is above high river edge retaining walls
- Reach E4 – US 131 to the end of the floodwall 2,880 feet downstream of Wealthy Street
  - 790 feet of earth embankment
  - 4,250 feet of floodwall and concrete bridge abutments.
- Reach E5 – Ring levee around the Water Resources Recovery Facility (WRRF)
  - 7,630 feet of earth embankment levee.
- Reach W1 – City Boundary downstream to Indian Mill Creek including left (north) bank of Indian Mill Creek from Grand River to second upstream railroad crossing.
  - 6,150 feet of natural ground along the Grand River and Indian Mill Creek
  - 3,060 feet of floodwall along the Grand River and Indian Mill Creek
- Reach W2 – Confluence of Indian Mill Creek to I-196 including right (south) bank of Indian Mill Creek from Grand River to second upstream railroad crossing.
  - 6,130 feet of floodwall and concrete bridge abutments along the Grand River and Indian Mill Creek
  - 3,655 feet of earth embankment along the Grand River and Indian Mill Creek
  - 390 feet of natural ground along the Grand River

- Reach W3 – I-196 downstream to Fulton Street
  - 2,405 feet of earth embankment
  - 215 feet of concrete bridge abutment
  - 1,300 feet of natural ground
- Reach W4 – Fulton Street downstream to the West End Ditch
  - 1,970 feet of earth embankment
  - 3,970 feet of floodwall and concrete bridge abutments

The reaches of the GRFPS contain natural ground, earth embankments, railroad embankments, bridge abutments, and floodwalls that were constructed and/or maintained by Grand Rapids and Walker to meet or exceed the level of the base 100-year return interval flood.

100-Year Water Surface Profile

The original Flood Insurance Rate Map (FIRM) for the City of Grand Rapids (City) was dated November 5, 1982 and Flood Boundary Floodway Map (FBFM) was dated January 17, 1979. The 100-year flood and floodway boundaries were developed from a river model prepared using U.S. Geological Survey (USGS) computer programs E431 *Computer Applications for Step-Backwater and Floodway Analyses* and J635 *Step-Backwater and Floodway Analyses*. The elevations in the USGS model were referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). In 2008 FEMA introduced a new model of the Grand River from the downstream Kent County boundary to the upstream City boundary using the U.S. Army Corps of Engineers (USACE) HEC-RAS River Analysis System program. This model included all the former river cross-sections from the original USGS Grand River model plus additional surveyed cross-sections, and referenced the elevation data to the North American Vertical Datum of 1988 (NAVD88). The conversion of the NGVD29 datum to the NAVD88 datum used the following equation:

$$\text{NAVD88} = \text{NGVD29} - 0.45 \text{ feet}$$

In discussions between FEMA, the City and Fishbeck following release of the 2008 HEC-RAS model, it was agreed that the model should be extended to Lake Michigan by including previously developed HEC-RAS models for the Grand River communities downstream of Kent County. The resulting Grand River HEC-RAS model was completed in 2010. Subsequent corrections to cross-section geometry were accepted by Fishbeck resulting in the HEC-RAS model dated July 2015. Finally, the 2009 change in the NAVD88 datum for western Michigan of -0.13 feet was incorporated into the model in December 2017. The December 2017 HEC-RAS model results for 100-year water surface profile are included in Appendix 1. The initial survey of the GRFPS crest elevation was performed by Fishbeck in the period 2008-2009. In subsequent years, Grand Rapids and Walker made improvements to the floodwalls, earth embankments, and road grades with the locations shown in Figure 2. In the period 2016-2017 the GRFPS was resurveyed to document the freeboard improvements. The survey point numbers and survey dates are identified in Tables 1 through 9.

Freeboard

Freeboard – Reaches E1, E2, E3, E4, W1, W2, W3, and W4

According to 44 CFR 65.10(b)(1)(i), the required freeboard (additional height above the regulatory flood elevation) for riverine levees must be 3-feet above the 100-year flood water surface elevation (Base Flood Elevation, BFE) with an additional 1-foot within 100-feet of a structure (e.g. bridge) and an additional 0.5-foot at the upstream end of the levee tapering to the minimum 3-feet of freeboard at the downstream end of the system.

Under the provisions of FEMA's Analysis and Mapping Procedures for Non-Accredited Levee Systems, dated January 2016, the City is seeking Freeboard Deficient Reach status for Reaches E1, E2, E3, E4, W1, W2, W3, and W4 of the GRFPS. For Freeboard Deficient Reach status, the following conditions must be met:

- The flood protection floodwalls and embankments (levees) and any closure structures within the effective reaches must be above the Base Flood Elevation (BFE) defined as the 100-year return interval flood elevation.
- An Operations and Maintenance Plan covering the effective reaches must meet the standards of 44CFR65.10(c).
- The structural design of floodwalls and levees within the effective reaches must meet the design standards for closures in 44CFR65.10(b)(2).

The 100-year flood elevations and GRFPS crest elevations for each reach are presented in Tables 1 through 4 and 6 through 9 and the resulting profiles are shown in Figures 3 through 6 and 8 through 11. Note that in Reach W2, the flood protection crest elevation at river station 216020.2 in Fish Ladder Park reflects the crest of the closure structure at this location (see Closure Analysis Report). A 10-foot-wide by 5-foot-tall closure structure will be installed during extreme floods. In Reach W4 the flood protection crest elevation at river station 209683.80 at the CSX bridge abutment reflects the crest of the closure structure at this location. A 40-foot-wide by 1.5-foot-tall closure structure will be installed during extreme floods.

Freeboard – Reach E5

The ring levee around the WRRF, Reach E5, meets the freeboard requirements for 44 CFR 65.10(b)(1)(i); therefore, the City is seeking full accreditation as a Sound Reach for this reach.

The crest elevations for the ring levee are presented in Table 5 and the 100-year flood and levee crest elevation profiles are shown in Figures 7A through 7D.

Conclusion

The crest elevations of the entire lengths of all reaches of the GRFPS are above the BFE except as noted above for Reach W2 and W4. Reaches E1, E2, E3, E4, W1, W2, W3, and W4 do not meet freeboard requirements for riverine levees provided in 44 CFR 65.10(b)(1)(i); however, these reaches all have flood protection above the BFE. At this time, the City is seeking Freeboard Deficient Reach certification for these reaches.

Reach E5 consists of the ring levee around the WRRF. This levee fully meets the requirements of 44 CFR 65.10(b)(1)(i); therefore, the City requests full accreditation as a Sound Reach for this levee.

Figures

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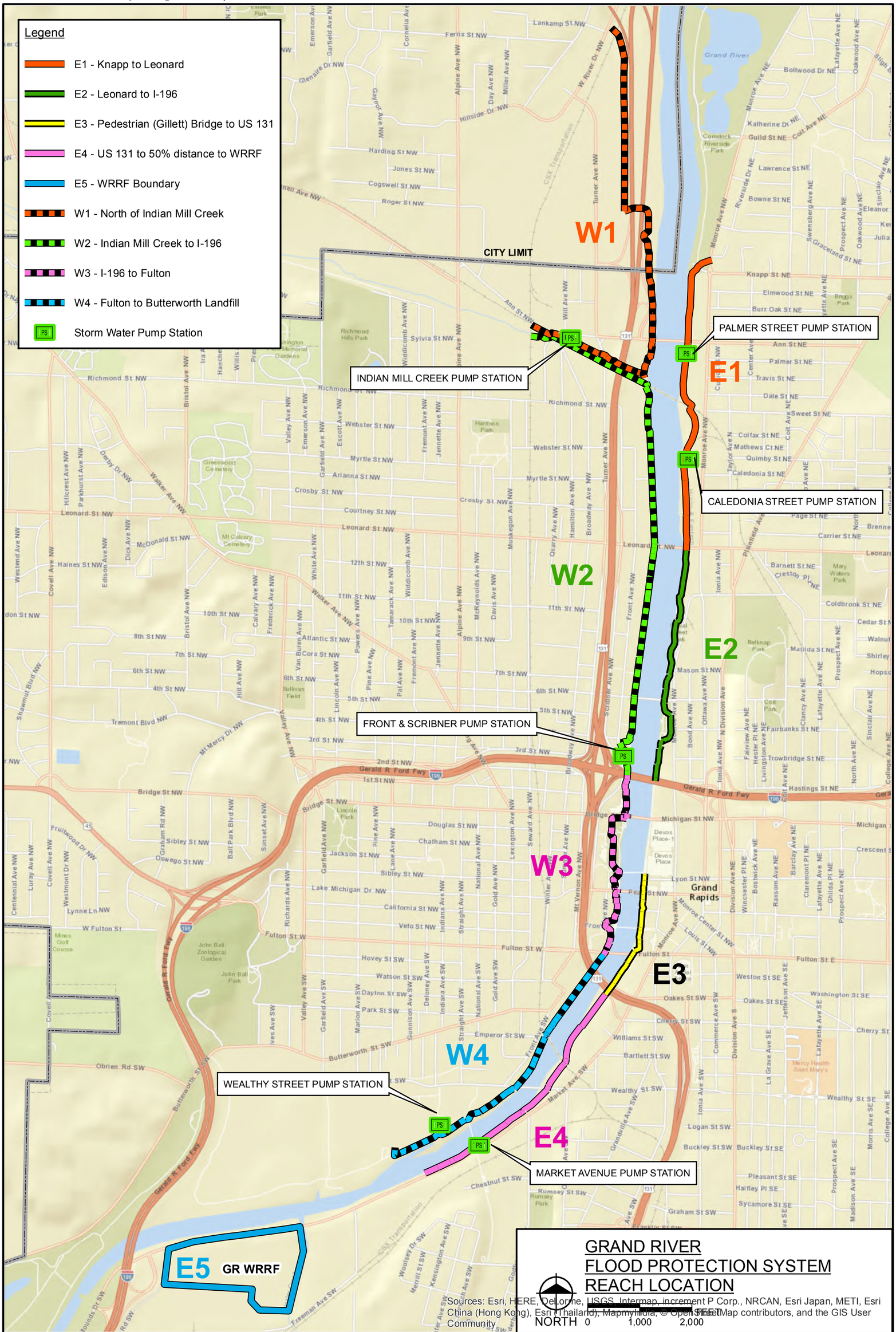

GRAND RIVER FLOOD PROTECTION SYSTEM REACH LOCATION

City of Grand Rapids
Kent County, Michigan

Freeboard Evaluation

PROJECT NO. G120330LMP

FIGURE NO. 1

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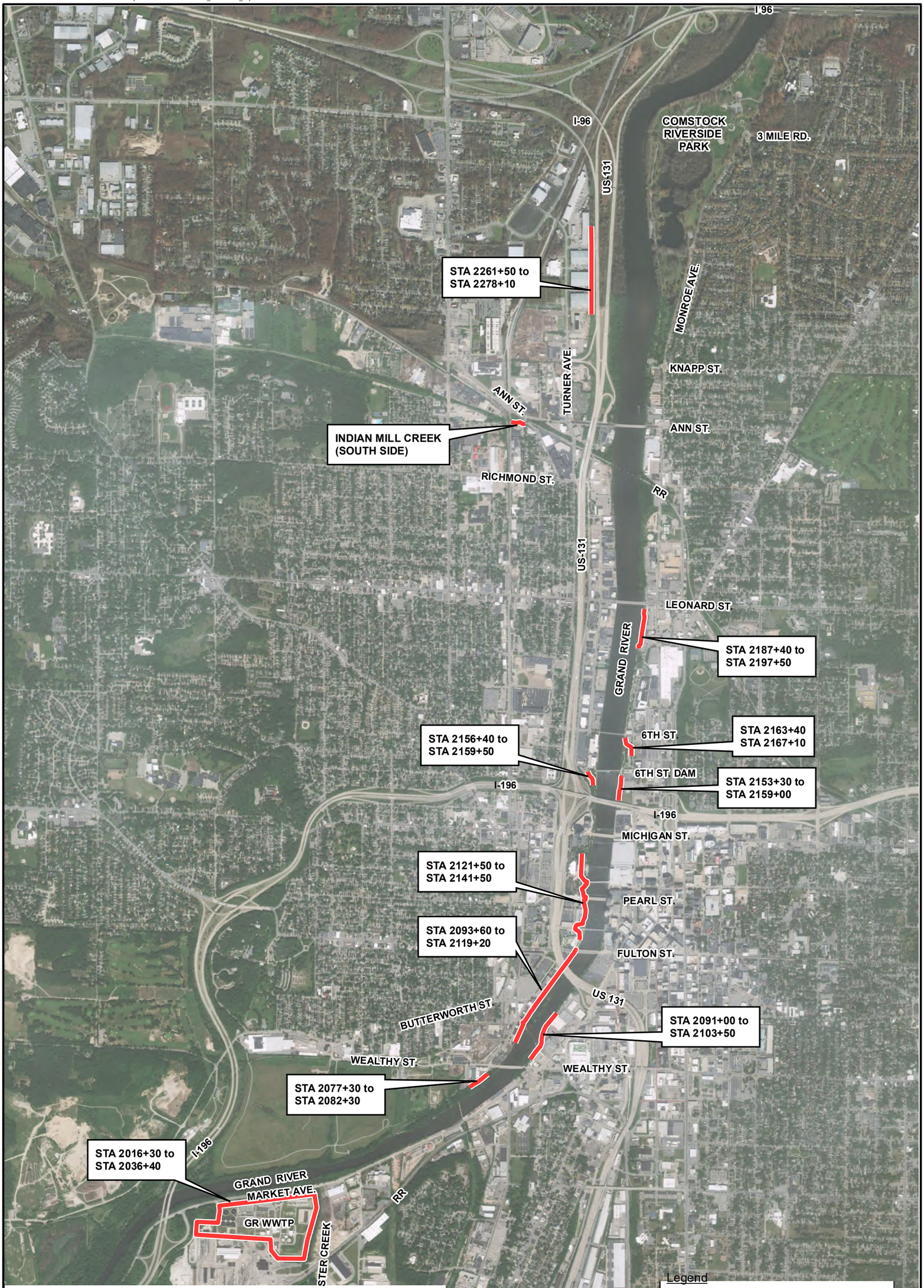

NORTH

FREEBOARD IMPROVEMENTS 2016/2017

0 1,000 2,000 FEET

FIGURE NO. 2

PROJECT NO. G120330LMP

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City of Grand Rapids

Kent County, Michigan

Freeboard Evaluation

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engineers

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Figure 3
East Bank Grand River Profile - Grand Rapids Reach E1

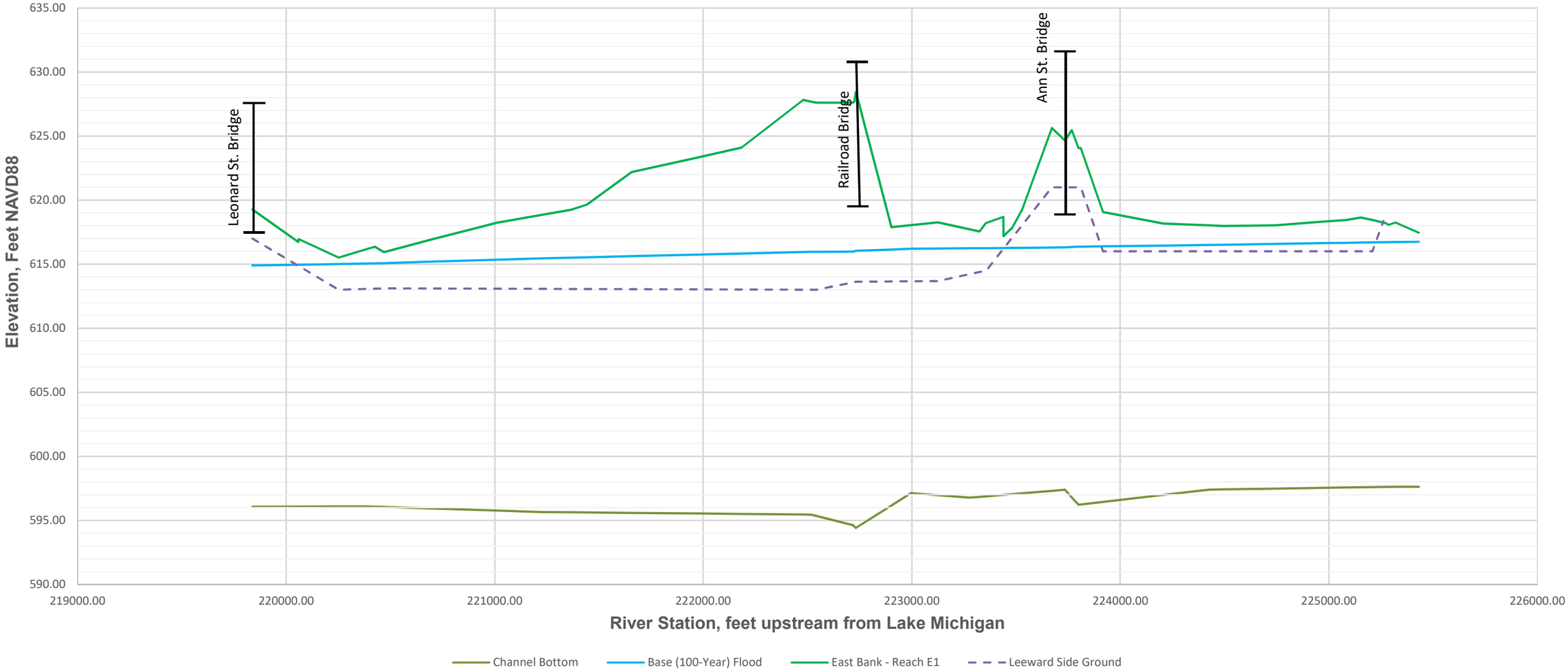


Figure 4
East Bank Grand River Profile - Grand Rapids Reach E2

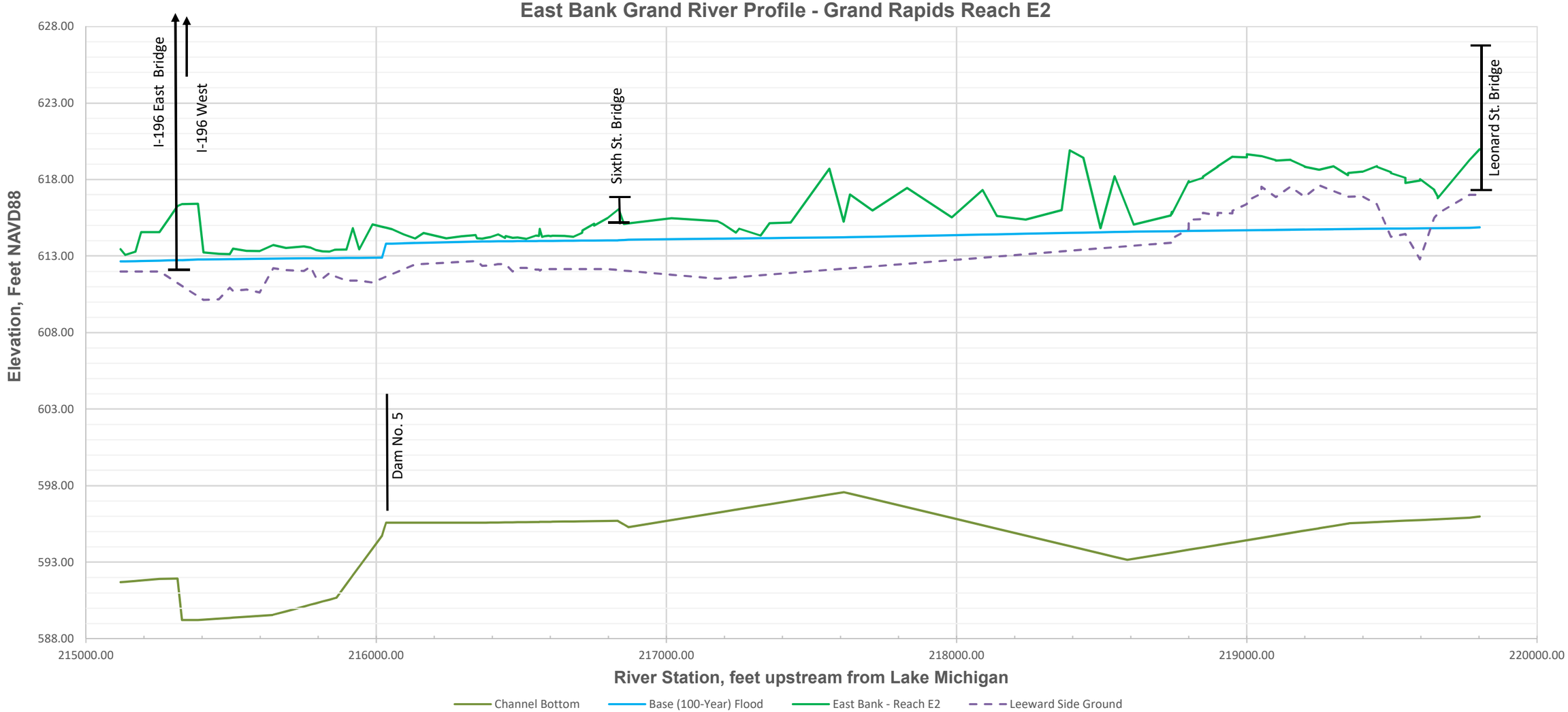


Figure 5
East Bank Grand River Profile - Grand Rapids Reach E3

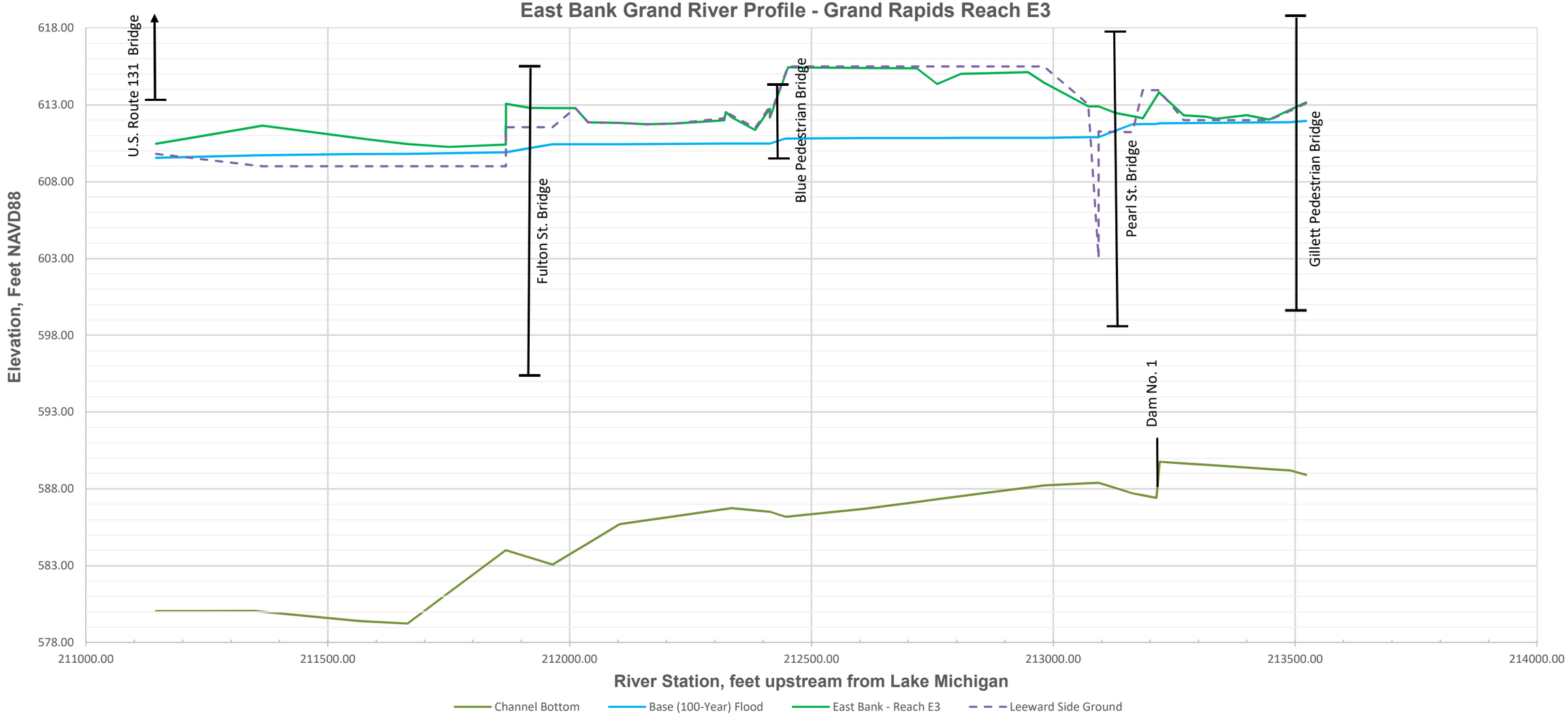


Figure 6
East Bank Grand River Profile - Grand Rapids Reach E4

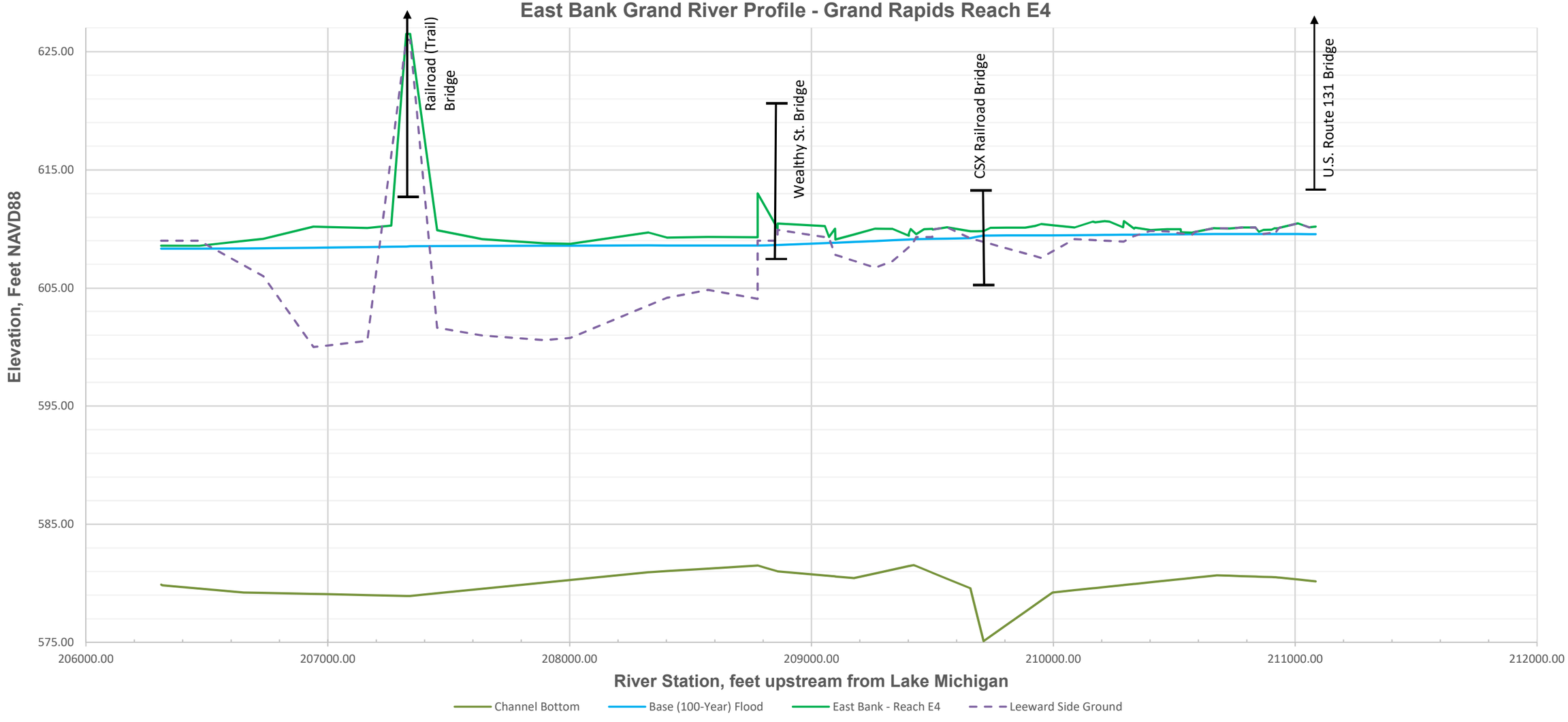


Figure 7A
WRRF East Levee Profile - Grand Rapids Reach E5

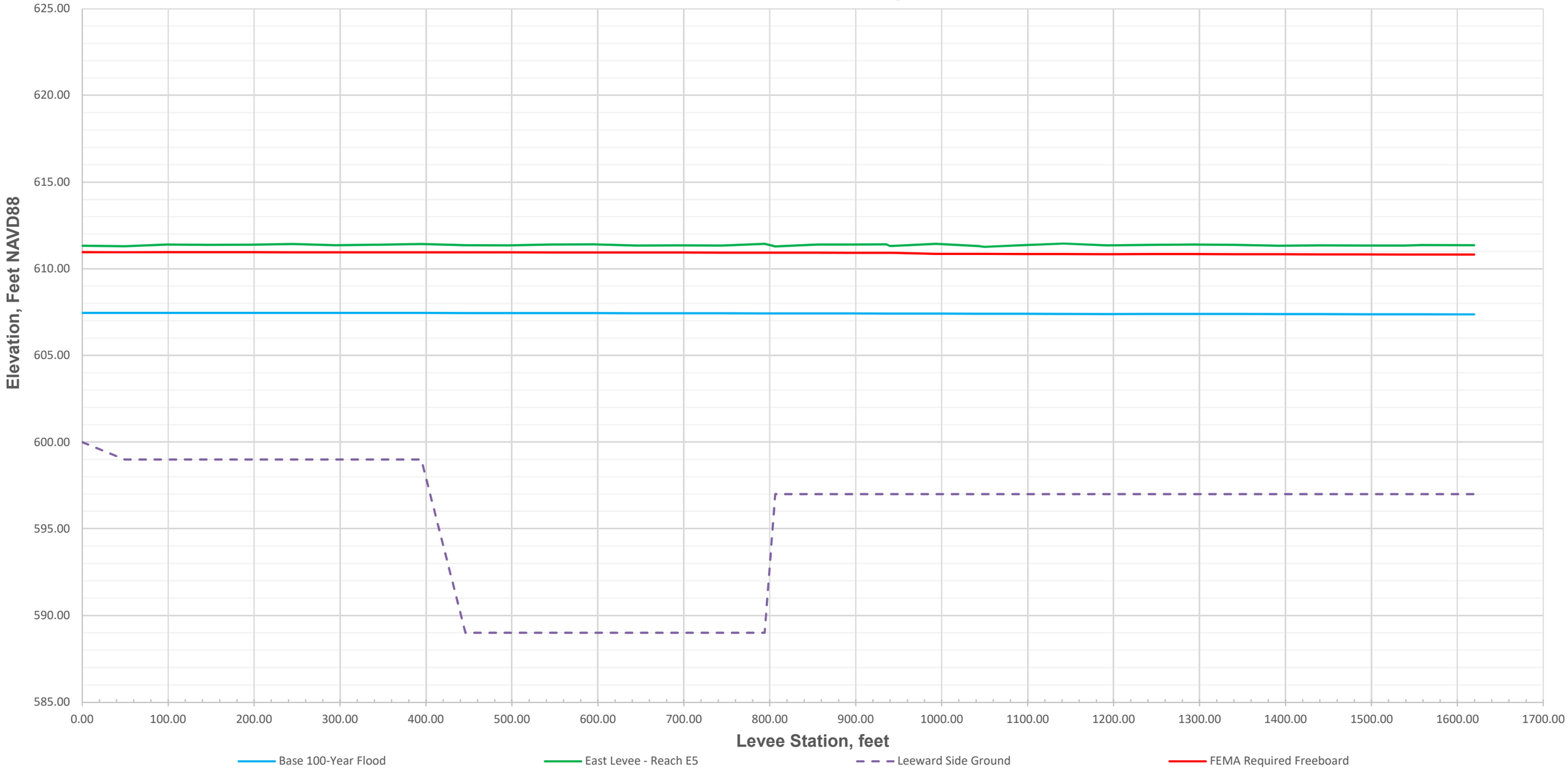


Figure 7B
WRRF South Levee Profile - Grand Rapids Reach E5

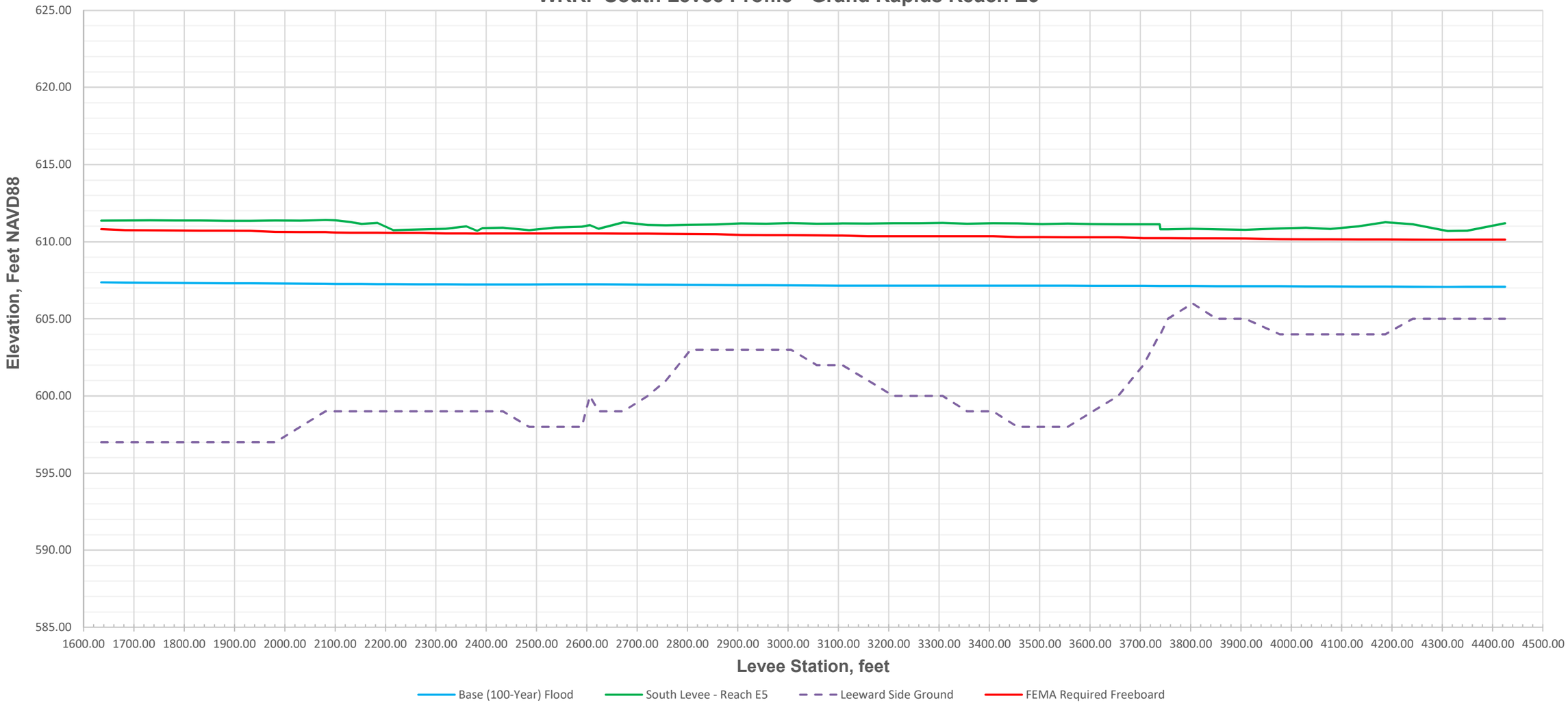


Figure 7C
WRRF West Levee Profile - Grand Rapids Reach E5

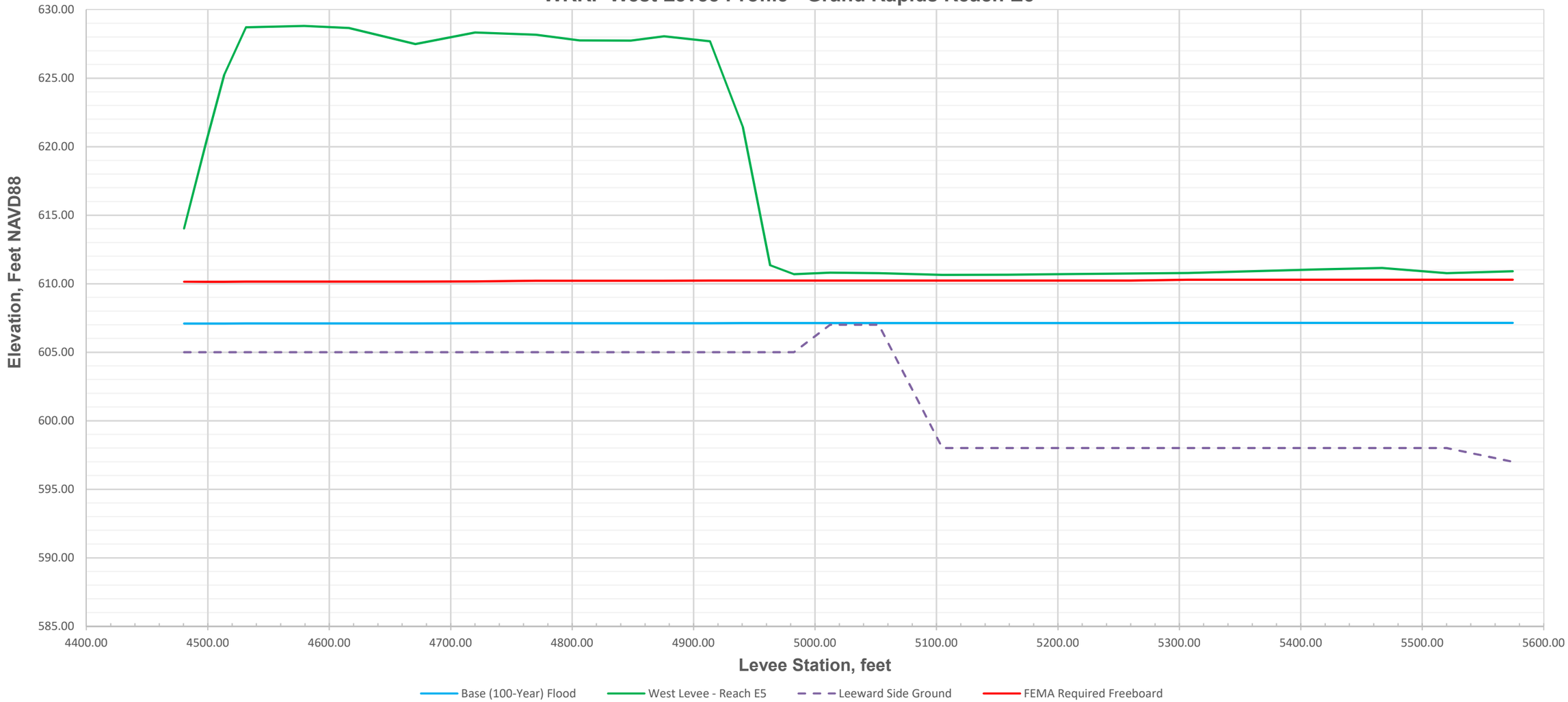


Figure 7D
WRRF North Levee Profile - Grand Rapids Reach E5

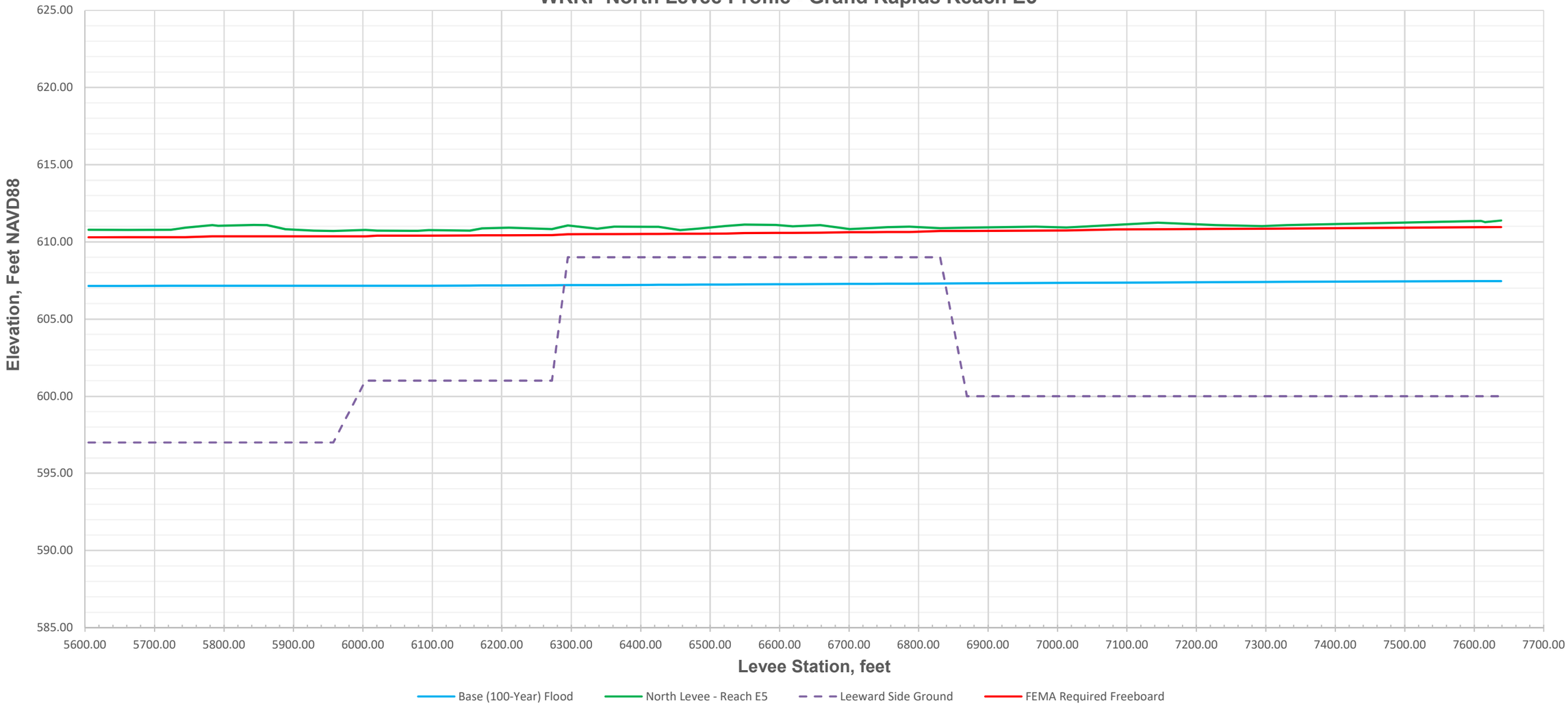


Figure 8A
West Bank Grand River Profile - Grand Rapids Reach W1

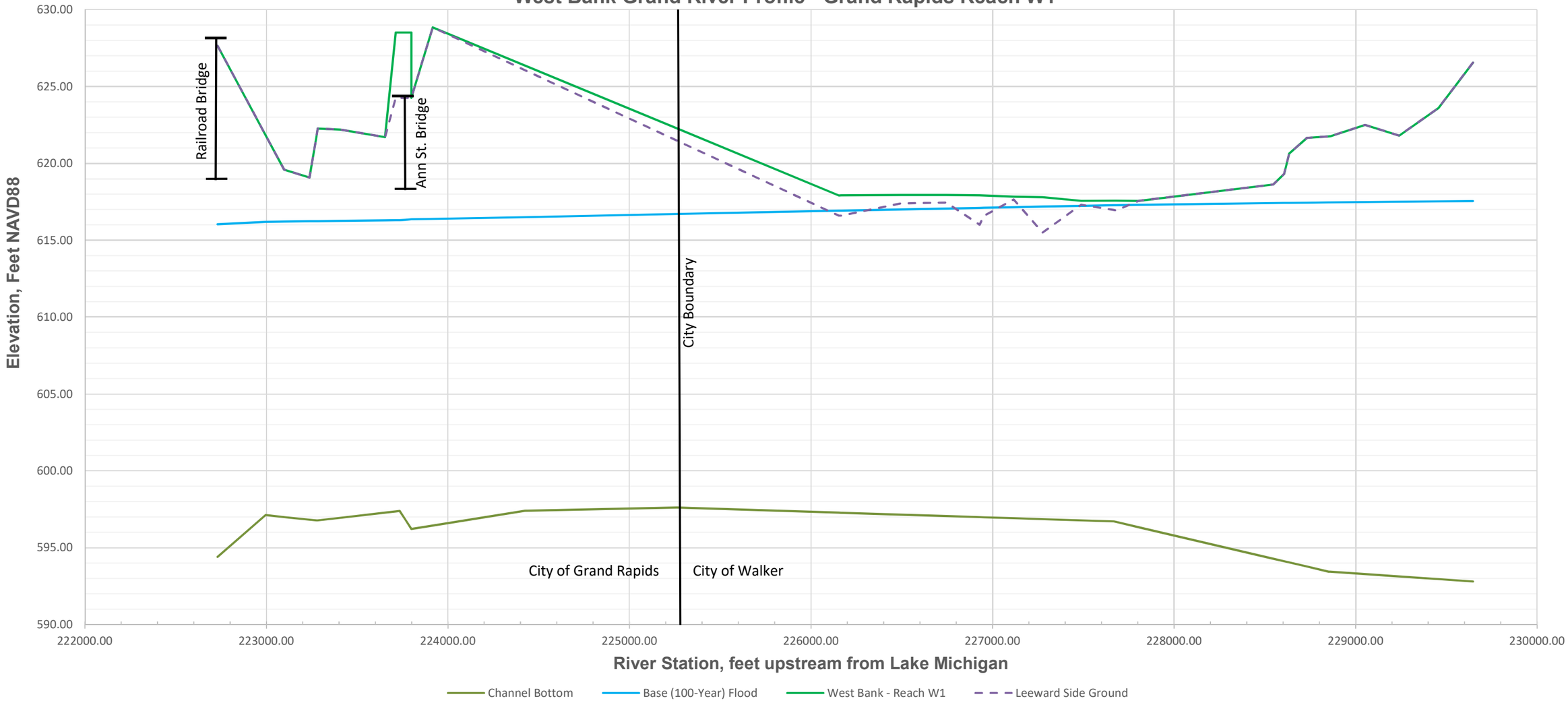


Figure 8B
North Bank Indian Mill Creek Profile - Grand Rapids Reach W1

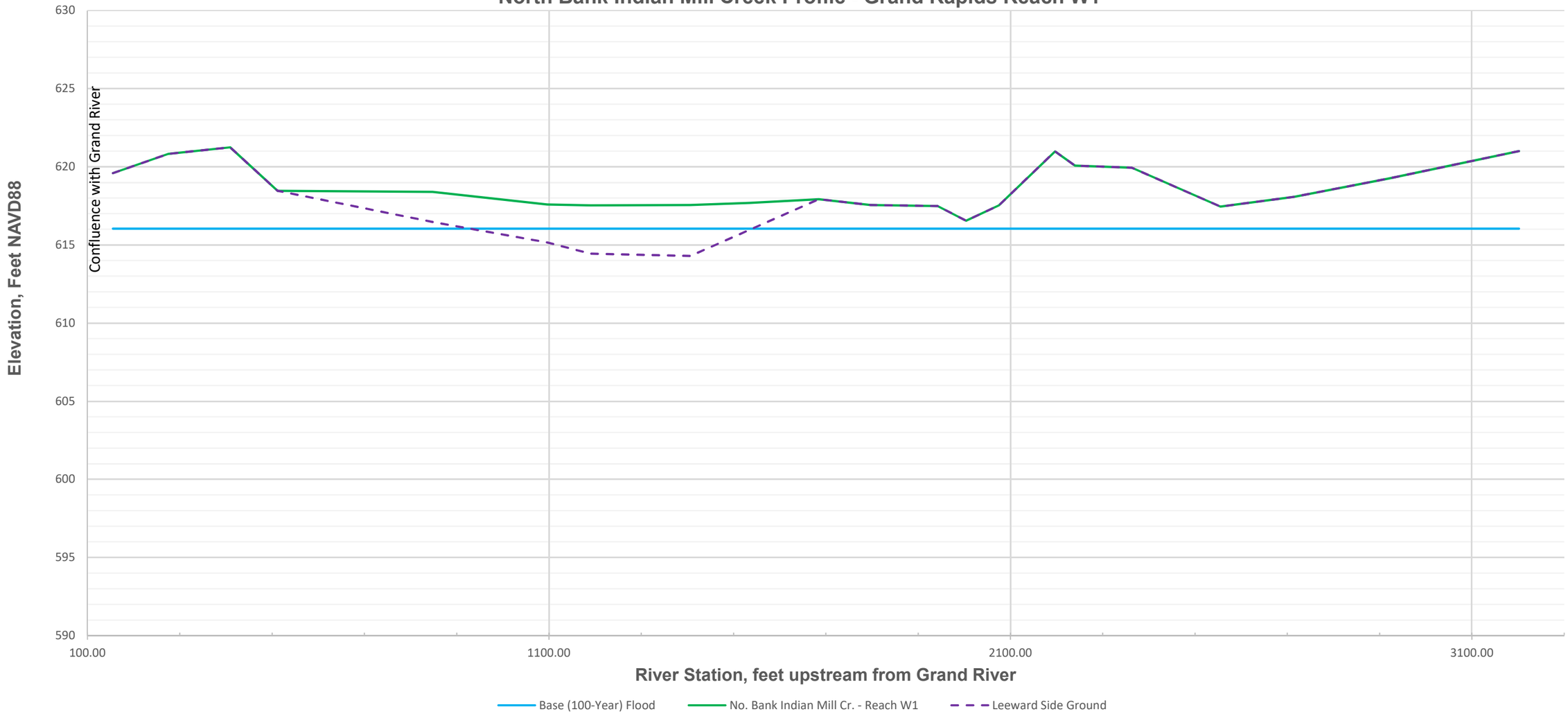


Figure 9A
West Bank Grand River Profile - Grand Rapids Reach W2

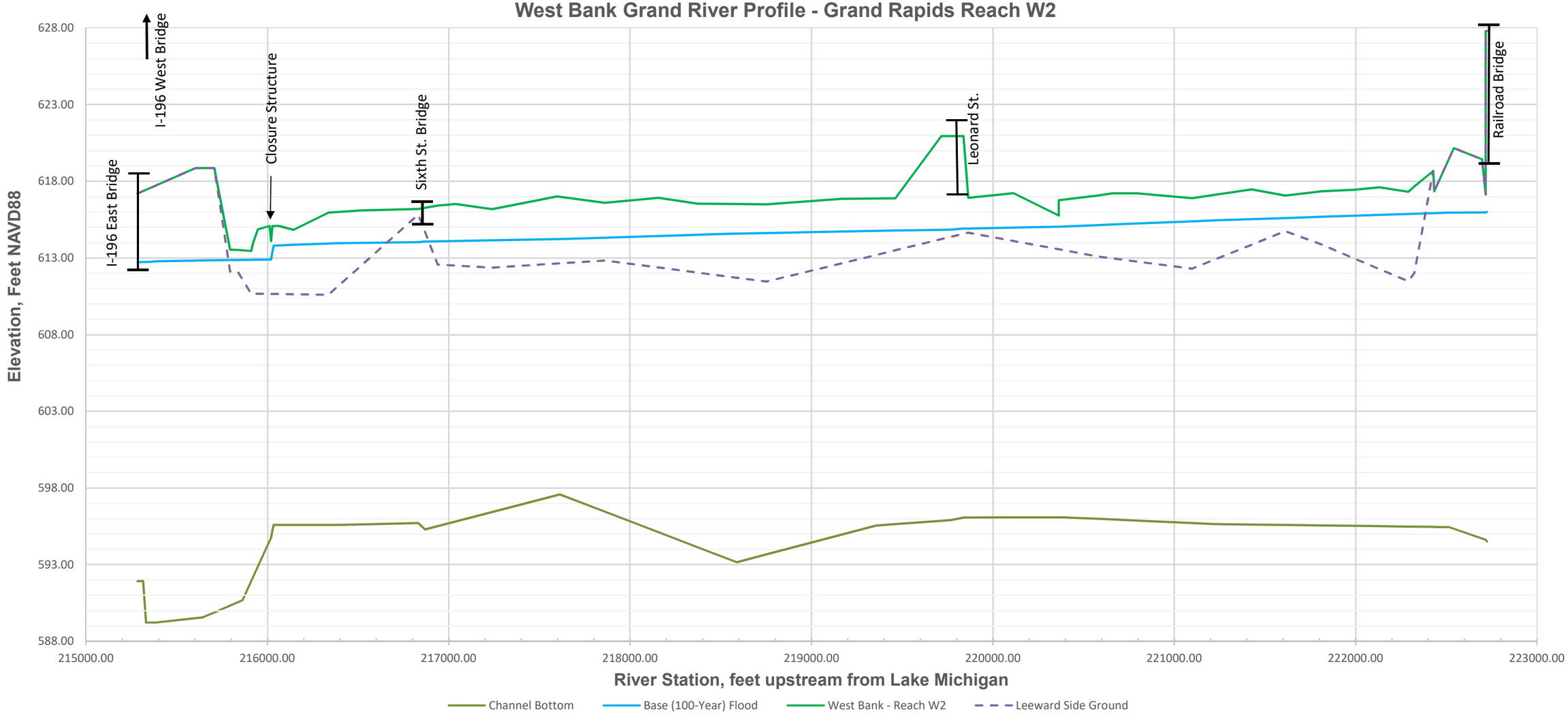


Figure 9B
South Bank Indian Mill Creek Profile - Grand Rapids Reach W2

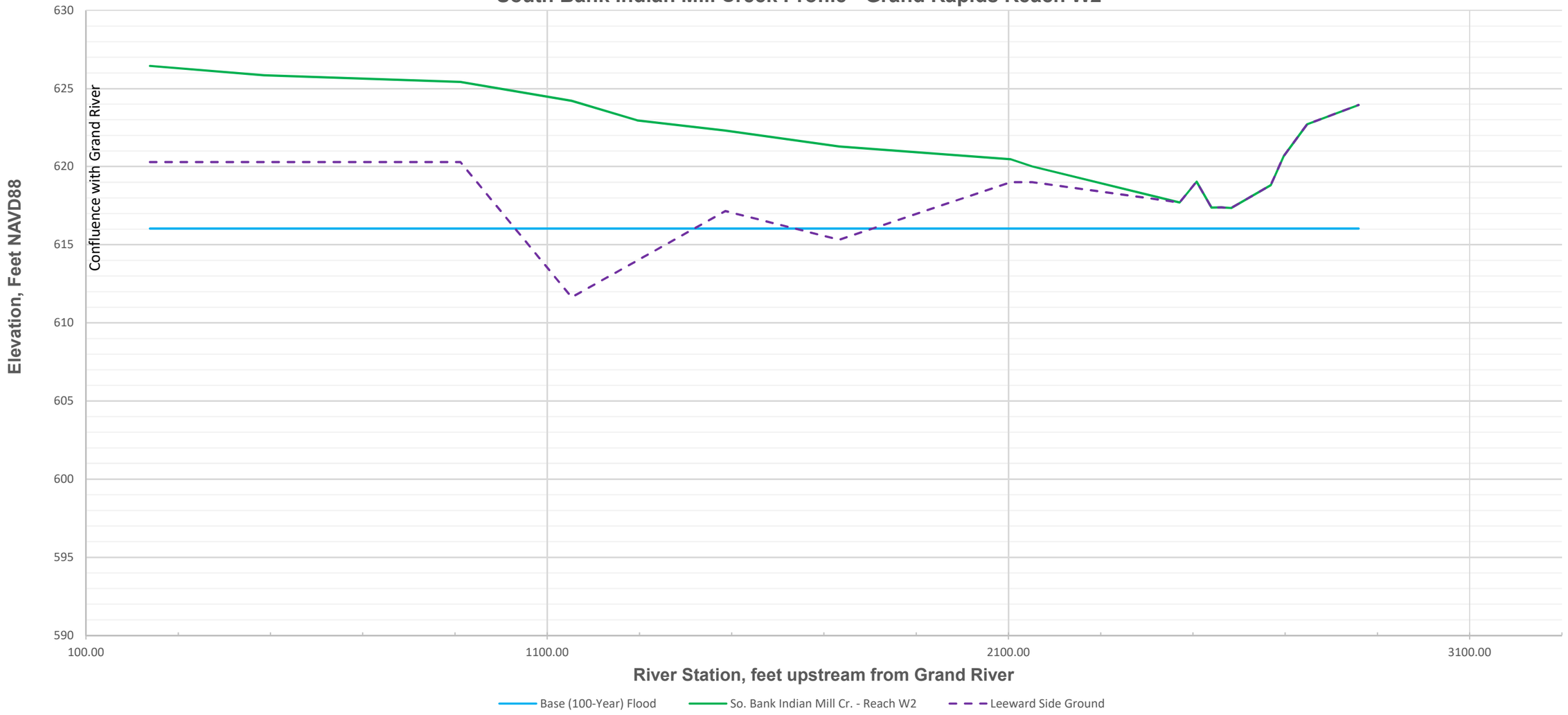


Figure 10
West Bank Grand River Profile - Grand Rapids Reach W3

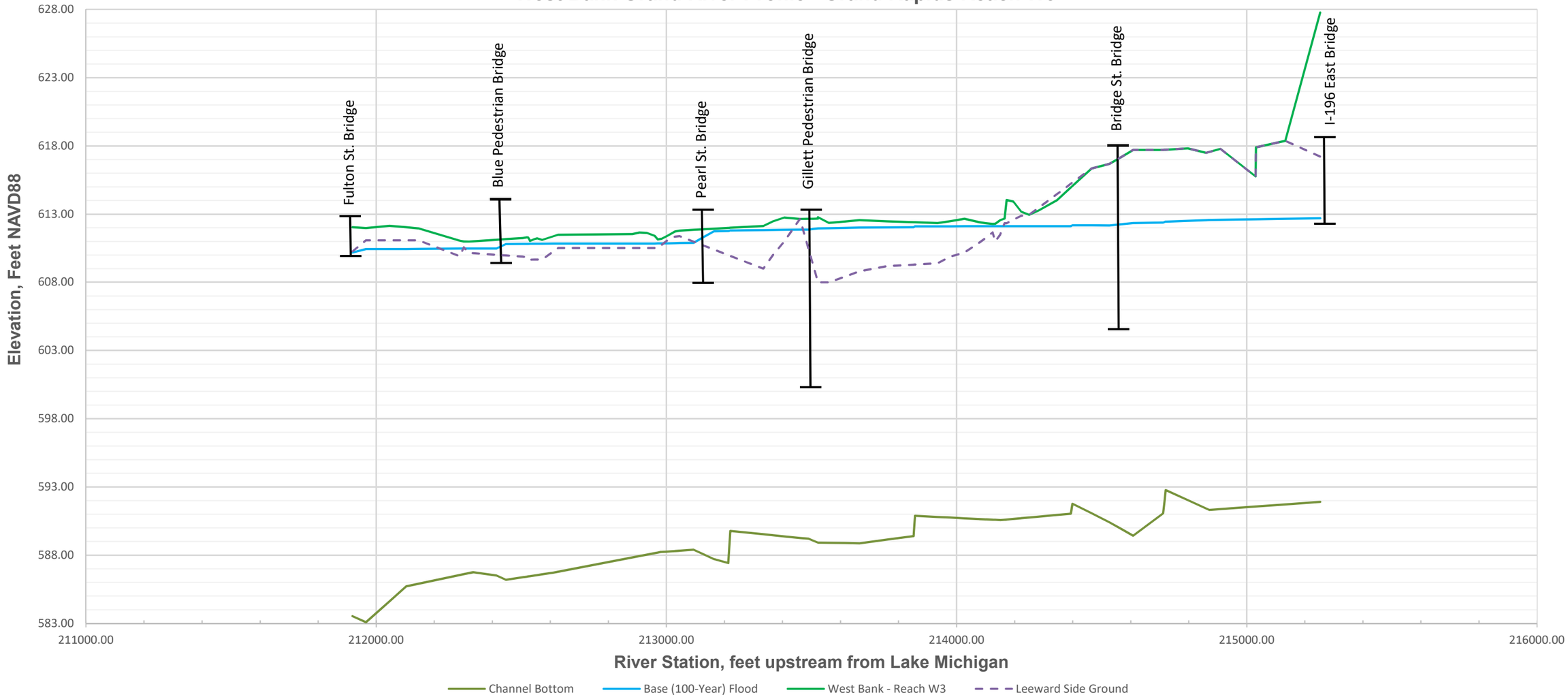
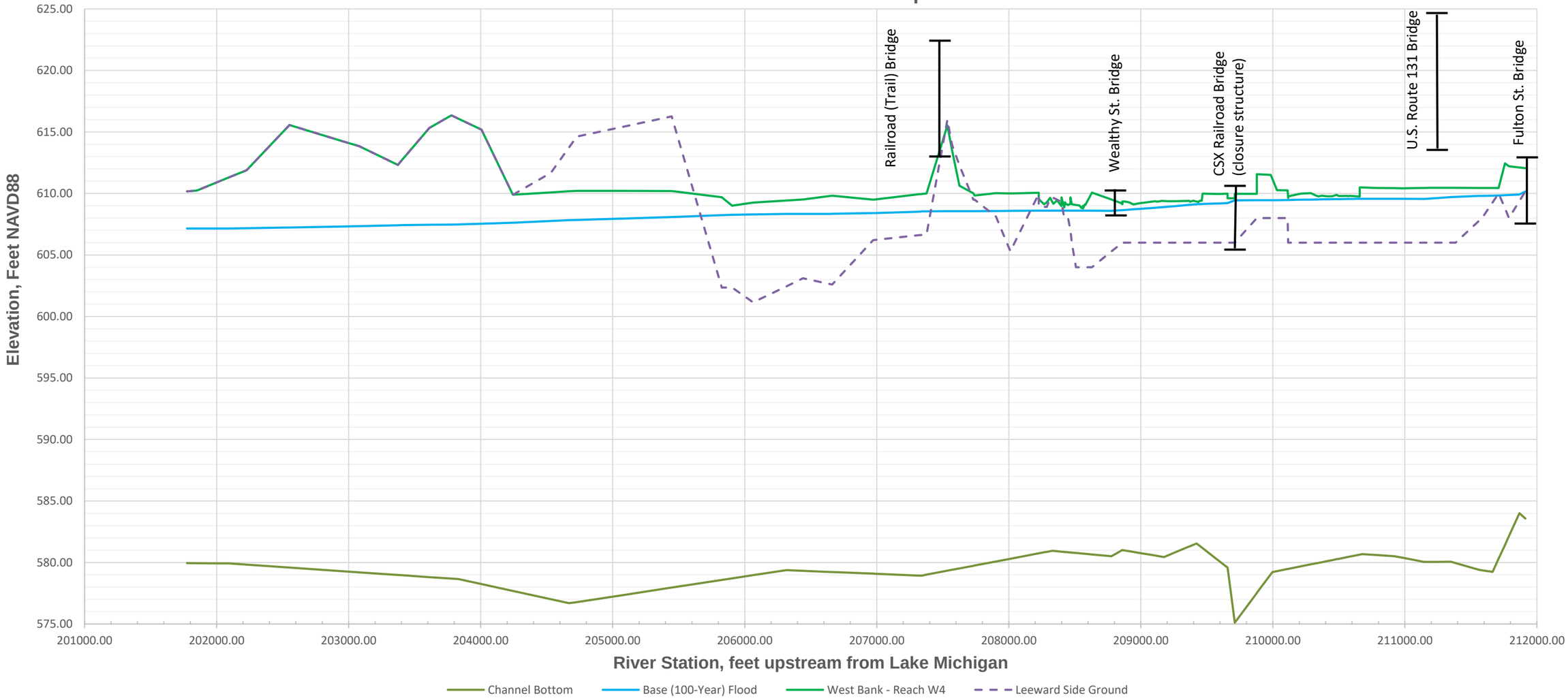


Figure 11
West Bank Grand River Profile - Grand Rapids Reach W4



Tables

Table 1 – Flood Protection Crest Profile: Reach E1
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
219837.80	Leonard St U/S	Not Required	614.91	619.27	----	Interpolated	0.34	4.02	596.07	617.00
219837.80		Not Required	614.90	619.27	101562	4/9/2008	0.34	4.03	596.07	617.00
220057.84		Not Required	614.96	616.73	101564	4/9/2008	0.34	1.43	596.08	614.87
220059.04		Not Required	614.96	616.96	101565	4/9/2008	0.34	1.66	596.08	614.86
220251.33		Not Required	615.01	615.52	127066	4/9/2008	0.34	0.17	596.09	613.00
220387.90	XS 29	Not Required	615.05	616.17	----	Interpolated	0.34	0.78	596.09	613.07
220425.83		Not Required	615.06	616.36	101566	4/9/2008	0.34	0.96	596.07	613.09
220467.76		Not Required	615.08	615.93	104410	4/9/2008	0.34	0.51	596.05	613.11
220691.20		Not Required	615.19	616.90	101569	4/9/2008	0.34	1.37	595.93	613.10
221010.41		Not Required	615.35	618.24	101572	4/9/2008	0.34	2.55	595.76	613.08
221221.60	XS 30	Not Required	615.45	618.84	----	Interpolated	0.34	3.05	595.65	613.07
221364.78		Not Required	615.51	619.24	101575	4/9/2008	0.34	3.40	595.63	613.06
221441.35		Not Required	615.54	619.65	101576	4/9/2008	0.34	3.77	595.62	613.06
221655.73		Not Required	615.62	622.19	101579	4/9/2008	0.34	6.23	595.58	613.05
221978.27		Not Required	615.75	623.35	101581	4/9/2008	0.34	7.26	595.53	613.03
222182.85		Not Required	615.83	624.09	101582	4/9/2008	0.34	7.92	595.50	613.02
222479.02		Not Required	615.95	627.82	101585	4/9/2008	0.34	11.53	595.46	613.00
222516.40	XS 31	Not Required	615.96	627.69	----	Interpolated	0.34	11.39	595.45	613.00
222540.66		Not Required	615.96	627.61	101587	4/9/2008	0.34	11.31	595.35	613.00
222717.40	RR3 D/S	Not Required	615.97	627.61	101587	4/9/2008	0.34	11.30	594.63	613.57
222724.20	RR3	Not Required	616.01	627.69	----	Interpolated	0.34	11.34	594.51	613.59
222730.90	RR3 U/S	Not Required	616.04	628.44	101588	4/9/2008	0.34	12.06	594.40	613.62
222732.00		Not Required	616.04	628.44	101588	4/9/2008	0.34	12.06	594.41	613.62
222901.86		Not Required	616.14	617.89	101269	4/9/2008	0.34	1.41	596.16	613.65
222995.30	XS 32	Not Required	616.20	618.05	----	Interpolated	0.34	1.51	597.12	613.66
223125.06		Not Required	616.21	618.26	101268	4/9/2008	0.34	1.71	596.96	613.68
223275.70	XS 33	Not Required	616.24	617.72	----	Interpolated	0.34	1.14	596.77	614.22
223324.67		Not Required	616.24	617.54	101266	4/9/2008	0.34	0.96	596.84	614.39
223354.73		Not Required	616.24	618.21	104419	4/9/2008	0.34	1.63	596.88	614.45
223438.56		Not Required	616.26	618.69	11458	4/9/2008	0.34	2.09	596.99	616.19
223439.57		Not Required	616.26	617.18	11454	4/9/2008	0.34	0.58	596.99	616.21
223476.10		Not Required	616.26	617.78	11440	4/9/2008	0.34	1.17	597.04	616.96
223477.73		Not Required	616.27	617.75	11435	4/9/2008	0.34	1.14	597.04	617.00
223527.21		Not Required	616.27	619.22	101262	4/9/2008	0.34	2.60	597.11	618.02
223670.96		Not Required	616.30	625.63	126063	4/9/2008	0.34	8.99	597.30	621.00
223733.80	Ann St D/S	Not Required	616.31	624.65	----	Interpolated	0.24	8.10	597.39	621.00
223766.00	Ann St	Not Required	616.34	625.46	101261	4/9/2008	0.24	8.89	596.81	621.00
223767.24		Not Required	616.34	625.46	101261	4/9/2008	0.24	8.88	596.78	621.00
223798.20	Ann St U/S	Not Required	616.36	624.07	----	Interpolated	0.24	7.47	596.22	621.00
223809.86		Not Required	616.36	624.05	101260	4/9/2008	0.24	7.45	596.24	621.00
223916.76		Not Required	616.39	619.07	101259	4/9/2008	0.24	2.44	596.44	616.00
224205.82		Not Required	616.45	618.17	101258	4/9/2008	0.24	1.48	596.99	616.00
224424.10	XS 34	Not Required	616.50	618.03	----	Interpolated	0.24	1.29	597.40	616.00
224494.93		Not Required	616.52	617.98	101257	4/9/2008	0.24	1.22	597.42	616.00
224743.28		Not Required	616.58	618.04	101256	4/9/2008	0.24	1.22	597.48	616.00
224987.91		Not Required	616.64	618.34	101255	4/9/2008	0.24	1.46	597.54	616.00
225077.45		Not Required	616.66	618.43	101254	4/9/2008	0.24	1.53	597.56	616.00
225153.17		Not Required	616.68	618.63	101253	4/9/2008	0.24	1.71	597.58	616.00
225208.02		Not Required	616.70	618.45	101252	4/9/2008	0.24	1.52	597.60	616.00

Table 1 – Flood Protection Crest Profile: Reach E1
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
225261.30	XS 35 - Knapp St.	Not Required	616.71	618.24	----	Interpolated	0.24	1.29	597.61	618.37
225273.99		Not Required	616.71	618.19	101251	4/9/2008	0.24	1.24	597.61	
225284.27		Not Required	616.71	618.06	104005	4/9/2008	0.24	1.11	597.61	
225318.97		Not Required	616.73	618.25	104004	4/9/2008	0.24	1.28	597.62	
225341.46		Not Required	616.73	618.08	101250	4/9/2008	0.24	1.11	597.62	
225430.39		Not Required	616.75	617.45	104017	4/9/2008	0.24	0.46	597.62	

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 2 – Flood Protection Crest Profile: Reach E2
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
215119.00		Not Required	612.65	613.45	4140	12/11/2013	0.06	0.74	591.70	612.00
215135.00		Not Required	612.66	613.08	8027	1/20/2014	0.06	0.36	591.72	612.00
215171.00		Not Required	612.67	613.29	8023	1/20/2014	0.06	0.56	591.78	612.00
215190.00		Not Required	612.68	614.57	8035	1/20/2014	0.06	1.83	591.81	612.00
215253.20	I-196 East D/S	Not Required	612.70	614.57	8035	1/20/2014	0.06	1.81	591.91	612.00
215284.20	I-196 East	Not Required	612.72	615.42	----	Interpolated	0.06	2.64	591.93	611.62
215315.20	I-196 East U/S	Not Required	612.74	616.27	200051	8/22/2017	0.06	3.47	591.94	611.24
215330.50	I-196 West D/S	YES - Contract No. 2 (2016)	612.74	616.40	4206	12/11/2013	0.06	3.60	589.23	611.05
215358.10	I-196 West	YES - Contract No. 2 (2016)	612.76	616.41	----	Interpolated	0.06	3.59	589.23	610.71
215385.60	I-196 West U/S	YES - Contract No. 2 (2016)	612.78	616.42	200048	8/22/2017	0.06	3.58	589.23	610.37
215404.53		YES - Contract No. 2 (2016)	612.78	613.24	200047	8/22/2017	0.06	0.40	589.25	610.14
215457.28		YES - Contract No. 2 (2016)	612.80	613.15	200061	8/22/2017	0.06	0.29	589.32	610.17
215495.69		YES - Contract No. 2 (2016)	612.81	613.13	200037	8/22/2017	0.06	0.27	589.37	610.94
215506.62		YES - Contract No. 2 (2016)	612.81	613.49	200064	8/22/2017	0.06	0.62	589.39	610.72
215553.45		YES - Contract No. 2 (2016)	612.82	613.35	200065	8/22/2017	0.06	0.47	589.45	610.82
215598.22		YES - Contract No. 2 (2016)	612.83	613.33	200070	8/22/2017	0.06	0.44	589.50	610.62
215642.20	XS 23	YES - Contract No. 2 (2016)	612.84	613.70	----	Interpolated	0.06	0.80	589.56	612.11
215645.18		YES - Contract No. 2 (2016)	612.84	613.73	200072	8/22/2017	0.06	0.83	589.58	612.21
215689.14		YES - Contract No. 2 (2016)	612.85	613.53	200077	8/22/2017	0.06	0.63	589.80	612.08
215750.79		YES - Contract No. 2 (2016)	612.85	613.63	200084	8/22/2017	0.06	0.72	590.11	612.03
215773.77		YES - Contract No. 2 (2016)	612.86	613.55	200085	8/22/2017	0.06	0.64	590.23	612.31
215792.38		YES - Contract No. 2 (2016)	612.86	613.39	200086	8/22/2017	0.06	0.47	590.32	611.60
215815.98		YES - Contract No. 2 (2016)	612.86	613.31	200097	8/22/2017	0.06	0.38	590.44	611.55
215839.06		YES - Contract No. 2 (2016)	612.87	613.29	200099	8/22/2017	0.06	0.37	590.56	611.89
215856.17		YES - Contract No. 2 (2016)	612.87	613.41	200107	8/22/2017	0.06	0.48	590.65	611.69
215862.70	XS 24	YES - Contract No. 2 (2016)	612.87	613.42	----	Interpolated	0.06	0.49	590.68	611.64
215897.90		YES - Contract No. 2 (2016)	612.88	613.43	200113	8/22/2017	0.06	0.49	591.59	611.40
215919.44		Not Required	612.88	614.82	3316	12/11/2013	0.06	1.88	592.15	611.40
215941.30		Not Required	612.88	613.44	200115	8/22/2017	0.06	0.49	592.71	611.40
215987.05		Not Required	612.89	615.07	3288	12/11/2013	0.06	2.12	593.89	611.28
216020.20	Dam No. 5 D/S	Not Required	612.90	614.92	----	Interpolated	0.06	1.96	594.75	611.55
216028.20	Dam No. 5	Not Required	613.42	614.88	----	Interpolated	0.06	1.40	595.23	611.61
216034.20	Dam No. 5 U/S	Not Required	613.81	614.85	----	Interpolated	0.06	0.98	595.59	611.66
216054.66		Not Required	613.82	614.76	7540	8/22/2017	0.06	0.88	595.59	611.82
216094.58		Not Required	613.84	614.42	7538	8/22/2017	0.06	0.52	595.59	612.14
216134.44		Not Required	613.85	614.15	7535	8/22/2017	0.06	0.24	595.59	612.46
216163.01		Not Required	613.87	614.51	101294	4/9/2008	0.06	0.58	595.59	612.49
216241.43		Not Required	613.90	614.16	7505	8/22/2017	0.06	0.20	595.59	612.57
216294.72		Not Required	613.92	614.29	10585	8/22/2017	0.06	0.31	595.59	612.63
216342.80		YES - Contract No. 2 (2016)	613.94	614.37	7502	8/22/2017	0.06	0.37	595.59	612.68
216344.34		YES - Contract No. 2 (2016)	613.95	614.28	200032	8/22/2017	0.06	0.27	595.59	612.68
216347.18		YES - Contract No. 2 (2016)	613.95	614.17	10584	8/22/2017	0.06	0.16	595.59	612.68
216365.30		YES - Contract No. 2 (2016)	613.95	614.14	200029	8/22/2017	0.06	0.13	595.59	612.36
216378.80	XS 25	YES - Contract No. 2 (2016)	613.96	614.19	----	Interpolated	0.06	0.17	595.59	612.38

Table 2 – Flood Protection Crest Profile: Reach E2
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
216709.79		Not Required	614.01	614.52	7492	1/10/2014	0.06	0.45	595.59	612.39
216710.71		Not Required	614.01	614.67	7491	1/10/2014	0.06	0.60	595.59	612.39
216750.79		Not Required	614.02	615.11	7494	1/10/2014	0.00	1.09	595.60	612.48
216750.99		Not Required	614.02	614.99	7493	1/10/2014	0.00	0.98	595.61	612.48
216796.96		Not Required	614.02	615.49	101526	4/9/2008	0.00	1.46	595.61	612.48
216832.00	Sixth St D/S	Not Required	614.03	616.01	----	Interpolated	0.00	1.98	595.61	612.00
216835.52		Not Required	614.03	616.06	101027	4/9/2008	0.00	2.03	595.62	612.23
216850.90	Sixth St	Not Required	614.05	615.25	----	Interpolated	0.00	1.20	595.63	612.23
216853.72		Not Required	614.05	615.10	101529	4/9/2008	0.00	1.04	595.64	612.12
216869.40	Sixth St U/S	Not Required	614.07	615.13	----	Interpolated	0.00	1.06	595.64	612.12
217017.82		Not Required	614.10	615.48	101289	4/9/2008	0.00	1.38	595.64	612.05
217175.56		Not Required	614.14	615.29	104403	8/22/2017	0.00	1.15	595.64	612.15
217194.33		Not Required	614.14	615.10	101530	4/9/2008	0.00	0.96	595.64	612.15
217240.05		Not Required	614.15	614.54	101288	4/9/2008	0.00	0.39	595.65	612.15
217251.06		Not Required	614.15	614.79	125030	8/22/2017	0.00	0.64	595.65	612.15
217324.47		Not Required	614.17	614.34	135000	8/22/2017	0.00	0.17	595.65	612.15
217355.33		Not Required	614.17	615.16	125031	8/22/2017	0.00	0.98	595.66	612.15
217427.96		Not Required	614.19	615.19	101287	4/9/2008	0.00	1.00	595.67	612.15
217561.84		Not Required	614.22	618.71	101286	4/9/2008	0.00	4.49	595.68	612.15
217610.92		Not Required	614.23	615.25	101285	4/9/2008	0.04	0.98	595.68	612.15
217611.50	XS 26	Not Required	614.23	615.30	----	Interpolated	0.00	1.07	595.58	612.18
217632.65		Not Required	614.24	617.03	101284	4/9/2008	0.00	2.79	597.48	612.21
217710.09		Not Required	614.27	615.99	101536	4/9/2008	0.00	1.72	597.13	612.33
217829.34		Not Required	614.31	617.46	845	4/9/2008	0.00	3.15	596.59	612.51
217983.60		Not Required	614.37	615.53	844	4/9/2008	0.00	1.16	595.90	612.74

Table 2 – Flood Protection Crest Profile: Reach E2
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
218089.52		Not Required	614.41	617.32	101281	4/9/2008	0.00	2.91	595.42	612.90
218138.78		Not Required	614.42	615.63	101280	4/9/2008	0.04	1.16	595.19	612.97
218238.16		Not Required	614.46	615.38	101541	4/9/2008	0.00	0.92	594.74	613.12
218362.26		Not Required	614.51	616.01	101279	4/9/2008	0.00	1.50	594.18	613.31
218389.99		Not Required	614.52	619.92	101278	4/9/2008	0.04	5.36	594.06	613.35
218436.77		Not Required	614.53	619.43	101277	4/9/2008	0.04	4.86	593.85	613.42
218496.14		Not Required	614.56	614.83	101547	4/9/2008	0.04	0.23	593.58	613.51
218544.77		Not Required	614.57	618.22	101275	4/9/2008	0.04	3.60	593.36	613.58
218588.50	XS 27	Not Required	614.59	616.11	----	Interpolated	0.04	1.48	593.16	613.65
218610.46		Not Required	614.60	615.06	101274	4/9/2008	0.04	0.42	593.23	613.68
218738.42		YES - Coldbrook Improvements (2016)	614.63	615.65	101273	4/9/2008	0.04	0.99	593.63	613.87
218741.92		YES - Coldbrook Improvements (2016)	614.63	615.89	30302	8/23/2017	0.04	1.22	593.64	613.88
218742.04		YES - Coldbrook Improvements (2016)	614.63	615.75	30301	8/23/2017	0.04	1.08	593.64	614.14
218799.73		YES - Coldbrook Improvements (2016)	614.64	617.90	30240	8/23/2017	0.04	3.22	593.82	614.76
218799.94		YES - Coldbrook Improvements (2016)	614.64	617.81	30239	8/23/2017	0.04	3.13	593.82	615.37
218849.30		YES - Coldbrook Improvements (2016)	614.65	618.11	30227	8/28/2017	0.04	3.42	593.97	615.42
218849.39		YES - Coldbrook Improvements (2016)	614.65	618.19	30226	8/23/2017	0.04	3.50	593.97	615.82
218900.28		YES - Coldbrook Improvements (2016)	614.66	618.85	30215	8/23/2017	0.04	4.15	594.13	615.65
218900.29		YES - Coldbrook Improvements (2016)	614.66	618.87	30214	8/23/2017	0.04	4.17	594.13	615.82
218950.67		YES - Coldbrook Improvements (2016)	614.68	619.49	30203	8/23/2017	0.04	4.78	594.29	615.79
218950.74		YES - Coldbrook Improvements (2016)	614.68	619.48	30204	8/23/2017	0.04	4.77	594.29	615.97
219000.05		YES - Coldbrook Improvements (2016)	614.69	619.45	30185	8/23/2017	0.04	4.73	594.44	616.40
219000.23		YES - Coldbrook Improvements (2016)	614.69	619.65	30186	8/23/2017	0.04	4.92	594.45	616.61
219050.63		YES - Coldbrook Improvements (2016)	614.70	619.53	30176	8/23/2017	0.04	4.79	594.60	617.08
219050.79		YES - Coldbrook Improvements (2016)	614.70	619.53	30177	8/23/2017	0.04	4.79	594.60	617.53
219100.58		YES - Coldbrook Improvements (2016)	614.71	619.27	30163	8/23/2017	0.04	4.51	594.76	616.86
219100.61		YES - Coldbrook Improvements (2016)	614.71	619.24	30164	8/23/2017	0.04	4.49	594.76	616.86
219149.98		YES - Coldbrook Improvements (2016)	614.72	619.29	30149	8/23/2017	0.04	4.53	594.91	617.53
219150.10		YES - Coldbrook Improvements (2016)	614.72	619.28	30150	8/23/2017	0.04	4.52	594.91	617.53
219199.68		YES - Coldbrook Improvements (2016)	614.73	618.85	630138	8/23/2017	0.04	4.08	595.07	616.87
219199.82		YES - Coldbrook Improvements (2016)	614.73	618.83	30139	8/23/2017	0.04	4.06	595.07	616.87
219249.23		YES - Coldbrook Improvements (2016)	614.75	618.65	30124	8/23/2017	0.04	3.86	595.22	617.62
219249.36		YES - Coldbrook Improvements (2016)	614.75	618.64	30125	8/23/2017	0.04	3.86	595.22	617.62
219298.75		YES - Coldbrook Improvements (2016)	614.76	618.86	30112	8/23/2017	0.04	4.07	595.38	617.25
219298.90		YES - Coldbrook Improvements (2016)	614.76	618.87	30113	8/23/2017	0.04	4.07	595.38	617.25
219348.81		YES - Coldbrook Improvements (2016)	614.77	618.29	30098	8/23/2017	0.04	3.48	595.53	616.88
219349.04		YES - Coldbrook Improvements (2016)	614.77	618.43	30099	8/23/2017	0.04	3.62	595.53	616.88
219354.20	XS 28	YES - Coldbrook Improvements (2016)	614.77	618.44	----	Interpolated	0.04	3.63	595.55	616.88
219398.04		YES - Coldbrook Improvements (2016)	614.78	618.52	30088	8/23/2017	0.04	3.70	595.59	616.90
219398.08		YES - Coldbrook Improvements (2016)	614.78	618.51	30089	8/23/2017	0.04	3.69	595.59	616.90
219447.96		YES - Coldbrook Improvements (2016)	614.79	618.87	30079	8/23/2017	0.04	4.05	595.63	616.40
219447.98		YES - Coldbrook Improvements (2016)	614.79	618.83	30080	8/23/2017	0.04	4.00	595.63	616.40
219496.48		YES - Coldbrook Improvements (2016)	614.80	618.49	30067	8/23/2017	0.04	3.65	595.67	614.26
219496.59		YES - Coldbrook Improvements (2016)	614.80	618.42	30066	8/23/2017	0.04	3.58	595.67	614.26

Table 2 – Flood Protection Crest Profile: Reach E2
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
			614.81						595.72	614.44
			614.81						595.72	614.44
			614.82						595.76	612.79
			614.82						595.76	612.79
			614.83						595.80	615.50
			614.83						595.80	615.50
			614.83						595.81	615.76
			614.83						595.81	615.78
219767.80	Leonard St D/S	Not Required	614.85	619.27	----	Interpolated	0.04	4.38	595.91	617.00
219802.80	Leonard St	Not Required	614.88	619.99	101561	4/9/2008	0.04	5.07	595.99	617.00
219837.80	Leonard St U/S	Not Required	614.91	619.27	101562	4/9/2008	0.04	4.32	596.07	617.00

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 3 – Flood Protection Crest Profile: Reach E3
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

No Improvements Needed After Further Review Survey Information

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
211144.80	US Hwy 131 D/S	Not Required	609.55	610.47	----	Interpolated	0.00	0.92	580.05	609.81
211242.40	US Hwy 131	Not Required	609.63	610.99	----	Interpolated	0.00	1.36	580.05	609.45
211348.60	US Hwy 131 U/S	Not Required	609.71	611.55	----	Interpolated	0.00	1.84	580.06	609.06
211364.96		Not Required	609.72	611.64	101112	4/9/2008	0.00	1.93	580.01	609.00
211561.30	XS 14	Not Required	609.80	610.84		Interpolated	0.00	1.04	579.41	609.00
211577.82		Not Required	609.80	610.77	101111	4/9/2008	0.00	0.97	579.38	609.00
211664.80	XS 15	Not Required	609.81	610.45	----	Interpolated	0.00	0.64	579.24	609.00
211750.28		Not Required	609.85	610.26	7102	1/10/2014	0.00	0.41	581.25	609.00
211867.68		Not Required	609.91	610.41	101321	4/9/2008	0.00	0.50	584.00	609.00
211868.10		Not Required	609.91	611.64	7106	1/10/2014	0.00	1.73	584.01	609.00
211868.10		Not Required	609.91	610.94	7113	1/10/2014	0.00	1.03	584.01	609.00
211868.10		Not Required	609.91	611.84	7107	1/10/2014	0.00	1.93	584.01	609.00
211868.10	Fulton St D/S	Not Required	609.91	613.07	----	Interpolated	0.00	3.16	584.01	611.55
211918.10	Fulton St	Not Required	610.18	612.80	----	Interpolated	0.00	2.62	583.53	611.55
211964.70	Fulton St U/S	Not Required	610.44	612.79	----	Interpolated	0.00	2.35	583.08	611.55
212011.92		Not Required	610.44	612.79	120062	10/22/2012	0.00	2.35	583.97	612.79
212038.01		Not Required	610.44	611.85	120063	10/22/2012	0.00	1.41	584.47	611.85
212101.51		Not Required	610.44	611.83	120064	10/22/2012	0.00	1.39	585.67	611.83
212103.50	XS 16	Not Required	610.44	611.83	----	Interpolated	0.00	1.39	585.71	611.83
212159.61		Not Required	610.45	611.74	120065	10/22/2012	0.00	1.29	585.96	611.74
212215.09		Not Required	610.46	611.78	120066	10/22/2012	0.00	1.32	586.21	611.78
212319.47		Not Required	610.48	612.00	101106	4/9/2008	0.00	1.52	586.68	612.13
212322.82		Not Required	610.48	612.53	120067	10/22/2012	0.00	2.05	586.70	612.53
212334.20	XS 17	Not Required	610.48	612.20	----	Interpolated	0.00	1.72	586.75	612.33
212383.19		Not Required	610.48	611.37	570	4/9/2008	0.00	0.89	586.60	611.50
212413.76		Not Required	610.48	612.75	1105	4/9/2008	0.00	2.27	586.51	612.88
212413.94		Not Required	610.48	612.17	1106	4/9/2008	0.00	1.69	586.51	612.30
212414.50	ped bridge D/S	Not Required	610.48	612.22	----	Interpolated	0.00	1.74	586.51	612.35
212431.80	Blue Ped Bridge	Not Required	610.66	613.72	----	Interpolated	0.00	3.06	586.34	613.82
212446.80	ped bridge U/S	Not Required	610.81	615.02	----	Interpolated	0.00	4.21	586.19	615.09
212451.65		Not Required	610.81	615.44	1434	4/9/2008	0.00	4.63	586.21	615.50
212611.50	XS 18	Not Required	610.84	615.40	----	Interpolated	0.00	4.56	586.72	615.50
212717.76		Not Required	610.84	615.37	1435	4/9/2008	0.00	4.53	587.15	615.50
212760.00		Not Required	610.84	614.35	120068	10/22/2012	0.00	3.51	587.33	615.50
212809.03		Not Required	610.85	615.02	120071	10/22/2012	0.00	4.17	587.53	615.50
212855.41		Not Required	610.85	615.05	127069	10/22/2012	0.00	4.20	587.72	615.50
212947.55		Not Required	610.85	615.12	127070	10/22/2012	0.00	4.27	588.10	615.50
212980.50	XS 19	Not Required	610.85	614.44	----	Interpolated	0.00	3.59	588.23	615.50
213072.27		Not Required	610.89	612.90	101617	4/9/2008	0.00	2.01	588.37	613.03
213093.70		Not Required	610.90	612.90	101617	4/9/2008	0.00	2.00	588.40	603.03
213093.70	Pearl St D/S	Not Required	610.90	612.90	101617	4/9/2008	0.00	2.00	588.40	611.27
213128.60	Pearl St	Not Required	611.32	612.47	101616	4/9/2008	0.00	1.15	588.06	611.25
213163.80	Pearl St U/S	Not Required	611.74	612.26	----	Interpolated	0.00	0.52	587.71	611.22
213185.11		Not Required	611.75	612.13	108005	4/9/2008	0.00	0.38	587.58	613.95
213213.00	Dam No. 1 D/S*	Not Required	611.76	613.54	----	Interpolated	0.00	1.78	587.42	613.95

Table 3 – Flood Protection Crest Profile: Reach E3
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

No Improvements Needed After Further Review Survey Information

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
213216.50	Dam No. 1	Not Required	611.78	613.72	----	Interpolated	0.00	1.94	588.60	613.95
213218.47		Not Required	611.79	613.82	108004	4/9/2008	0.00	2.03	589.26	613.95
213218.47		Not Required	611.79	613.82	137	4/9/2008	0.00	2.03	589.26	613.95
213220.00	Dam No. 1 U/S	Not Required	611.80	613.78	----	Interpolated	0.00	1.98	589.77	613.89
213269.54		Not Required	611.81	612.32	108003	4/9/2008	0.00	0.51	589.67	612.00
213315.37		Not Required	611.82	612.23	108002	4/9/2008	0.00	0.41	589.57	612.00
213336.80		Not Required	611.83	612.09	140030	4/9/2008	0.00	0.26	589.52	612.00
213399.76		Not Required	611.85	612.33	140039	4/9/2008	0.00	0.48	589.39	612.00
213446.12		Not Required	611.86	612.04	108006	4/9/2008	0.00	0.18	589.29	612.00
213489.90	ped bridge D/S	Not Required	611.87	612.68	----	Interpolated	0.00	0.81	589.20	612.61
213506.20	Gillett Ped Bridge	Not Required	611.91	612.92	----	Interpolated	0.00	1.01	589.06	612.86
213522.50	ped bridge U/S	Not Required	611.95	613.16	101591	4/9/2008	0.00	1.21	588.92	613.09

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 4 – Flood Protection Crest Profile: Reach E4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

No Improvements Needed - Areas resurveyed since LAMP

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
Grand River										
206310.93		Not Required	608.33	608.57	----	Interpolated	0.13	0.11	579.90	609.00
206315.80	XS 8	Not Required	608.33	608.57	----	Interpolated	0.13	0.11	579.83	609.00
206468.30		Not Required	608.33	608.57	120024	10/22/2012	0.13	0.10	579.56	609.00
206651.90		Not Required	608.34	608.98	----	Interpolated	0.13	0.51	579.23	606.92
206733.21		Not Required	608.36	609.16	120025	10/22/2012	0.13	0.68	579.20	606.00
206940.77		Not Required	608.40	610.19	120026	10/22/2012	0.13	1.66	579.11	600.00
206988.00		Not Required	608.41	610.16	----	Interpolated	0.13	1.62	579.09	600.11
207163.13		Not Required	608.46	610.07	104398	11/30/2012	0.13	1.48	579.01	600.52
207262.40		Not Required	608.49	610.27	120027	10/22/2012	0.13	1.65	578.97	616.22
207324.20	RR1 D/S	Not Required	608.51	626.50	6470	12/18/2013	0.13	17.86	578.94	626.00
207332.50	RR1	Not Required	608.53	626.50	6470	12/18/2013	0.13	17.84	578.94	626.00
207340.50	RR1 U/S*	Not Required	608.54	626.50	6470	12/18/2013	0.13	17.83	578.94	626.00
207451.68		Not Required	608.55	609.89	101120	4/9/2008	0.13	1.21	579.17	601.63
207638.74		Not Required	608.56	609.13	101122	4/9/2008	0.13	0.44	579.55	600.98
207895.98		Not Required	608.57	608.77	101124	4/9/2008	0.13	0.07	580.07	600.58
208003.05		Not Required	608.58	608.74	101125	4/9/2008	0.13	0.03	580.29	600.78
208325.50		Not Required	608.60	609.69	120029	10/22/2012	0.13	0.96	580.95	603.52
208327.80	XS 9	Not Required	608.60	609.68	----	Interpolated	0.13	0.95	580.95	603.54
208402.18		Not Required	608.60	609.26	101128	4/9/2008	0.13	0.53	581.04	604.17
208573.54		Not Required	608.59	609.32	101130	4/9/2008	0.13	0.59	581.26	604.84
208777.10		Not Required	608.59	609.29	101131	4/9/2008	0.13	0.57	581.51	604.08
208777.10		Not Required	608.59	612.36	948	12/18/2013	0.13	3.64	581.51	604.08
208777.10	Wealthy St D/S	Not Required	608.59	613.00	7047	12/18/2013	0.13	4.28	581.51	609.00
208814.80	Wealthy St	Not Required	608.61	611.65	----	Interpolated	0.13	2.91	581.28	609.00
208859.80	Wealthy St U/S	Not Required	608.64	610.04	7023	12/18/2013	0.13	1.27	581.01	609.00
208859.80		Not Required	608.64	610.45	7058	12/18/2013	0.13	1.68	581.01	609.91
209055.59		Not Required	608.80	610.24	7057	12/18/2013	0.13	1.32	580.66	609.31
209072.55		Not Required	608.81	609.32	7066	12/18/2013	0.13	0.38	580.63	609.24
209097.56		Not Required	608.83	610.02	50036	8/23/2017	0.13	1.06	580.59	607.80
209098.54		Not Required	608.83	609.10	6289	12/18/2013	0.13	0.14	580.59	607.80
209175.50	XS 10	YES - Contract No. 2 (2016)	608.89	609.53	----	Interpolated	0.13	0.51	580.45	607.29
209263.37		YES - Contract No. 2 (2016)	608.97	610.02	50037	8/23/2017	0.13	0.92	580.84	606.71
209334.50		YES - Contract No. 2 (2016)	609.04	610.00	50038	8/23/2017	0.13	0.83	581.16	607.26
209402.44		YES - Contract No. 2 (2016)	609.10	609.43	956	12/18/2013	0.13	0.20	581.46	608.44
209402.47		YES - Contract No. 2 (2016)	609.10	609.61	6360	12/18/2013	0.13	0.38	581.46	608.44
209410.05		YES - Contract No. 2 (2016)	609.11	609.99	50039	8/23/2017	0.13	0.75	581.50	608.44
209422.20	XS 11	YES - Contract No. 2 (2016)	609.12	609.76	----	Interpolated	0.13	0.51	581.55	608.90
209432.79		YES - Contract No. 2 (2016)	609.12	609.56	6362	12/18/2013	0.13	0.30	581.46	609.30
209465.44		YES - Contract No. 2 (2016)	609.14	609.97	50042	8/23/2017	0.13	0.70	581.19	609.30

Table 4 – Flood Protection Crest Profile: Reach E4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

No Improvements Needed - Areas resurveyed since LAMP

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
209499.52		YES - Contract No. 2 (2016)	609.15	610.00	50040	8/23/2017	0.13	0.72	580.90	609.30
209501.04		YES - Contract No. 2 (2016)	609.15	609.95	50041	8/23/2017	0.13	0.67	580.89	609.95
209560.47		YES - Contract No. 2 (2016)	609.18	610.13	50045	8/23/2017	0.13	0.82	580.39	610.13
209656.60	RR2 D/S	No - Area Resurveyed (2017)	609.22	609.80	30205	8/23/2017	0.13	0.45	579.59	609.20
209683.80	RR2	No - Area Resurveyed (2017)	609.33	609.80	30203	8/23/2017	0.13	0.34	577.37	609.05
209711.40	RR2 U/S	No - Area Resurveyed (2017)	609.44	609.82	30202	8/23/2017	0.13	0.25	575.11	608.89
209740.14		YES - Contract No. 2 (2016)	609.44	610.10	50047	8/23/2017	0.13	0.53	575.52	608.73
209807.64		YES - Contract No. 2 (2016)	609.44	610.10	50048	8/23/2017	0.13	0.53	576.50	608.35
209883.44		YES - Contract No. 2 (2016)	609.45	610.10	50050	8/23/2017	0.13	0.53	577.59	607.92
209925.17		YES - Contract No. 2 (2016)	609.45	610.25	7341	1/10/2014	0.13	0.67	578.19	607.69
209949.96		YES - Contract No. 2 (2016)	609.45	610.41	101141	1/10/2014	0.13	0.83	578.55	607.55
209996.90	XS 12A	YES - Contract No. 2 (2016)	609.45	610.31	----	Interpolated	0.13	0.73	579.23	608.09
210087.50		YES - Contract No. 2 (2016)	609.47	610.12	101139	1/10/2014	0.13	0.52	579.42	609.13
210163.18		YES - Contract No. 2 (2016)	609.48	610.62	7342	1/10/2014	0.13	1.01	579.59	609.05
210173.56		YES - Contract No. 2 (2016)	609.48	610.56	7345	1/10/2014	0.13	0.94	579.61	609.04
210212.19		YES - Contract No. 2 (2016)	609.49	610.67	7346	1/10/2014	0.13	1.05	579.69	609.00
210232.39		YES - Contract No. 2 (2016)	609.49	610.62	7349	1/10/2014	0.13	0.99	579.73	608.98
210288.58		YES - Contract No. 2 (2016)	609.50	610.14	50054	8/23/2017	0.13	0.50	579.85	608.92
210291.91		YES - Contract No. 2 (2016)	609.50	610.66	7350	1/10/2014	0.13	1.02	579.86	608.92
210334.59		YES - Contract No. 2 (2016)	609.51	610.01	7326	1/10/2014	0.13	0.37	579.95	609.41
210337.77		YES - Contract No. 2 (2016)	609.51	610.11	50052	8/23/2017	0.13	0.47	579.96	609.41
210402.29		Not Required	609.52	609.90	932	12/18/2013	0.13	0.25	580.10	609.83
210471.15		Not Required	609.53	609.97	7316	1/10/2014	0.13	0.31	580.24	609.79
210526.22		Not Required	609.54	609.97	7313	1/10/2014	0.13	0.30	580.36	609.61
210527.93		Not Required	609.54	609.72	7311	1/10/2014	0.13	0.04	580.36	609.61
210573.96		Not Required	609.55	609.68	20041	10/22/2012	0.13	0.00	580.46	609.51
210586.33		Not Required	609.55	609.74	7300	1/10/2014	0.13	0.05	580.49	609.74
210664.22		Not Required	609.57	610.06	7298	1/10/2014	0.13	0.36	580.65	610.06
210676.00	XS 12B	Not Required	609.57	610.05	----	Interpolated	0.13	0.35	580.68	610.06
210728.58		Not Required	609.57	610.04	7287	1/10/2014	0.13	0.34	580.65	610.04
210779.27		Not Required	609.57	610.12	7284	1/10/2014	0.13	0.42	580.61	610.12
210835.49		Not Required	609.57	610.12	7285	1/10/2014	0.13	0.42	580.57	610.12
210850.32		Not Required	609.57	609.76	35079	11/30/2014	0.13	0.06	580.57	609.76
210869.21		Not Required	609.57	609.91	7246	1/10/2014	0.13	0.21	580.55	609.57
210902.15		Not Required	609.57	609.93	135080	11/30/2012	0.13	0.23	580.53	609.67
210914.16		Not Required	609.57	610.04	135081	11/30/2012	0.13	0.34	580.52	609.53
210918.90	XS 13	Not Required	609.57	610.04	----	Interpolated	0.13	0.34	580.52	609.68
210930.73		Not Required	609.57	610.05	7268	1/10/2014	0.13	0.35	580.50	610.04
210934.48		Not Required	609.57	610.10	7269	1/10/2014	0.13	0.40	580.49	610.10
211011.23		Not Required	609.56	610.47	7276	1/10/2014	0.13	0.78	580.33	610.47

Table 4 – Flood Protection Crest Profile: Reach E4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

No Improvements Needed - Areas resurveyed since LAMP

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	East Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
211057.77		Not Required	609.56	610.13	7275	1/10/2014	0.13	0.44	580.23	610.13
211084.84		Not Required	609.56	610.19	7262	1/10/2014	0.13	0.50	580.17	610.03

Notes:

1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 5 – Flood Protection Crest Profile: Reach E5 - Water Resource Recovery Facility
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

WWTP Levee Station	HEC-RAS Model River Station	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	Reach Taper Adjustment	100-Year Water Surface Elevation, with Taper (feet, NAVD88)	100-Year Water Surface Elevation, with Taper, plus 3 feet (feet, NAVD88)	Top of Levee Elevation	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
Water Resource Recovery Facility - East Face													
0.00	203640.11	YES - (2015)	607.45	0.50	607.95	610.95	611.33	30027	8/28/2017	0.16	0.22	NA	600.00
49.45	203646.38	YES - (2015)	607.45	0.50	607.95	610.95	611.30	30032	8/28/2017	0.16	0.19	NA	599.00
98.96	203641.37	YES - (2015)	607.45	0.50	607.95	610.95	611.40	30038	8/28/2017	0.16	0.29	NA	599.00
146.29	203638.65	YES - (2015)	607.45	0.50	607.95	610.95	611.38	30045	8/28/2017	0.16	0.27	NA	599.00
195.66	203635.50	YES - (2015)	607.45	0.50	607.95	610.95	611.39	30050	8/28/2017	0.16	0.28	NA	599.00
244.98	203630.70	YES - (2015)	607.45	0.50	607.95	610.95	611.43	30055	8/28/2017	0.16	0.32	NA	599.00
294.26	203622.60	YES - (2015)	607.45	0.50	607.95	610.95	611.36	30060	8/28/2017	0.16	0.25	NA	599.00
344.85	203612.12	YES - (2015)	607.45	0.50	607.95	610.95	611.39	30065	8/28/2017	0.16	0.28	NA	599.00
394.58	203605.31	YES - (2015)	607.45	0.50	607.95	610.95	611.43	30070	8/28/2017	0.16	0.32	NA	599.00
445.88	203589.05	YES - (2015)	607.45	0.50	607.95	610.95	611.36	30083	8/28/2017	0.16	0.25	NA	589.00
495.39	203573.61	YES - (2015)	607.44	0.50	607.94	610.94	611.35	30090	8/28/2017	0.16	0.25	NA	589.00
544.92	203554.29	YES - (2015)	607.44	0.50	607.94	610.94	611.40	30095	8/28/2017	0.16	0.30	NA	589.00
595.38	203533.69	YES - (2015)	607.44	0.50	607.94	610.94	611.41	30100	8/28/2017	0.16	0.31	NA	589.00
645.04	203510.08	YES - (2015)	607.44	0.50	607.94	610.94	611.34	30106	8/28/2017	0.16	0.24	NA	589.00
694.43	203492.06	YES - (2015)	607.43	0.50	607.93	610.93	611.35	30110	8/28/2017	0.16	0.26	NA	589.00
744.58	203473.40	YES - (2015)	607.43	0.50	607.93	610.93	611.34	30114	8/28/2017	0.16	0.25	NA	589.00
794.16	203446.76	YES - (2015)	607.43	0.50	607.93	610.93	611.44	30120	8/28/2017	0.16	0.35	NA	589.00
806.30	203443.73	YES - (2015)	607.43	0.50	607.93	610.93	611.29	30129	8/28/2017	0.16	0.20	NA	597.00
855.83	203418.14	YES - (2015)	607.42	0.50	607.92	610.92	611.40	30155	8/28/2017	0.16	0.32	NA	597.00
894.03	203399.32	YES - (2015)	607.42	0.50	607.92	610.92	611.40	30158	8/28/2017	0.16	0.32	NA	597.00
935.64	203378.72	YES - (2015)	607.42	0.50	607.92	610.92	611.41	30167	8/28/2017	0.16	0.33	NA	597.00
939.31	203379.93	YES - (2015)	607.42	0.50	607.92	610.92	611.32	30201	8/28/2017	0.16	0.24	NA	597.00
943.57	203379.29	YES - (2015)	607.42	0.50	607.92	610.92	611.32	30162	8/28/2017	0.16	0.24	NA	597.00
993.13	203349.98	YES - (2015)	607.41	0.45	607.86	610.86	611.44	30208	8/28/2017	0.16	0.42	NA	597.00
1043.26	203328.18	YES - (2015)	607.40	0.45	607.85	610.85	611.31	30213	8/28/2017	0.16	0.30	NA	597.00
1049.45	203324.23	YES - (2015)	607.40	0.45	607.85	610.85	611.26	30227	8/28/2017	0.16	0.25	NA	597.00
1092.86	203315.11	YES - (2015)	607.40	0.45	607.85	610.85	611.36	30218	8/28/2017	0.16	0.35	NA	597.00
1142.28	203279.73	YES - (2015)	607.39	0.45	607.84	610.84	611.45	30232	8/28/2017	0.16	0.45	NA	597.00
1192.53	203256.24	YES - (2015)	607.39	0.45	607.84	610.84	611.35	30238	8/28/2017	0.16	0.35	NA	597.00
1242.81	203300.63	YES - (2015)	607.40	0.45	607.85	610.85	611.38	30243	8/28/2017	0.16	0.37	NA	597.00
1292.24	203281.44	YES - (2015)	607.39	0.45	607.84	610.84	611.40	30353	8/28/2017	0.16	0.40	NA	597.00
1341.64	203260.20	YES - (2015)	607.39	0.45	607.84	610.84	611.38	30260	8/28/2017	0.16	0.38	NA	597.00
1391.96	203245.00	YES - (2015)	607.38	0.45	607.83	610.83	611.33	30266	8/28/2017	0.16	0.34	NA	597.00
1440.80	203228.08	YES - (2015)	607.38	0.45	607.83	610.83	611.35	30273	8/28/2017	0.16	0.36	NA	597.00
1490.31	203209.11	YES - (2015)	607.38	0.45	607.83	610.83	611.34	30283	8/28/2017	0.16	0.35	NA	597.00
1539.39	203191.91	YES - (2015)	607.37	0.45	607.82	610.82	611.34	30291	8/28/2017	0.16	0.36	NA	597.00
1558.20	203182.93	YES - (2015)	607.37	0.45	607.82	610.82	611.37	30299	8/28/2017	0.16	0.39	NA	597.00
1619.55	203167.03	YES - (2015)	607.37	0.45	607.82	610.82	611.36	30308	8/28/2017	0.16	0.38	NA	597.00

Table 5 – Flood Protection Crest Profile: Reach E5 - Water Resource Recovery Facility
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

WWTP Levee Station	HEC-RAS Model River Station	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	Reach Taper Adjustment	100-Year Water Surface Elevation, with Taper (feet, NAVD88)	100-Year Water Surface Elevation, with Taper, plus 3 feet (feet, NAVD88)	Top of Levee Elevation	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
Water Resource Recovery Facility - South Face													
1635.09	203151.50	YES - (2015)	607.36	0.45	607.81	610.81	611.36	30317	8/28/2017	0.16	0.39	NA	597.00
1682.76	203104.89	YES - (2015)	607.35	0.40	607.75	610.75	611.38	30329	8/28/2017	0.16	0.47	NA	597.00
1732.74	203055.26	YES - (2015)	607.34	0.40	607.74	610.74	611.39	30336	8/28/2017	0.16	0.49	NA	597.00
1782.98	203006.28	YES - (2015)	607.33	0.40	607.73	610.73	611.38	30346	8/28/2017	0.16	0.49	NA	597.00
1832.44	202956.76	YES - (2015)	607.32	0.40	607.72	610.72	611.37	30352	8/28/2017	0.16	0.49	NA	597.00
1882.09	202908.70	YES - (2015)	607.31	0.40	607.71	610.71	611.35	30361	8/28/2017	0.16	0.48	NA	597.00
1931.21	202861.02	YES - (2015)	607.30	0.40	607.70	610.70	611.35	30370	8/28/2017	0.16	0.49	NA	597.00
1981.09	202811.41	YES - (2015)	607.29	0.35	607.64	610.64	611.37	30377	8/28/2017	0.16	0.57	NA	597.00
2030.70	202763.90	YES - (2015)	607.28	0.35	607.63	610.63	611.36	30387	8/28/2017	0.16	0.57	NA	598.00
2080.64	202713.97	YES - (2015)	607.27	0.35	607.62	610.62	611.40	30393	8/28/2017	0.16	0.62	NA	599.00
2100.65	202695.18	YES - (2015)	607.26	0.325	607.59	610.59	611.39	30401	8/28/2017	0.16	0.64	NA	599.00
2130.19	202665.54	YES - (2015)	607.26	0.325	607.58	610.58	611.27	30407	8/28/2017	0.16	0.53	NA	599.00
2152.53	202645.88	YES - (2015)	607.25	0.325	607.58	610.58	611.15	35173	12/30/2015	0.16	0.41	NA	599.00
2183.83	202629.62	YES - (2015)	607.25	0.325	607.58	610.58	611.22	35176	12/30/2015	0.16	0.48	NA	599.00
2215.35	202603.34	YES - (2015)	607.24	0.325	607.57	610.57	610.75	35180	12/30/2015	0.16	0.02	NA	599.00
2267.14	202580.02	YES - (2015)	607.24	0.325	607.57	610.57	610.79	35182	12/30/2015	0.16	0.06	NA	599.00
2319.27	202545.74	YES - (2015)	607.23	0.30	607.53	610.53	610.84	35185	12/30/2015	0.16	0.15	NA	599.00
2360.53	202523.39	YES - (2015)	607.23	0.30	607.53	610.53	610.99	35186	12/30/2015	0.16	0.30	NA	599.00
2382.02	202512.74	YES - (2015)	607.23	0.30	607.53	610.53	610.70	35188	12/30/2015	0.16	0.01	NA	599.00
2392.71	202523.25	YES - (2015)	607.23	0.30	607.53	610.53	610.88	35191	12/30/2015	0.16	0.19	NA	599.00
2433.39	202526.03	YES - (2015)	607.23	0.30	607.53	610.53	610.90	35191	12/30/2015	0.16	0.21	NA	599.00
2485.64	202530.46	YES - (2015)	607.23	0.30	607.53	610.53	610.75	35193	12/30/2015	0.16	0.06	NA	598.00
2537.70	202540.02	YES - (2015)	607.23	0.30	607.53	610.53	610.92	35194	12/30/2015	0.16	0.23	NA	598.00
2589.90	202549.82	YES - (2015)	607.23	0.30	607.53	610.53	610.97	35197	12/30/2015	0.16	0.28	NA	598.00
2606.23	202558.94	YES - (2015)	607.24	0.30	607.54	610.54	611.07	35199	12/30/2015	0.16	0.37	NA	600.00
2623.45	202559.29	YES - (2015)	607.24	0.30	607.54	610.54	610.84	35200	12/30/2015	0.16	0.14	NA	599.00
2672.42	202515.77	YES - (2015)	607.23	0.30	607.53	610.53	611.25	35232	12/30/2015	0.16	0.56	NA	599.00
2721.22	202468.04	YES - (2015)	607.22	0.30	607.52	610.52	611.08	35233	12/30/2015	0.16	0.40	NA	600.00
2757.38	202432.62	YES - (2015)	607.21	0.30	607.51	610.51	611.06	35240	12/30/2015	0.16	0.39	NA	601.00
2806.66	202384.39	YES - (2015)	607.20	0.30	607.50	610.50	611.09	35241	12/30/2015	0.16	0.43	NA	603.00
2856.87	202335.28	YES - (2015)	607.19	0.30	607.49	610.49	611.12	35244	12/30/2015	0.16	0.47	NA	603.00
2906.67	202286.56	YES - (2015)	607.18	0.25	607.43	610.43	611.18	35245	12/30/2015	0.16	0.59	NA	603.00
2956.53	202237.77	YES - (2015)	607.18	0.25	607.43	610.43	611.16	35248	12/30/2015	0.16	0.57	NA	603.00
3005.96	202189.43	YES - (2015)	607.17	0.25	607.42	610.42	611.21	35249	12/30/2015	0.16	0.63	NA	603.00
3056.95	202139.54	YES - (2015)	607.16	0.25	607.41	610.41	611.16	35252	12/30/2015	0.16	0.59	NA	602.00
3098.47	202097.90	YES - (2015)	607.15	0.25	607.40	610.40	611.18	35253	12/30/2015	0.16	0.62	NA	602.00
3107.92	202089.68	YES - (2015)	607.15	0.25	607.40	610.40	611.18	35254	12/30/2015	0.16	0.62	NA	602.00
3159.14	202039.56	YES - (2015)	607.15	0.20	607.35	610.35	611.17	35256	12/30/2015	0.16	0.66	NA	601.00
3209.42	201990.37	YES - (2015)	607.15	0.20	607.35	610.35	611.20	35257	12/30/2015	0.16	0.69	NA	600.00
3259.37	201941.50	YES - (2015)	607.15	0.20	607.35	610.35	611.19	35260	12/30/2015	0.16	0.68	NA	600.00
3307.39	201894.50	YES - (2015)	607.15	0.20	607.35	610.35	611.22	35261	12/30/2015	0.16	0.71	NA	600.00
3355.86	201847.10	YES - (2015)	607.15	0.20	607.35	610.35	611.16	35264	12/30/2015	0.16	0.65	NA	599.00
3407.28	201796.80	YES - (2015)	607.15	0.20	607.35	610.35	611.19	35265	12/30/2015	0.16	0.68	NA	599.00

Table 5 – Flood Protection Crest Profile: Reach E5 - Water Resource Recovery Facility
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

WWTP Levee Station	HEC-RAS Model River Station	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	Reach Taper Adjustment	100-Year Water Surface Elevation, with Taper (feet, NAVD88)	100-Year Water Surface Elevation, with Taper, plus 3 feet (feet, NAVD88)	Top of Levee Elevation	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
3456.25	201748.88	YES - (2015)	607.15	0.15	607.30	610.30	611.18	35268	12/30/2015	0.16	0.72	NA	598.00
3505.20	201700.98	YES - (2015)	607.15	0.15	607.30	610.30	611.14	35269	12/30/2015	0.16	0.68	NA	598.00
3555.76	201651.52	YES - (2015)	607.14	0.15	607.29	610.29	611.17	35272	12/30/2015	0.16	0.72	NA	598.00
3605.83	201602.56	YES - (2015)	607.14	0.15	607.29	610.29	611.14	35273	12/30/2015	0.16	0.69	NA	599.00
3656.12	201553.39	YES - (2015)	607.13	0.15	607.28	610.28	611.13	35276	12/30/2015	0.16	0.69	NA	600.00
3706.35	201504.26	YES - (2015)	607.13	0.10	607.23	610.23	611.13	35280	12/30/2015	0.16	0.74	NA	602.00
3738.63	201472.70	YES - (2015)	607.13	0.10	607.23	610.23	611.13	35281	12/30/2015	0.16	0.74	NA	604.00
3739.82	201471.49	YES - (2015)	607.13	0.10	607.23	610.23	610.80	35283	12/30/2015	0.16	0.41	NA	604.00
3754.94	201457.34	YES - (2015)	607.13	0.10	607.23	610.23	610.80	35285	12/30/2015	0.16	0.41	NA	605.00
3803.89	201411.36	YES - (2015)	607.12	0.10	607.22	610.22	610.84	35288	12/30/2015	0.16	0.46	NA	606.00
3851.22	201364.96	YES - (2015)	607.12	0.10	607.22	610.22	610.80	20059	1/4/2016	0.16	0.42	NA	605.00
3908.60	201309.22	YES - (2015)	607.11	0.10	607.21	610.21	610.77	20056	1/4/2016	0.16	0.40	NA	605.00
3977.30	201242.01	YES - (2015)	607.11	0.05	607.16	610.16	610.86	20053	1/4/2016	0.16	0.54	NA	604.00
4029.30	201191.07	YES - (2015)	607.10	0.05	607.15	610.15	610.90	20050	1/4/2016	0.16	0.59	NA	604.00
4077.87	201143.82	YES - (2015)	607.10	0.05	607.15	610.15	610.83	20047	1/4/2016	0.16	0.52	NA	604.00
4133.14	201089.78	YES - (2015)	607.10	0.05	607.15	610.15	610.99	20044	1/4/2016	0.16	0.68	NA	604.00
4187.16	201036.73	YES - (2015)	607.09	0.05	607.14	610.14	611.26	20041	1/4/2016	0.16	0.96	NA	604.00
4241.60	200984.05	YES - (2015)	607.08	0.05	607.13	610.13	611.13	20039	1/4/2016	0.16	0.84	NA	605.00
4310.79	200965.37	YES - (2015)	607.07	0.05	607.12	610.12	610.69	20037	1/4/2016	0.16	0.41	NA	605.00
4350.08	200973.42	YES - (2015)	607.08	0.05	607.13	610.13	610.71	20036	1/4/2016	0.16	0.42	NA	605.00
4425.06	200991.37	YES - (2015)	607.08	0.05	607.13	610.13	611.20	20035	1/4/2016	0.16	0.91	NA	605.00

Table 5 – Flood Protection Crest Profile: Reach E5 - Water Resource Recovery Facility
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

WWTP Levee Station	HEC-RAS Model River Station	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	Reach Taper Adjustment	100-Year Water Surface Elevation, with Taper (feet, NAVD88)	100-Year Water Surface Elevation, with Taper, plus 3 feet (feet, NAVD88)	Top of Levee Elevation	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
Water Resource Recovery Facility - West Face													
4480.45	201026.59	Not Required	607.09	0.05	607.14	610.14	614.03	8608	1/4/2016	0.16	3.73	NA	605.00
4498.51	201045.62	Not Required	607.09	0.05	607.14	610.14	620.30	8603	1/4/2016	0.16	10.00	NA	605.00
4513.55	201056.40	Not Required	607.09	0.05	607.14	610.14	625.24	5827	1/4/2016	0.16	14.94	NA	605.00
4531.41	201071.42	Not Required	607.09	0.05	607.14	610.14	628.71	5826	1/4/2016	0.16	18.41	NA	605.00
4579.39	201116.61	Not Required	607.10	0.05	607.15	610.15	628.81	5825	1/4/2016	0.16	18.50	NA	605.00
4616.13	201151.39	Not Required	607.10	0.05	607.15	610.15	628.66	5657	1/4/2016	0.16	18.35	NA	605.00
4670.90	201203.66	Not Required	607.11	0.05	607.16	610.16	627.48	5656	1/4/2016	0.16	17.16	NA	605.00
4720.09	201250.25	Not Required	607.11	0.05	607.16	610.16	628.33	5654	1/4/2016	0.16	18.01	NA	605.00
4770.15	201297.91	Not Required	607.11	0.10	607.21	610.21	628.16	5651	1/4/2016	0.16	17.79	NA	605.00
4806.12	201324.58	Not Required	607.12	0.10	607.22	610.22	627.75	5650	1/4/2016	0.16	17.37	NA	605.00
4848.44	201349.48	Not Required	607.12	0.10	607.22	610.22	627.74	5647	1/4/2016	0.16	17.36	NA	605.00
4875.72	201357.98	Not Required	607.12	0.10	607.22	610.22	628.05	5646	1/4/2016	0.16	17.67	NA	605.00
4913.52	201368.66	Not Required	607.12	0.10	607.22	610.22	627.69	5643	1/4/2016	0.16	17.31	NA	605.00
4940.59	201371.93	YES - (2015)	607.12	0.10	607.22	610.22	621.44	5641	1/4/2016	0.16	11.06	NA	605.00
4963.01	201394.10	YES - (2015)	607.12	0.10	607.22	610.22	611.34	20031	1/4/2016	0.16	0.96	NA	605.00
4982.61	201412.84	YES - (2015)	607.12	0.10	607.22	610.22	610.69	20030	1/4/2016	0.16	0.31	NA	605.00
5012.43	201439.25	YES - (2015)	607.12	0.10	607.22	610.22	610.81	20029	1/4/2016	0.16	0.43	NA	607.00
5052.41	201443.97	YES - (2015)	607.13	0.10	607.23	610.23	610.77	20027	1/4/2016	0.16	0.38	NA	607.00
5104.88	201453.01	YES - (2015)	607.13	0.10	607.23	610.23	610.64	20026	1/4/2016	0.16	0.25	NA	598.00
5158.74	201473.83	YES - (2015)	607.13	0.10	607.23	610.23	610.65	20024	1/4/2016	0.16	0.26	NA	598.00
5212.53	201490.74	YES - (2015)	607.13	0.10	607.23	610.23	610.70	20022	1/4/2016	0.16	0.31	NA	598.00
5260.12	201511.96	YES - (2015)	607.13	0.10	607.23	610.23	610.74	20019	1/4/2016	0.16	0.35	NA	598.00
5307.33	201529.55	YES - (2015)	607.13	0.15	607.28	610.28	610.78	20015	1/4/2016	0.16	0.34	NA	598.00
5359.22	201539.82	YES - (2015)	607.13	0.15	607.28	610.28	610.91	20014	1/4/2016	0.16	0.47	NA	598.00
5415.86	201543.64	YES - (2015)	607.13	0.15	607.28	610.28	611.04	20010	1/4/2016	0.16	0.60	NA	598.00
5466.94	201553.52	YES - (2015)	607.13	0.15	607.28	610.28	611.15	20007	1/4/2016	0.16	0.71	NA	598.00
5520.22	201575.02	YES - (2015)	607.14	0.15	607.29	610.29	610.77	20004	1/4/2016	0.16	0.32	NA	598.00
5574.48	201608.67	YES - (2015)	607.14	0.15	607.29	610.29	610.90	20001	1/4/2016	0.16	0.45	NA	597.00

Table 5 – Flood Protection Crest Profile: Reach E5 - Water Resource Recovery Facility
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

WWTP Levee Station	HEC-RAS Model River Station	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	Reach Taper Adjustment	100-Year Water Surface Elevation, with Taper (feet, NAVD88)	100-Year Water Surface Elevation, with Taper, plus 3 feet (feet, NAVD88)	Top of Levee Elevation	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
Water Resource Recovery Facility - North Face along Grand River													
5605.01	201636.26	YES - (2015)	607.14	0.15	607.29	610.29	610.78	621	12/30/2015	0.16	0.33	NA	597.00
5661.69	201692.96	YES - (2015)	607.15	0.15	607.30	610.30	610.77	620	12/30/2015	0.16	0.31	NA	597.00
5723.71	201754.98	YES - (2015)	607.15	0.15	607.30	610.30	610.78	619	12/30/2015	0.16	0.32	NA	597.00
5744.32	201775.59	YES - (2015)	607.15	0.15	607.30	610.30	610.92	622	12/30/2015	0.16	0.46	NA	597.00
5783.19	201814.55	YES - (2015)	607.15	0.20	607.35	610.35	611.08	35091	12/30/2015	0.16	0.57	NA	597.00
5791.59	201823.01	YES - (2015)	607.15	0.20	607.35	610.35	611.04	618	12/30/2015	0.16	0.53	NA	597.00
5842.82	201874.25	YES - (2015)	607.15	0.20	607.35	610.35	611.09	623	12/30/2015	0.16	0.58	NA	597.00
5861.80	201893.21	YES - (2015)	607.15	0.20	607.35	610.35	611.08	617	12/30/2015	0.16	0.57	NA	597.00
5888.80	201920.22	YES - (2015)	607.15	0.20	607.35	610.35	610.82	624	12/30/2015	0.16	0.31	NA	597.00
5928.90	201960.29	YES - (2015)	607.15	0.20	607.35	610.35	610.73	616	12/30/2015	0.16	0.22	NA	597.00
5957.39	201988.81	YES - (2015)	607.15	0.20	607.35	610.35	610.70	625	12/30/2015	0.16	0.19	NA	597.00
6003.74	202035.08	YES - (2015)	607.15	0.20	607.35	610.35	610.77	615	12/30/2015	0.16	0.26	NA	601.00
6020.29	202051.66	YES - (2015)	607.15	0.25	607.40	610.40	610.73	626	12/30/2015	0.16	0.17	NA	601.00
6066.78	202097.90	YES - (2015)	607.15	0.25	607.40	610.40	610.71	612	12/30/2015	0.16	0.15	NA	601.00
6079.23	202110.46	YES - (2015)	607.15	0.25	607.40	610.40	610.71	614	12/30/2015	0.16	0.15	NA	601.00
6094.86	202126.19	YES - (2015)	607.16	0.25	607.41	610.41	610.76	627	12/30/2015	0.16	0.19	NA	601.00
6153.95	202185.24	YES - (2015)	607.17	0.25	607.42	610.42	610.72	613	12/30/2015	0.16	0.14	NA	601.00
6171.49	202202.81	YES - (2015)	607.17	0.25	607.42	610.42	610.87	628	12/30/2015	0.16	0.29	NA	601.00
6210.20	202241.47	YES - (2015)	607.18	0.25	607.43	610.43	610.91	629	12/30/2015	0.16	0.32	NA	601.00
6272.09	202303.29	YES - (2015)	607.19	0.25	607.44	610.44	610.83	630	12/30/2015	0.16	0.23	NA	601.00
6295.02	202326.13	YES - (2015)	607.19	0.30	607.49	610.49	611.06	611	12/30/2015	0.16	0.41	NA	609.00
6337.32	202368.46	YES - (2015)	607.20	0.30	607.50	610.50	610.85	631	12/30/2015	0.16	0.19	NA	609.00
6361.86	202392.77	YES - (2015)	607.20	0.30	607.50	610.50	610.98	610	12/30/2015	0.16	0.32	NA	609.00
6412.00	202442.87	YES - (2015)	607.21	0.30	607.51	610.51	610.97	609	12/30/2015	0.16	0.30	NA	609.00
6425.50	202456.56	YES - (2015)	607.21	0.30	607.51	610.51	610.97	633	12/30/2015	0.16	0.30	NA	609.00
6456.91	202488.00	YES - (2015)	607.22	0.30	607.52	610.52	610.76	608	12/30/2015	0.16	0.08	NA	609.00
6486.75	202517.78	YES - (2015)	607.23	0.30	607.53	610.53	610.87	634	12/30/2015	0.16	0.18	NA	609.00
6522.73	202553.75	YES - (2015)	607.23	0.30	607.53	610.53	611.03	607	12/30/2015	0.16	0.34	NA	609.00
6549.32	202580.33	YES - (2015)	607.24	0.325	607.57	610.57	611.12	635	12/30/2015	0.16	0.39	NA	609.00
6594.51	202625.60	YES - (2015)	607.25	0.325	607.57	610.57	611.09	606	12/30/2015	0.16	0.36	NA	609.00
6618.83	202649.91	YES - (2015)	607.25	0.325	607.58	610.58	611.01	636	12/30/2015	0.16	0.27	NA	609.00
6658.52	202689.55	YES - (2015)	607.26	0.325	607.59	610.59	611.08	605	12/30/2015	0.16	0.33	NA	609.00
6700.78	202731.23	YES - (2015)	607.27	0.35	607.62	610.62	610.83	604	12/30/2015	0.16	0.05	NA	609.00
6732.66	202763.24	YES - (2015)	607.28	0.35	607.63	610.63	610.89	637	12/30/2015	0.16	0.10	NA	609.00
6755.03	202785.47	YES - (2015)	607.28	0.35	607.63	610.63	610.95	603	12/30/2015	0.16	0.16	NA	609.00
6786.90	202817.80	YES - (2015)	607.29	0.35	607.64	610.64	610.98	602	12/30/2015	0.16	0.18	NA	609.00
6831.09	202862.09	YES - (2015)	607.30	0.40	607.70	610.70	610.88	600	12/30/2015	0.16	0.02	NA	609.00
6869.71	202900.69	YES - (2015)	607.31	0.40	607.71	610.71	610.91	638	12/30/2015	0.16	0.04	NA	600.00
6968.41	202999.33	YES - (2015)	607.33	0.40	607.73	610.73	610.98	639	12/30/2015	0.16	0.09	NA	600.00
7012.72	203043.66	YES - (2015)	607.34	0.40	607.74	610.74	610.93	640	12/30/2015	0.16	0.03	NA	600.00
7082.54	203113.56	YES - (2015)	607.35	0.45	607.80	610.80	611.09	641	12/30/2015	0.16	0.13	NA	600.00
7144.37	203175.38	YES - (2015)	607.37	0.45	607.82	610.82	611.24	642	12/30/2015	0.16	0.26	NA	600.00
7228.25	203259.23	YES - (2015)	607.39	0.45	607.84	610.84	611.08	643	12/30/2015	0.16	0.08	NA	600.00

Table 5 – Flood Protection Crest Profile: Reach E5 - Water Resource Recovery Facility
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

WWTP Levee Station	HEC-RAS Model River Station	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	Reach Taper Adjustment	100-Year Water Surface Elevation, with Taper (feet, NAVD88)	100-Year Water Surface Elevation, with Taper, plus 3 feet (feet, NAVD88)	Top of Levee Elevation	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leeward Elevation (feet NAVD88)
7294.58	203311.48	YES - (2015)	607.40	0.45	607.85	610.85	611.02	644	12/30/2015	0.16	0.01	NA	600.00
7330.72	203347.46	YES - (2015)	607.41	0.45	607.86	610.86	611.08	645	12/30/2015	0.16	0.06	NA	600.00
7609.67	203629.29	YES - (2015)	607.45	0.50	607.95	610.95	611.35	30010	8/28/2017	0.16	0.24	NA	600.00
7615.21	203629.83	YES - (2015)	607.45	0.50	607.95	610.95	611.27	30017	8/28/2017	0.16	0.16	NA	600.00
7638.76	203639.15	YES - (2015)	607.45	0.50	607.95	610.95	611.38	30021	8/28/2017	0.16	0.27	NA	600.00

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 6 – Flood Protection Crest Profile: Reach W1
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD 88)
Grand River										
222730.90	RR3 U/S	Not Required	616.04	627.65	----	Interpolated	0.00	11.61	594.40	627.65
222995.30	XS 32	Not Required	616.20	621.84	----	Interpolated	0.00	5.64	597.12	621.84
223097.61		Not Required	616.21	619.59	126046	10/23/2012	0.00	3.37	596.99	619.59
223237.43		Not Required	616.23	619.07	126045	10/23/2012	0.00	2.84	596.82	619.07
223275.70	XS 33	Not Required	616.24	621.76	----	Interpolated	0.00	5.52	596.77	621.76
223282.90		Not Required	616.24	622.27	126044	10/23/2012	0.00	6.03	596.78	622.27
223407.57		Not Required	616.26	622.19	126043	10/23/2012	0.00	5.93	596.95	622.19
223653.91		Not Required	616.30	621.71	126042	10/23/2012	0.00	5.41	597.28	621.71
223712.73		Not Required	616.31	628.52	126041	10/23/2012	0.00	12.21	597.36	624.26
223733.80	Ann St D/S	Not Required	616.31	628.52	125041	10/23/2012	0.00	12.21	597.39	624.26
223766.00	Ann St	Not Required	616.34	628.52	125041	10/23/2012	0.00	12.18	596.81	624.26
223798.20	Ann St U/S	Not Required	616.36	628.52	125041	10/23/2012	0.00	12.16	596.22	624.26
223798.20		Not Required	616.36	624.26	126039	10/23/2012	0.00	7.90	596.22	624.26
223915.76		Not Required	616.39	628.85	126040	10/23/2012	0.00	12.46	596.44	628.85
224424.10	XS 34	Not Required	616.50	626.36	----	Interpolated	0.00	9.86	597.40	626.07
225261.30	US City Bndry XS 35	Not Required	616.71	622.27	----	Interpolated	0.00	5.56	597.61	621.48
226153.60		YES - Contract No. 2 (2016)	616.92	617.91	200121	8/22/2017	0.00	0.99	597.28	616.60
226166.32		YES - Contract No. 2 (2016)	616.92	617.92	200120	8/22/2017	0.00	1.00	597.27	616.60
226494.49		YES - Contract No. 2 (2016)	617.00	617.94	200122	8/22/2017	0.00	0.94	597.15	617.39
226746.09		YES - Contract No. 2 (2016)	617.06	617.94	200123	8/22/2017	0.00	0.88	597.05	617.45
226928.92		YES - Contract No. 2 (2016)	617.10	617.92	200124	8/22/2017	0.00	0.82	596.99	616.00
226951.72		YES - Contract No. 2 (2016)	617.11	617.91	200125	8/22/2017	0.00	0.80	596.98	616.58
227116.43		YES - Contract No. 2 (2016)	617.15	617.83	200126	8/22/2017	0.00	0.68	596.92	617.65
227276.33		YES - Contract No. 2 (2016)	617.19	617.79	200127	8/22/2017	0.00	0.60	596.86	615.50
227488.64		YES - Contract No. 2 (2016)	617.24	617.56	200128	8/22/2017	0.00	0.33	596.78	617.30
227668.50	XS 36	YES - Contract No. 2 (2016)	617.28	617.58	200131	8/22/2017	0.00	0.30	596.71	616.96
227681.84		YES - Contract No. 2 (2016)	617.28	617.58	200131	8/22/2017	0.00	0.29	596.67	616.94
227804.85		YES - Contract No. 2 (2016)	617.30	617.56	200136	8/22/2017	0.00	0.26	596.33	617.56
228546.46		Not Required	617.41	618.62	135041	11/30/2012	0.00	1.21	594.28	618.62
228605.78		Not Required	617.42	619.31	135045	11/30/2012	0.00	1.89	594.12	619.31
228634.31		Not Required	617.43	620.65	135046	11/30/2012	0.00	3.22	594.04	620.65
228731.91		Not Required	617.44	621.66	135047	11/30/2012	0.00	4.22	593.77	621.66
228851.20	XS 37	Not Required	617.46	621.75	----	Interpolated	0.00	4.29	593.44	621.75
228859.92		Not Required	617.46	621.76	135048	11/30/2012	0.00	4.30	593.43	621.76
229052.35		Not Required	617.48	622.50	135049	11/30/2012	0.00	5.02	593.28	622.50
229240.54		Not Required	617.50	621.81	135050	11/30/2012	0.00	4.30	593.13	621.81
229456.56		Not Required	617.53	623.60	135051	11/30/2012	0.00	6.07	592.95	623.60
229646.60		Not Required	617.55	626.56	135052	11/30/2012	0.00	9.01	592.80	626.56
Indian Mill Creek										
155.05		Not Required	616.04	619.59	126046	10/23/2012	0.00	3.55	NA	619.59
274.91		Not Required	616.04	620.82	126047	10/23/2012	0.00	4.78	NA	620.82
409.05		Not Required	616.04	621.24	126048	10/23/2012	0.00	5.20	NA	621.24
511.76		Not Required	616.04	618.46	126049	10/23/2012	0.00	2.42	NA	618.46
847.91		Not Required	616.04	618.39	126035	10/23/2012	0.00	2.35	NA	616.46
1096.32		Not Required	616.04	617.59	126000	10/23/2012	0.00	1.55	NA	615.15

Table 6 – Flood Protection Crest Profile: Reach W1
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD 88)
1190.35		Not Required	616.04	617.53	104353	10/23/2012	0.00	1.49	NA	614.44
1406.59		Not Required	616.04	617.55	126003	10/23/2012	0.00	1.51	NA	614.29
1534.51		Not Required	616.04	617.68	126004	10/23/2012	0.00	1.64	NA	615.96
1684.93		Not Required	616.04	617.92	126005	10/23/2012	0.00	1.88	NA	617.92
1796.54		Not Required	616.04	617.55	126006	10/23/2012	0.00	1.51	NA	617.55
1942.20		Not Required	616.04	617.48	126007	10/23/2012	0.00	1.44	NA	617.48
2004.06		Not Required	616.04	616.55	126008	10/23/2012	0.00	0.51	NA	616.55
2074.91		Not Required	616.04	617.53	126009	10/23/2012	0.00	1.49	NA	617.53
2196.76		Not Required	616.04	620.98	6851	12/18/2013	0.00	4.94	NA	620.98
2239.98		Not Required	616.04	620.07	126010	10/23/2012	0.00	4.03	NA	620.07
2363.28		Not Required	616.04	619.94	26011	10/23/2012	0.00	3.90	NA	619.94
2555.22		Not Required	616.04	617.46	126015	10/23/2012	0.00	1.42	NA	617.46
2715.33		Not Required	616.04	618.08	126038	10/23/2012	0.00	2.04	NA	618.08
2919.10		Not Required	616.04	619.24	126037	10/23/2012	0.00	3.20	NA	619.24
3202.21		Not Required	616.04	621.01	126036	10/23/2012	0.00	4.97	NA	621.01

Notes:

1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 7 – Flood Protection Crest Profile: Reach W2

HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet)
Grand River										
215284.20	I-196 East	Not Required	612.72	617.21	----	Interpolated	0.00	4.49	591.93	617.21
215315.20	I-196 East U/S	Not Required	612.74	617.37	----	Interpolated	0.00	4.63	591.94	617.37
215330.50	I-196 West D/S	Not Required	612.74	617.44	----	Interpolated	0.00	4.70	589.23	617.44
215358.10	I-196 West	Not Required	612.76	617.59	----	Interpolated	0.00	4.83	589.23	617.59
215385.60	I-196 West U/S	Not Required	612.78	617.73	----	Interpolated	0.00	4.95	589.23	617.73
215603.92		Not Required	612.83	618.86	125006	10/22/2012	0.00	6.03	589.51	618.86
215642.20	XS 23	YES - Contract No. 2 (2016)	612.84	618.86	----	Interpolated	0.00	6.02	589.56	618.86
215707.06		YES - Contract No. 2 (2016)	612.85	618.86	125005	10/22/2012	0.00	6.01	589.89	618.86
215794.90		YES - Contract No. 2 (2016)	612.86	613.53	50077	8/23/2017	0.00	0.67	590.34	612.11
215836.74		YES - Contract No. 2 (2016)	612.87	613.53	50072	8/23/2017	0.00	0.66	590.55	612.11
215862.70	XS 24	YES - Contract No. 2 (2016)	612.87	613.50	----	Interpolated	0.00	0.63	590.68	611.60
215910.56		YES - Contract No. 2 (2016)	612.88	613.45	50067	8/23/2017	0.00	0.57	591.92	610.67
215921.52		YES - Contract No. 2 (2016)	612.88	614.00	50063	8/23/2017	0.00	1.12	592.20	610.67
215947.57		YES - Contract No. 2 (2016)	612.89	614.85	50057	8/23/2017	0.00	1.97	592.87	610.67
216012.66		Not Required	612.90	615.08	120113	10/22/2012	0.00	2.18	594.56	610.67
216020.20	Dam No. 5 D/S	Not Required	612.90	614.10	----	Closure Struct	0.00	1.20	594.75	610.66
216028.20	Dam No. 5	Not Required	613.41	615.09	----	Interpolated	0.00	1.67	595.23	610.66
216034.20	Dam No. 5 U/S	Not Required	613.81	615.09	----	Interpolated	0.00	1.28	595.59	610.65
216060.51		Not Required	613.82	615.10	120114	10/22/2012	0.00	1.27	595.59	610.65
216144.59		Not Required	613.86	614.84	125018	10/22/2012	0.00	0.98	595.59	610.63
216336.89		Not Required	613.94	615.96	101030	10/22/2012	0.00	2.02	595.59	610.60
216378.80	XS 25	Not Required	613.96	615.99	----	Interpolated	0.00	2.03	595.59	611.04
216522.39		Not Required	613.98	616.11	125019	10/22/2012	0.00	2.13	595.63	612.56
216832.00		Not Required	614.03	616.19	101027	10/22/2012	0.00	2.16	595.71	615.82
216832.00	Sixth St D/S	Not Required	614.03	616.19	----	Interpolated	0.00	2.16	595.71	615.82
216850.90	Sixth St	Not Required	614.05	616.23	----	Interpolated	0.00	2.18	595.50	615.25
216869.40	Sixth St U/S	Not Required	614.07	616.27	----	Interpolated	0.00	2.20	595.30	614.69
216939.10		Not Required	614.09	616.42	104374	10/22/2012	0.00	2.33	595.51	612.57
217038.47		Not Required	614.11	616.52	106000	10/22/2012	0.00	2.41	595.82	612.50
217239.82		Not Required	614.15	616.18	101025	10/22/2012	0.00	2.03	596.44	612.37
217596.47		Not Required	614.23	617.01	106001	10/22/2012	0.00	2.78	597.53	612.63
217611.50	XS 26	Not Required	614.23	616.98	----	Interpolated	0.00	2.75	597.58	612.65
217861.01		Not Required	614.32	616.60	101024	10/22/2012	0.00	2.28	596.45	612.83
218155.76		Not Required	614.43	616.93	106003	10/22/2012	0.00	2.50	595.12	612.38
218372.48		Not Required	614.51	616.55	106002	10/22/2012	0.00	2.03	594.14	612.04
218588.50	XS 27	Not Required	614.59	616.52	----	Interpolated	0.00	1.93	593.16	611.71
218751.66		Not Required	614.63	616.49	101021	10/22/2012	0.00	1.86	593.67	611.46
219163.97		Not Required	614.73	616.86	106004	10/22/2012	0.00	2.13	594.96	612.64
219354.20	XS 28	Not Required	614.77	616.88	----	Interpolated	0.00	2.11	595.55	613.19
219462.76		Not Required	614.79	616.89	106005	10/22/2012	0.00	2.10	595.64	613.50
219717.04		Not Required	614.84	620.95	106006	10/22/2012	0.00	6.11	595.87	614.23
219767.80	Leonard St D/S	Not Required	614.85	620.95	----	Interpolated	0.00	6.10	595.91	614.37

Table 7 – Flood Protection Crest Profile: Reach W2

HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet)
219802.80	Leonard St	Not Required	614.88	620.95	----	Interpolated	0.00	6.07	595.99	614.47
219837.80	Leonard St U/S	Not Required	614.91	620.95	----	Interpolated	0.00	6.04	596.07	614.57
219864.47		Not Required	614.92	616.92	101019	10/22/2012	0.00	2.00	596.07	614.65
220113.35		Not Required	614.98	617.22	106007	10/22/2012	0.00	2.24	596.08	614.11
220362.92		Not Required	615.04	615.77	101017	10/22/2012	0.00	0.72	596.09	613.56
220363.01		Not Required	615.04	616.77	101018	10/22/2012	0.00	1.73	596.09	613.56
220387.90	XS 29	Not Required	615.05	616.80	----	Interpolated	0.00	1.75	596.09	613.51
220575.80		Not Required	615.14	617.07	104369	10/22/2012	0.00	1.92	595.99	613.10
220658.50		Not Required	615.18	617.22	106008	10/22/2012	0.00	2.04	595.95	612.97
220796.62		Not Required	615.25	617.22	106009	10/22/2012	0.00	1.97	595.87	612.76
221098.22		Not Required	615.39	616.91	101014	10/22/2012	0.00	1.51	595.72	612.30
221221.60	XS 30	Not Required	615.45	617.12	----	Interpolated	0.00	1.67	595.65	612.89
221426.41		Not Required	615.53	617.47	106010	10/22/2012	0.00	1.94	595.62	613.86
221612.03		Not Required	615.60	617.06	101013	10/22/2012	0.00	1.46	595.59	614.75
221813.78		Not Required	615.68	617.35	126060	10/22/2012	0.00	1.67	595.56	613.87
221992.40		Not Required	615.75	617.45	126059	10/22/2012	0.00	1.69	595.53	612.96
222132.63		Not Required	615.81	617.60	126057	10/22/2012	0.00	1.79	595.51	612.26
222290.71		Not Required	615.87	617.31	101010	10/22/2012	0.00	1.44	595.48	611.48
222323.45		Not Required	615.88	617.66	126055	10/23/2012	0.00	1.78	595.48	612.00
222428.29		Not Required	615.93	618.67	126053	10/23/2012	0.00	2.75	595.46	618.67
222433.58		Not Required	615.93	617.35	126054	10/23/2012	0.00	1.43	595.46	617.35
222516.40	XS 31	Not Required	615.96	619.50	----	Interpolated	0.00	3.54	595.45	619.50
222541.94		Not Required	615.96	620.16	126052	10/23/2012	0.00	4.20	595.35	620.16
222697.65		Not Required	615.97	619.43	126051	10/23/2012	0.00	3.46	594.71	619.43
222717.40		Not Required	615.97	617.14	101001	10/22/2012	0.00	1.17	594.63	617.14
222717.40	RR3 D/S	Not Required	615.97	627.80	----	Interpolated	0.00	11.83	594.63	627.80
222724.20		Not Required	616.01	627.80	101000	10/22/2012	0.00	11.79	594.51	627.80
222724.20	RR3	Not Required	616.01	627.80	----	Interpolated	0.00	11.79	594.51	627.80
Indian Mill Creek										
238.76		Not Required	616.04	626.45	126062	10/23/2012	0.00	10.41	602.00	620.30
486.42		Not Required	616.04	625.85	100001	10/22/2012	0.00	9.81	602.40	620.30
911.94		Not Required	616.04	625.42	100021	10/22/2012	0.00	9.38	603.08	620.30
1152.85		Not Required	616.04	624.22	126030	10/22/2012	0.00	8.18	603.47	611.64
1295.15		Not Required	616.04	622.96	101005	10/22/2012	0.00	6.92	603.70	613.99
1486.46		Not Required	616.04	622.31	126029	10/23/2012	0.00	6.27	604.01	617.16
1733.32		Not Required	616.04	621.29	126028	10/23/2012	0.00	5.25	604.40	615.32
2105.14		Not Required	616.04	620.47	126027	10/23/2012	0.00	4.43	605.00	619.01
2151.74		YES - Contract No. 2 (2016)	616.04	620.01	6104	12/18/2013	0.00	3.97	605.07	619.01
2471.25		YES - Contract No. 2 (2016)	616.04	617.71	6167	12/18/2013	0.00	1.67	605.59	617.71
2508.13		YES - Contract No. 2 (2016)	616.04	619.04	6171	12/18/2013	0.00	3.00	605.65	619.04
2540.04		Not Required	616.04	617.38	6182	12/18/2013	0.00	1.34	605.70	617.38
2561.71		Not Required	616.04	617.40	6183	12/18/2013	0.00	1.36	605.73	617.40
2582.83		Not Required	616.04	617.35	126017	10/23/2012	0.00	1.31	605.77	617.35

Table 7 – Flood Protection Crest Profile: Reach W2
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Were Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet)
2668.86		Not Required	616.04	618.81	101009	10/22/2012	0.00	2.77	605.91	618.81
2696.84		Not Required	616.04	620.68	126020	10/23/2012	0.00	4.64	605.95	620.68
2747.73		Not Required	616.04	622.71	126019	10/23/2012	0.00	6.67	606.03	622.71
2859.17		Not Required	616.04	623.95	126018	10/23/2012	0.00	7.91	606.21	623.95

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 8 – Flood Protection Crest Profile: Reach W3

HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

No Improvements Needed - Areas resurveyed since LAMP

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
211918.10	Fulton St	Not Required	610.18	612.04	----	Interpolated	0.05	1.81	583.53	610.26
211964.70	Fulton St U/S	Not Required	610.44	611.98	----	Interpolated	0.05	1.49	583.08	611.08
211964.70		Not Required	610.44	611.98	120103	10/22/2012	0.05	1.49	583.08	611.08
212045.59		Not Required	610.44	612.15	125001	10/22/2012	0.05	1.66	584.61	611.08
212103.50	XS 16	Not Required	610.44	612.04	----	Interpolated	0.05	1.55	585.71	611.08
212145.29		Not Required	610.45	611.96	125004	10/22/2012	0.05	1.46	585.90	611.08
212288.29		No - Area Resurveyed (2017)	610.47	611.05	30346	10/22/2012	0.05	0.53	586.54	609.91
212301.89		No - Area Resurveyed (2017)	610.47	611.00	30536	10/22/2012	0.05	0.47	586.60	610.57
212319.71		YES - Contract No. 3 (2017)	610.48	610.99	30505	10/22/2012	0.05	0.46	586.68	610.16
212334.20	XS 17	YES - Contract No. 3 (2017)	610.48	611.01	----	Interpolated	0.05	0.48	586.75	610.14
212414.50	ped bridge D/S	YES - Contract No. 3 (2017)	610.48	611.12	----	Interpolated	0.05	0.59	586.51	610.02
212431.80	ped bridge	YES - Contract No. 3 (2017)	610.66	611.15	----	Interpolated	0.05	0.44	586.34	609.99
212446.80	ped bridge U/S	YES - Contract No. 3 (2017)	610.81	611.17	----	Interpolated	0.05	0.31	586.19	609.97
212505.16		YES - Contract No. 3 (2017)	610.82	611.25	100987	8/22/2017	0.05	0.38	586.38	609.88
212519.12		YES - Contract No. 3 (2017)	610.82	611.30	30746	8/22/2017	0.05	0.42	586.42	609.83
212524.26		YES - Contract No. 3 (2017)	610.82	611.28	130722	8/22/2017	0.05	0.41	586.44	609.83
212529.98		YES - Contract No. 3 (2017)	610.83	611.03	30225	8/22/2017	0.05	0.15	586.46	609.66
212545.25		YES - Contract No. 3 (2017)	610.83	611.17	200140	8/22/2017	0.05	0.30	586.51	609.67
212554.53		YES - Contract No. 3 (2017)	610.83	611.22	200143	8/22/2017	0.05	0.34	586.54	609.67
212571.29		No - Area Resurveyed (2017)	610.83	611.11	30233	8/22/2017	0.05	0.22	586.59	609.67
212611.50	XS 18	No - Area Resurveyed (2017)	610.84	611.38	----	Interpolated	0.05	0.49	586.72	610.28
212627.30		No - Area Resurveyed (2017)	610.84	611.49	200322	8/22/2017	0.05	0.60	586.78	610.52
212882.44		No - Area Resurveyed (2017)	610.85	611.53	210031	8/24/2017	0.05	0.63	587.83	610.52
212906.84		No - Area Resurveyed (2017)	610.85	611.65	210032	8/24/2017	0.05	0.75	587.93	610.52
212932.25		YES - Contract No. 3 (2017)	610.85	611.62	210022	8/24/2017	0.05	0.72	588.03	610.52
212959.31		YES - Contract No. 3 (2017)	610.85	611.41	210029	8/24/2017	0.05	0.51	588.14	610.52
212970.11		YES - Contract No. 3 (2017)	610.85	611.14	210010	8/24/2017	0.05	0.24	588.19	610.52
212980.50	XS 19	YES - Contract No. 3 (2017)	610.85	611.18	----	Interpolated	0.05	0.28	588.23	610.69
212983.83		YES - Contract No. 3 (2017)	610.85	611.19	210015	8/24/2017	0.05	0.29	588.24	610.75
213004.34		YES - Contract No. 3 (2017)	610.86	611.43	210015	8/24/2017	0.05	0.52	588.27	611.09
213029.44		Not Required	610.87	611.73	210015	8/24/2017	0.05	0.81	588.30	611.35
213045.26		Not Required	610.88	611.79	210015	8/24/2017	0.05	0.87	588.33	611.38
213093.70	Pearl St D/S	Not Required	610.90	611.85	----	Interpolated	0.05	0.90	588.40	610.98
213128.60	Pearl St	Not Required	611.32	611.89	----	Interpolated	0.05	0.52	588.06	610.69
213163.80	Pearl St U/S	Not Required	611.74	611.93	----	Interpolated	0.05	0.14	587.71	610.40
213213.00	Dam No. 1 D/S	YES - Contract No. 3 (2017)	611.76	611.99	----	Interpolated	0.05	0.18	587.42	610.00
213216.50	Dam No. 1	YES - Contract No. 3 (2017)	611.78	612.00	----	Interpolated	0.05	0.17	588.60	609.97
213220.00	Dam No. 1 U/S	YES - Contract No. 3 (2017)	611.80	612.00	----	Interpolated	0.05	0.15	589.77	609.94
213334.01		YES - Contract No. 3 (2017)	611.83	612.14	200311	8/22/2017	0.05	0.26	589.53	609.00
213367.19		YES - Contract No. 3 (2017)	611.84	612.47	200308	8/22/2017	0.05	0.58	589.46	610.00
213406.51		YES - Contract No. 3 (2017)	611.85	612.75	200298	8/22/2017	0.05	0.85	589.38	611.00
213460.51		YES - Contract No. 3 (2017)	611.86	612.65	200294	8/22/2017	0.05	0.74	589.26	612.65

Table 8 – Flood Protection Crest Profile: Reach W3
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

No Improvements Needed - Areas resurveyed since LAMP

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
213489.90	ped bridge D/S	Not Required	611.87	612.66	----	Interpolated	0.05	0.74	589.20	610.45
213506.20	ped bridge	Not Required	611.91	612.66	----	Interpolated	0.05	0.70	589.06	609.22
213522.50	ped bridge U/S	Not Required	611.95	612.67	----	Interpolated	0.05	0.67	588.92	608.00
213522.50		YES - Contract No. 3 (2017)	611.95	612.67	200289	8/22/2017	0.05	0.67	588.92	608.00
213522.50		YES - Contract No. 3 (2017)	611.95	612.71	200320	8/22/2017	0.05	0.71	588.92	608.00
213522.50		YES - Contract No. 3 (2017)	611.95	612.78	200288	8/22/2017	0.05	0.78	588.92	608.00
213559.98		YES - Contract No. 3 (2017)	611.97	612.35	200283	8/22/2017	0.05	0.34	588.91	608.00
213614.80		YES - Contract No. 3 (2017)	611.99	612.46	200278	8/22/2017	0.05	0.42	588.89	608.41
213664.48		YES - Contract No. 3 (2017)	612.02	612.56	200273	8/22/2017	0.05	0.49	588.87	608.80
213666.40	XS 20	YES - Contract No. 3 (2017)	612.02	612.55	----	Interpolated	0.05	0.48	588.87	608.81
213761.11		YES - Contract No. 3 (2017)	612.03	612.47	200265	8/22/2017	0.05	0.39	589.14	609.19
213851.60	Dam No. 2 D/S	YES - Contract No. 3 (2017)	612.04	612.41	----	Interpolated	0.05	0.32	589.40	609.29
213854.30	Dam No. 2	YES - Contract No. 3 (2017)	612.07	612.41	----	Interpolated	0.05	0.29	590.15	609.30
213856.90	Dam No. 2 U/S	YES - Contract No. 3 (2017)	612.10	612.40	----	Interpolated	0.05	0.25	590.88	609.30
213933.96		YES - Contract No. 3 (2017)	612.11	612.35	200254	8/22/2017	0.05	0.19	590.80	609.39
213978.60		YES - Contract No. 3 (2017)	612.11	612.48	200247	8/22/2017	0.05	0.32	590.75	609.89
214027.13		YES - Contract No. 3 (2017)	612.11	612.65	200241	8/22/2017	0.05	0.49	590.70	610.19
214078.49		YES - Contract No. 3 (2017)	612.12	612.40	200238	8/22/2017	0.05	0.24	590.65	610.91
214101.44		YES - Contract No. 3 (2017)	612.12	612.33	200232	8/22/2017	0.05	0.16	590.62	611.26
214124.46		YES - Contract No. 3 (2017)	612.12	612.29	200228	8/22/2017	0.05	0.12	590.60	611.66
214133.36		YES - Contract No. 3 (2017)	612.12	612.30	30008	8/28/2017	0.05	0.13	590.59	611.00
214150.23		YES - Contract No. 3 (2017)	612.12	612.56	200194	8/22/2017	0.05	0.39	590.57	611.50
214151.60	XS 21	Not Required	612.12	612.57	----	Interpolated	0.05	0.40	590.57	611.58
214165.13		Not Required	612.12	612.68	200201	8/22/2017	0.05	0.51	590.60	612.33
214172.52		Not Required	612.12	614.04	200206	8/22/2017	0.05	1.87	590.61	612.33
214195.51		Not Required	612.12	613.92	200212	8/22/2017	0.05	1.75	590.66	612.59
214222.89		Not Required	612.12	613.18	200217	8/22/2017	0.05	1.00	590.71	612.87
214249.82		Not Required	612.12	612.95	200219	8/22/2017	0.05	0.78	590.76	612.95
214282.46		Not Required	612.12	613.27	140010	12/3/2012	0.05	1.09	590.82	613.47
214345.77		Not Required	612.12	614.02	140011	12/3/2012	0.05	1.85	590.95	614.47
214393.30	Dam No. 3 D/S	Not Required	612.12	614.95	----	Interpolated	0.05	2.78	591.04	615.22
214396.40	Dam No. 3	Not Required	612.15	615.01	----	Interpolated	0.05	2.81	591.41	615.27
214399.50	Dam No. 3 U/S	Not Required	612.18	615.07	----	Interpolated	0.05	2.84	591.77	615.32
214464.98		Not Required	612.17	616.35	858	12/18/2013	0.05	4.13	591.07	616.35
214464.98		Not Required	612.17	616.35	101303	12/18/2013	0.05	4.13	591.07	616.35
214526.80		Not Required	612.17	616.68	857	12/18/2013	0.05	4.46	590.41	616.68
214526.80	Bridge St D/S	Not Required	612.17	616.68	----	Interpolated	0.05	4.46	590.41	616.68
214566.80	Bridge St	Not Required	612.25	617.18	----	Interpolated	0.05	4.88	589.92	617.18
214608.30	Bridge St U/S	Not Required	612.34	617.70	----	Interpolated	0.05	5.31	589.42	617.70
214608.30		Not Required	612.34	617.70	125012	10/22/2012	0.05	5.31	589.42	617.70
214707.95		Not Required	612.38	617.71	125013	10/22/2012	0.05	5.28	591.00	617.71
214711.50	Dam No. 4 D/S	Not Required	612.38	617.71	----	Interpolated	0.05	5.28	591.06	617.71
214716.20	Dam No. 4	Not Required	612.42	617.72	----	Interpolated	0.05	5.25	591.92	617.72
214720.80	Dam No. 4 U/S	Not Required	612.45	617.72	----	Interpolated	0.05	5.22	592.77	617.72

Table 8 – Flood Protection Crest Profile: Reach W3
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

No Improvements Needed - Areas resurveyed since LAMP

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
214796.84		Not Required	612.51	617.82	125014	10/22/2012	0.05	5.26	592.03	617.82
214796.84		Not Required	612.51	617.82	125014	10/22/2012	0.05	5.26	592.03	617.82
214860.15		Not Required	612.56	617.49	101065	10/22/2012	0.05	4.88	591.41	617.49
214870.90	XS 22	Not Required	612.57	617.56	----	Interpolated	0.05	4.94	591.31	617.56
214909.77		Not Required	612.58	617.78	125015	10/22/2012	0.05	5.15	591.37	617.78
215030.26		Not Required	612.62	615.77	125017	10/22/2012	0.05	3.09	591.56	615.77
215031.58		Not Required	612.62	617.90	125016	10/22/2012	0.05	5.23	591.56	617.90
215133.11		Not Required	612.66	618.37	125011	10/22/2012	0.05	5.66	591.72	618.37
215253.20	I-196 East D/S	Not Required	612.70	627.78	125010	10/22/2012	0.05	15.03	591.91	617.21

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.

Table 9 – Flood Protection Crest Profile: Reach W4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
Grand River										
201775.20		Not Required	607.15	610.17	127050	10/23/2012	0.37	2.65	579.95	610.17
201849.56		Not Required	607.15	610.24	127051	10/23/2012	0.37	2.72	579.94	610.24
202097.90	XS 5	Not Required	607.15	611.33	----	Interpolated	0.37	3.81	579.93	611.33
202226.22		Not Required	607.17	611.89	127052	10/23/2012	0.37	4.35	579.84	611.89
202531.50		Not Required	607.23	615.34	----	Interpolated	0.37	7.74	579.61	615.34
202551.66		Not Required	607.23	615.57	----	Interpolated	0.37	7.96	579.60	615.57
202965.10		Not Required	607.32	614.21	----	Interpolated	0.37	6.52	579.29	614.21
203078.71		Not Required	607.35	613.84	127054	10/23/2012	0.37	6.12	579.21	613.84
203372.60		Not Required	607.41	612.32	127055	10/23/2012	0.37	4.54	578.99	612.32
203398.80		Not Required	607.42	612.65	----	Interpolated	0.37	4.86	578.97	612.65
203611.13		Not Required	607.45	615.32	127056	10/23/2012	0.37	7.50	578.81	615.32
203777.78		Not Required	607.47	616.35	127039	10/23/2012	0.37	8.51	578.69	616.35
203832.40	XS 6	Not Required	607.48	616.07	----	Interpolated	0.37	8.22	578.65	616.07
204006.56		Not Required	607.54	615.19	127037	10/23/2012	0.37	7.28	578.24	615.19
204243.99		Not Required	607.62	609.89	127036	10/23/2012	0.37	1.91	577.69	609.89
204250.50		Not Required	607.62	609.90	----	Interpolated	0.37	1.91	577.67	609.93
204531.26		Not Required	607.76	610.09	127059	10/23/2012	0.37	1.96	577.01	611.68
204668.70	XS 7	Not Required	607.83	610.17	----	Interpolated	0.37	1.97	576.69	613.73
204728.63		Not Required	607.85	610.21	127037	10/23/2012	0.37	1.99	576.79	614.62
205080.50		Not Required	607.96	610.21	----	Interpolated	0.37	1.88	577.36	615.42
205446.30		Not Required	608.08	610.20	127062	10/23/2012	0.37	1.75	577.96	616.26
205492.20		Not Required	608.10	610.14	----	Interpolated	0.37	1.67	578.04	614.58
205826.03		Not Required	608.23	609.69	127020	10/23/2012	0.37	1.09	578.58	602.35
205903.55		Not Required	608.26	609.00	127022	10/23/2012	0.37	0.37	578.71	602.35
205904.00		Not Required	608.26	609.00	----	Interpolated	0.37	0.37	578.71	602.35
206063.12		Not Required	608.29	609.25	127018	10/23/2012	0.37	0.60	578.97	601.15
206315.80	XS 8	Not Required	608.33	609.42	----	Interpolated	0.37	0.72	579.38	602.45
206441.52		Not Required	608.33	609.50	127016	10/23/2012	0.37	0.80	579.32	603.10
206651.90		Not Required	608.34	609.80	----	Interpolated	0.37	1.09	579.23	602.62
206662.22		Not Required	608.34	609.81	127014	10/23/2012	0.37	1.10	579.23	602.60
206971.31		Not Required	608.41	609.49	127012	10/23/2012	0.37	0.71	579.10	606.20
206988.00		Not Required	608.41	609.51	----	Interpolated	0.37	0.73	579.09	606.22
207324.20	RR1 D/S	Not Required	608.51	609.94	----	Interpolated	0.37	1.06	578.94	606.61
207332.50	RR1	Not Required	608.53	609.95	----	Interpolated	0.37	1.05	578.94	606.62
207340.50	RR1 U/S*	Not Required	608.54	609.96	----	Interpolated	0.37	1.05	578.94	606.63
207376.64		Not Required	608.54	610.00	127010	10/23/2012	0.37	1.09	579.01	606.67
207535.46		Not Required	608.55	615.54	6385	12/18/2013	0.37	6.62	579.34	616.00
207568.23		Not Required	608.55	613.59	6400	12/18/2013	0.37	4.66	579.40	614.00
207626.07		Not Required	608.56	610.62	6401	12/18/2013	0.37	1.70	579.52	612.29
207731.82		YES - Contract No. 2 (2016)	608.56	610.01	50001	8/23/2017	0.37	1.08	579.74	609.49
207741.39		YES - Contract No. 2 (2016)	608.56	609.83	6817	12/18/2013	0.37	0.90	579.76	609.49
207902.28		YES - Contract No. 2 (2016)	608.57	610.03	50002	8/23/2017	0.37	1.08	580.08	608.12

Table 9 – Flood Protection Crest Profile: Reach W4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
208011.82		YES - Contract No. 2 (2016)	608.58	610.01	50003	8/23/2017	0.37	1.05	580.31	605.30
208227.12		YES - Contract No. 2 (2016)	608.59	610.05	50002	8/23/2017	0.37	1.09	580.75	609.97
208227.33		YES - Contract No. 2 (2016)	608.59	609.53	50003	8/23/2017	0.37	0.57	580.75	608.97
208267.93		Not Required	608.60	609.12	6786	12/18/2013	0.37	0.15	580.83	608.91
208288.18		Not Required	608.60	609.28	6482	12/18/2013	0.37	0.31	580.87	608.91
208313.66		Not Required	608.60	609.65	6484	12/18/2013	0.37	0.68	580.92	609.64
208327.80	XS 9	Not Required	608.60	609.36	----	Interpolated	0.37	0.39	580.95	609.64
208337.42		Not Required	608.60	609.16	6485	12/18/2013	0.37	0.19	580.94	609.64
208366.43		Not Required	608.60	609.44	6782	12/18/2013	0.37	0.47	580.91	609.49
208398.31		Not Required	608.60	608.97	6489	12/18/2013	0.37	0.01	580.88	609.32
208399.13		Not Required	608.60	609.68	27003	10/23/2012	0.37	0.71	580.88	609.32
208419.87		Not Required	608.60	608.86	6490	12/18/2013	0.01	0.25	580.86	608.00
208424.95		Not Required	608.60	609.28	6491	12/18/2013	0.01	0.68	580.85	608.00
208437.20		Not Required	608.60	609.12	6496	12/18/2013	0.01	0.51	580.84	608.00
208449.25		Not Required	608.60	609.07	6498	12/18/2013	0.01	0.46	580.83	608.00
208466.46		Not Required	608.60	609.14	6499	12/18/2013	0.01	0.53	580.81	607.00
208467.01		Not Required	608.60	609.67	6777	12/18/2013	0.01	1.07	580.81	607.00
208477.40		Not Required	608.60	609.12	6501	12/18/2013	0.01	0.51	580.80	606.00
208508.21		Not Required	608.60	609.06	6506	12/18/2013	0.01	0.45	580.77	604.00
208535.50		Not Required	608.60	609.02	6508	12/18/2013	0.01	0.41	580.75	604.00
208550.62		Not Required	608.60	608.81	6726	12/18/2013	0.01	0.20	580.73	604.00
208561.47		Not Required	608.59	609.00	6510	12/18/2013	0.01	0.39	580.72	604.00
208562.30		Not Required	608.59	608.78	6725	12/18/2013	0.01	0.17	580.72	604.00
208576.76		Not Required	608.59	609.10	6771	12/18/2013	0.01	0.50	580.71	604.00
208580.68		Not Required	608.59	609.07	6772	12/18/2013	0.01	0.46	580.70	604.00
208629.20		Not Required	608.59	610.07	6663	12/18/2013	0.01	1.47	580.65	604.00
208777.10	Wealthy St D/S	Not Required	608.59	609.51	----	Interpolated	0.01	0.91	580.51	605.28
208814.80	Wealthy St	Not Required	608.61	609.36	----	Interpolated	0.01	0.74	580.74	605.61
208859.80	Wealthy St U/S	Not Required	608.64	609.19	----	Interpolated	0.01	0.54	581.01	606.00
208859.80		Not Required	608.64	609.19	7127	1/10/2014	0.01	0.54	581.01	606.00
208859.80		Not Required	608.64	609.13	7126	1/10/2014	0.01	0.48	581.01	606.00
208859.80		Not Required	608.64	609.34	7125	1/10/2014	0.01	0.69	581.01	606.00
208880.35		Not Required	608.66	609.34	7124	1/10/2014	0.01	0.68	580.97	606.00
208912.48		Not Required	608.68	609.27	7123	1/10/2014	0.01	0.57	580.92	606.00
208944.14		Not Required	608.71	609.10	7122	1/10/2014	0.01	0.39	580.86	606.00
208987.77		Not Required	608.74	609.21	120047	10/22/2012	0.01	0.45	580.78	606.00
209110.49		Not Required	608.84	609.36	7135	1/10/2014	0.01	0.51	580.57	606.00
209122.84		Not Required	608.85	609.32	7134	1/10/2014	0.01	0.46	580.54	606.00
209160.31		Not Required	608.88	609.39	7133	1/10/2014	0.01	0.50	580.48	606.00
209175.50	XS 10	Not Required	608.89	609.38	----	Interpolated	0.01	0.48	580.45	606.00
209203.14		Not Required	608.92	609.37	7132	1/10/2014	0.01	0.44	580.57	606.00
209258.37		Not Required	608.97	609.37	7131	1/10/2014	0.01	0.39	580.82	606.00
209367.74		YES - Contract No. 2 (2016)	609.07	609.40	7128	1/10/2014	0.01	0.32	581.31	606.00

Table 9 – Flood Protection Crest Profile: Reach W4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
209373.05		YES - Contract No. 2 (2016)	609.07	609.32	226	2/12/2016	0.01	0.24	581.33	606.00
209397.88		YES - Contract No. 2 (2016)	609.10	609.41	7129	1/10/2014	0.01	0.30	581.44	606.00
209422.20	XS 11	YES - Contract No. 2 (2016)	609.12	609.34	----	Interpolated	0.01	0.21	581.55	606.00
209435.29		YES - Contract No. 2 (2016)	609.13	609.30	227	2/12/2016	0.01	0.17	581.44	606.00
209444.51		YES - Contract No. 2 (2016)	609.13	609.39	120048	10/22/2012	0.01	0.25	581.36	606.00
209461.57		YES - Contract No. 2 (2016)	609.14	609.41	7130	1/10/2014	0.01	0.26	581.22	606.00
209467.75		YES - Contract No. 2 (2016)	609.14	609.99	50013	8/23/2017	0.01	0.84	581.17	606.00
209593.90		YES - Contract No. 2 (2016)	609.19	609.96	50014	8/23/2017	0.01	0.76	580.11	606.00
209656.60		YES - Contract No. 2 (2016)	609.22	609.99	50011	8/23/2017	0.01	0.75	579.59	606.00
209656.60	RR2 D/S		609.22	609.60	----	closure struct.	0.01	0.37	579.59	606.00
209683.80	RR2		609.33	609.60	----	closure struct.	0.01	0.26	577.37	606.00
209711.40	RR2 U/S		609.44	609.60	----	closure struct.	0.01	0.15	575.11	606.00
209711.40		YES - Contract No. 2 (2016)	609.44	609.97	100010	8/23/2017	0.01	0.52	575.11	606.00
209878.98		YES - Contract No. 2 (2016)	609.45	609.97	50010	8/23/2017	0.01	0.52	577.53	608.00
209879.11		YES - Contract No. 2 (2016)	609.45	611.56	7244	1/10/2014	0.01	2.10	577.53	608.00
209983.80		YES - Contract No. 2 (2016)	609.45	611.51	7243	1/10/2014	0.01	2.05	579.04	608.00
209996.90	XS 12A	YES - Contract No. 2 (2016)	609.45	611.17	----	Interpolated	0.01	1.71	579.23	608.00
210031.43		YES - Contract No. 2 (2016)	609.46	610.26	50023	8/23/2017	0.01	0.79	579.30	608.00
210111.77		YES - Contract No. 2 (2016)	609.47	610.25	50022	8/23/2017	0.01	0.77	579.48	608.00
210116.06		YES - Contract No. 2 (2016)	609.47	609.64	50017	8/23/2017	0.01	0.15	579.48	606.00
210116.09		YES - Contract No. 2 (2016)	609.47	609.75	50019	8/23/2017	0.01	0.27	579.48	606.00
210211.18		YES - Contract No. 2 (2016)	609.49	609.99	50020	8/23/2017	0.01	0.49	579.69	606.00
210288.56		Not Required	609.50	610.03	50026	8/23/2017	0.01	0.51	579.85	606.00
210322.71		Not Required	609.51	609.84	7232	1/10/2014	0.01	0.32	579.93	606.00
210344.74		Not Required	609.51	609.76	120054	10/22/2012	0.01	0.23	579.97	606.00
210371.55		Not Required	609.52	609.81	7230	1/10/2014	0.01	0.29	580.03	606.00
210414.43		Not Required	609.52	609.76	7229	1/10/2014	0.01	0.23	580.12	606.00
210450.70		Not Required	609.53	609.78	7228	1/10/2014	0.01	0.23	580.20	606.00
210483.62		Not Required	609.54	609.88	7227	1/10/2014	0.01	0.34	580.27	606.00
210494.52		Not Required	609.54	609.82	7226	1/10/2014	0.01	0.27	580.29	606.00
210502.81		Not Required	609.54	609.79	7225	1/10/2014	0.01	0.24	580.31	606.00
210564.78		Not Required	609.55	609.80	7224	1/10/2014	0.01	0.24	580.44	606.00
210569.74		Not Required	609.55	609.78	120055	10/22/2012	0.01	0.22	580.45	606.00
210583.98		Not Required	609.55	609.81	7223	1/10/2014	0.01	0.24	580.48	606.00
210657.62		YES - Contract No. 2 (2016)	609.57	609.74	7222	1/10/2014	0.01	0.17	580.64	606.00
210658.12		YES - Contract No. 2 (2016)	609.57	610.49	50027	8/23/2017	0.01	0.92	580.64	606.00
210676.00	XS 12B	YES - Contract No. 2 (2016)	609.57	610.49	----	Interpolated	0.01	0.91	580.68	606.00
210784.22		YES - Contract No. 2 (2016)	609.57	610.45	50028	8/23/2017	0.01	0.87	580.61	606.00
210918.90	XS 13	YES - Contract No. 2 (2016)	609.57	610.43	----	Interpolated	0.01	0.85	580.52	606.00
210984.79		YES - Contract No. 2 (2016)	609.56	610.42	50029	8/23/2017	0.01	0.85	580.38	606.00
211144.80	US Hwy 131 D/S	YES - Contract No. 2 (2016)	609.55	610.45	----	Interpolated	0.01	0.89	580.05	606.00
211184.29		YES - Contract No. 2 (2016)	609.58	610.46	50030	8/23/2017	0.01	0.87	580.05	606.00
211242.40	US Hwy 131	YES - Contract No. 2 (2016)	609.63	610.46	----	Interpolated	0.01	0.82	580.05	606.00

Table 9 – Flood Protection Crest Profile: Reach W4
HEC-RAS December 2017 Grand River 100-year Flood Profile Model

Improvements made in 2016 or 2017

HEC-RAS Model River Station	Location	Where Improvements Completed?	100-Year Water Surface Elevation (feet, NAVD88)	West Bank Elevations (feet, NAVD88)	Point Number	Date Levee Elevation Surveyed	Estimated Potential Settlement (feet)	Freeboard above BFE Considering Potential Settlement (feet)	Channel Bottom Elevation (feet, NAVD88)	Leward Elevation (feet, NAVD88)
211348.60	US Hwy 131 U/S	YES - Contract No. 2 (2016)	609.71	610.46	----	Interpolated	0.01	0.74	580.06	606.00
211383.84		YES - Contract No. 2 (2016)	609.72	610.47	50031	8/23/2017	0.01	0.73	579.95	606.00
211561.30	XS 14	YES - Contract No. 2 (2016)	609.80	610.44	----	Interpolated	0.01	0.63	579.41	607.77
211584.55		YES - Contract No. 2 (2016)	609.80	610.44	50032	8/23/2017	0.01	0.63	579.37	608.00
211664.80	XS 15	YES - Contract No. 2 (2016)	609.81	610.45	----	Interpolated	0.01	0.63	579.24	609.27
211710.56		YES - Contract No. 2 (2016)	609.83	610.45	50033	8/23/2017	0.01	0.61	580.31	610.00
211757.90		YES - Contract No. 2 (2016)	609.86	612.45	100013	8/23/2017	0.01	2.58	581.42	608.79
211788.73		YES - Contract No. 2 (2016)	609.87	612.21	120102	10/22/2012	0.01	2.33	582.15	608.00
211868.10	Fulton St D/S	YES - Contract No. 2 (2016)	609.91	612.11	----	Interpolated	0.01	2.19	584.01	609.39
211912.72		YES - Contract No. 2 (2016)	610.15	612.05	----	Interpolated	0.01	1.88	583.58	610.17

Notes:
1. River stations in blue were determined by extending a line from a surveyed bank elevation perpendicular to the centerline of the Grand River. The centerline of the Grand River was stationed in the HEC-RAS model based on the distance in feet from the mouth at Lake Michigan.
2. All elevations in orange were interpolated from the HEC-RAS 100-year flood profile or the river bank surveyed point elevations.
3. Elevations in red indicate the need for a closure structure at a railroad bridge. The City is in negotiations with CSX Corporation to construct a closure structure by the end of June 2018 that will provide a minimum 100-year flood level of protection. Until the closure structure in constructed, temporary closure methods, such as a sandbag wall, will be used.

Appendix 1

100-Year Water Surface Profile HEC-RAS Results

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1%

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	17320	1%	56000.00	567.10	583.59		583.67	0.000153	2.30	25234.69	3129.50	0.14
Upper	21130	1%	55000.00	561.70	584.09		584.15	0.000100	1.98	32101.47	4699.12	0.11
Upper	23150	1%	55000.00	566.60	584.34		584.40	0.000162	2.07	28701.81	4259.31	0.13
Upper	25100	1%	55000.00	565.00	584.66		584.76	0.000203	2.57	21383.38	2543.50	0.15
Upper	27290	1%	55000.00	567.00	585.14		585.20	0.000187	1.82	30611.25	3948.88	0.11
Upper	29180	1%	55000.00	566.40	585.42		585.54	0.000155	3.22	25877.48	3156.85	0.15
Upper	32770	1%	55000.00	563.00	585.88		585.98	0.000107	2.66	24320.29	2968.19	0.12
Upper	34060	1%	55000.00	568.40	586.08		586.15	0.000156	2.20	26610.12	3425.10	0.12
Upper	36810	1%	55000.00	567.10	586.52		586.59	0.000168	2.24	27839.68	4029.14	0.13
Upper	38960	1%	55000.00	566.70	586.88		586.95	0.000169	2.17	27420.05	3521.43	0.13
Upper	41920	1%	55000.00	567.90	587.31		587.37	0.000127	1.99	27592.35	3051.93	0.11
Upper	42920.	1%	55000.00	567.80	587.40	576.98	587.50	0.000110	3.23	30774.77	4882.32	0.14
Upper	43289.2*	1%	55000.00	567.81	587.42	577.58	587.54	0.000124	3.43	28764.46	4775.88	0.15
Upper	43658.4*	1%	55000.00	567.81	587.44	577.90	587.58	0.000134	3.58	27405.79	4711.13	0.16
Upper	44027.7*	1%	55000.00	567.82	587.49	577.64	587.63	0.000127	3.49	27898.21	4612.03	0.16
Upper	44397.0*	1%	55000.00	567.83	587.57	577.50	587.67	0.000098	3.08	29676.79	4505.36	0.14
Upper	44766.2*	1%	55000.00	567.84	587.63	577.37	587.70	0.000075	2.70	32247.72	4628.85	0.12
Upper	45135.5*	1%	55000.00	567.84	587.68	577.26	587.73	0.000054	2.30	36225.77	4572.93	0.10
Upper	45504.9	1%	55000.00	567.85	587.71	577.16	587.75	0.000037	1.90	41513.45	4615.35	0.08
Upper	46703.4	1%	55000.00	567.90	587.76	578.25	587.80	0.000045	2.09	38515.92	3540.01	0.09
Upper	48216.53	1%	55000.00	567.90	587.81	576.94	587.85	0.000050	2.18	38991.18	3657.12	0.10
Upper	49807.05	1%	55000.00	567.90	587.88	577.99	587.96	0.000088	2.85	32958.07	3596.20	0.13
Upper	51541.92	1%	55000.00	567.90	588.01	578.42	588.21	0.000180	4.13	27750.15	3728.99	0.18
Upper	54820.11	1%	55000.00	568.90	588.58	578.17	588.75	0.000148	3.93	28937.74	3189.68	0.17
Upper	56250.84	1%	55000.00	568.90	588.82	577.16	588.93	0.000096	3.18	35049.14	3691.69	0.14
Upper	60534.04	1%	55000.00	569.40	589.26	578.46	589.40	0.000123	3.55	38346.68	4395.37	0.15
Upper	62758.86	1%	55000.00	569.40	589.52	578.46	589.76	0.000174	4.31	23282.62	2610.67	0.18
Upper	64131.47	1%	55000.00	569.40	589.72	578.09	590.03	0.000187	4.55	16745.81	1831.01	0.19
Upper	64834.35	1%	55000.00	569.40	589.89	578.28	590.16	0.000176	4.47	22388.20	2423.06	0.19
Upper	65900.13	1%	55000.00	569.40	590.08	579.21	590.36	0.000202	4.78	23284.80	2393.06	0.20
Upper	66712.2	1%	53000.00	569.40	590.30	579.96	590.54	0.000191	4.41	22208.81	2244.11	0.19
Upper	68182.47	1%	53000.00	569.40	590.58	581.28	590.85	0.000230	4.75	21360.94	2062.64	0.21
Upper	68853.37	1%	53000.00	569.40	590.80	580.21	590.99	0.000156	4.08	24069.11	2364.96	0.17
Upper	69624.23	1%	53000.00	569.40	590.95	579.92	591.10	0.000126	3.63	29091.14	2812.49	0.16
Upper	70109.29	1%	53000.00	569.40	591.00	580.30	591.18	0.000145	3.95	26063.64	2507.40	0.17
Upper	70874.28	1%	53000.00	569.40	591.07	579.95	591.32	0.000178	4.44	20550.86	2107.32	0.19
Upper	72036.69	1%	53000.00	570.40	591.26	581.97	591.60	0.000265	5.16	18209.71	1976.72	0.23
Upper	72977.86	1%	53000.00	570.40	591.52	581.49	591.83	0.000237	4.97	18643.67	1747.49	0.21
Upper	73988.11	1%	53000.00	570.40	591.76	581.33	592.06	0.000218	4.79	17783.17	1701.24	0.21
Upper	75286.55	1%	53000.00	570.40	592.02	581.53	592.37	0.000238	5.03	16395.16	1737.94	0.22
Upper	76268.0*	1%	53000.00	570.40	592.34	580.68	592.56	0.000147	4.03	19926.71	2078.50	0.17
Upper	77249.68	1%	53000.00	570.40	592.53	580.03	592.69	0.000106	3.46	20179.31	1582.31	0.14

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	77849.24	1%	53000.00	570.40	592.58	581.23	592.77	0.000134	3.85	20224.43	1769.72	0.16
Upper	78638.6	1%	53000.00	570.40	592.68	581.50	592.89	0.000148	4.12	18606.98	1554.61	0.17
Upper	79118.1*	1%	53000.00	570.40	592.75	581.44	592.97	0.000156	4.24	24717.40	2193.37	0.18
Upper	79597.75	1%	53000.00	570.40	592.92	581.38	593.05	0.000105	3.49	36083.18	3099.77	0.14
Upper	79765.5*	1%	53000.00	570.41	592.93	581.41	593.06	0.000110	3.58	34986.29	3082.50	0.15
Upper	79933.4*	1%	53000.00	570.42	592.94	581.45	593.09	0.000115	3.67	33898.27	3067.99	0.15
Upper	80101.3*	1%	53000.00	570.44	592.95	581.47	593.11	0.000121	3.76	32844.20	3046.63	0.16
Upper	80269.2*	1%	53000.00	570.45	592.97	581.52	593.13	0.000127	3.85	31828.41	3027.80	0.16
Upper	80437.1*	1%	53000.00	570.46	592.98	581.53	593.15	0.000133	3.94	30851.51	3010.27	0.16
Upper	80605.15	1%	53000.00	570.47	592.99	581.55	593.18	0.000139	4.03	29914.10	2990.98	0.17
Upper	80799.7*	1%	53000.00	570.29	593.02	581.21	593.20	0.000134	4.01	30104.17	3039.30	0.16
Upper	80994.4*	1%	53000.00	570.11	593.04	580.91	593.23	0.000129	3.98	30341.16	3087.04	0.16
Upper	81189.1*	1%	53000.00	569.94	593.07	580.57	593.25	0.000124	3.95	30649.10	3152.39	0.16
Upper	81383.8*	1%	53000.00	569.76	593.09	580.18	593.27	0.000118	3.90	31182.54	3256.63	0.15
Upper	81578.5*	1%	53000.00	569.58	593.12	579.78	593.29	0.000110	3.83	32195.76	3379.54	0.15
Upper	81773.33	1%	53000.00	569.40	593.15	579.35	593.31	0.000101	3.71	33769.49	3462.96	0.14
Upper	82849.54	1%	53000.00	569.40	593.31	580.14	593.41	0.000077	3.15	42398.35	3871.96	0.13
Upper	84632.06	1%	53000.00	569.40	593.45	579.41	593.54	0.000064	2.97	34043.62	2874.22	0.12
Upper	85783.24	1%	53000.00	569.40	593.55	580.76	593.61	0.000052	2.66	36156.39	3354.59	0.10
Upper	86385.12	1%	53000.00	569.40	593.61	580.22	593.65	0.000046	2.52	51316.30	5501.07	0.10
Upper	87843.46	1%	53000.00	569.40	593.69	579.88	593.71	0.000025	1.88	54764.78	4825.03	0.07
Upper	89526.04	1%	53000.00	569.40	593.72	579.24	593.78	0.000042	2.45	42715.04	4070.54	0.09
Upper	90444.94	1%	53000.00	569.40	593.75	578.37	593.85	0.000057	2.85	44049.66	3909.43	0.11
Upper	91320.22	1%	53000.00	569.40	593.79	579.04	593.92	0.000076	3.30	39723.14	3838.43	0.13
Upper	92519.51	1%	53000.00	569.40	593.88	579.00	594.01	0.000074	3.24	35534.72	3096.66	0.12
Upper	94208.01	1%	53000.00	569.40	594.01	579.10	594.14	0.000077	3.33	36954.68	3223.00	0.13
Upper	95931.14	1%	53000.00	571.40	594.14	581.11	594.30	0.000105	3.65	30793.10	2810.64	0.15
Upper	97879.37	1%	53000.00	571.40	594.33	580.63	594.49	0.000098	3.56	27728.72	2466.55	0.14
Upper	98853.15	1%	53000.00	571.40	594.42	580.77	594.59	0.000104	3.67	27091.29	2343.71	0.15
Upper	100505.5	1%	53000.00	571.40	594.59	580.46	594.76	0.000100	3.66	26678.75	2489.28	0.14
Upper	101473.5	1%	53000.00	571.40	594.60	581.72	594.94	0.000190	5.12	21886.87	2668.15	0.20
Upper	103145.8	1%	53000.00	571.40	594.91	581.21	595.24	0.000176	4.71	16824.08	1418.93	0.19
Upper	103245.5		Bridge									
Upper	103295.8	1%	53000.00	571.40	595.01	581.21	595.33	0.000232	4.65	16955.03	1421.02	0.19
Upper	103471.9	1%	53000.00	571.40	595.14	581.22	595.37	0.000185	4.15	18508.20	2011.87	0.17
Upper	104658.7	1%	53000.00	572.40	595.33	580.84	595.58	0.000174	4.27	18783.13	1801.62	0.16
Upper	105877.2	1%	53000.00	572.40	595.61	580.49	595.75	0.000111	3.41	29565.28	3100.52	0.13
Upper	107511.1	1%	53000.00	570.40	595.79	578.63	595.92	0.000094	3.19	26174.24	2077.29	0.12
Upper	108027.0	1%	53000.00	570.40	595.85	578.68	595.97	0.000085	3.05	26321.63	1979.21	0.11
Upper	110370.1	1%	52000.00	570.40	596.00	580.08	596.22	0.000108	4.15	22525.11	1963.82	0.15
Upper	110952.6	1%	52000.00	570.40	596.13	578.50	596.28	0.000067	3.30	23239.71	1677.60	0.12
Upper	111597.9	1%	52000.00	570.40	596.17	578.77	596.32	0.000070	3.38	23395.29	1687.16	0.12

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	113342.1	1%	52000.00	570.40	596.29	579.62	596.45	0.000080	3.61	26441.07	2403.76	0.13
Upper	113964.8	1%	52000.00	570.40	596.40	578.50	596.49	0.000047	2.79	33081.98	2570.58	0.10
Upper	114253.1	1%	52000.00	570.40	596.40	579.44	596.52	0.000063	3.19	29999.26	2531.49	0.12
Upper	114957.5	1%	52000.00	571.10	596.41	582.86	596.59	0.000118	4.31	28183.83	2564.14	0.16
Upper	115439.5	1%	52000.00	571.10	596.49	582.42	596.64	0.000101	3.89	28787.27	2558.90	0.15
Upper	115959.8	1%	52000.00	571.10	596.52	582.85	596.70	0.000115	4.14	27270.04	2485.69	0.15
Upper	116139.9	1%	52000.00	571.10	596.57	581.15	596.72	0.000085	3.63	28725.72	2537.91	0.13
Upper	117292.7	1%	52000.00	571.10	596.69	579.69	596.80	0.000060	3.06	29771.38	2602.47	0.11
Upper	117996.9	1%	52000.00	575.40	596.71	583.34	596.87	0.000106	3.72	27019.79	2674.27	0.15
Upper	119302.5	1%	52000.00	575.40	596.87	583.73	596.99	0.000090	3.48	30615.88	2663.18	0.14
Upper	120513.2	1%	52000.00	575.40	596.98	584.29	597.09	0.000088	3.44	33099.86	2822.31	0.13
Upper	121782.5	1%	52000.00	575.40	597.08	582.96	597.17	0.000061	2.86	36774.37	3104.07	0.11
Upper	122379.0	1%	52000.00	575.40	597.11	584.19	597.21	0.000080	3.23	33809.55	2926.37	0.13
Upper	122835.*	1%	52000.00	574.90	597.13	585.15	597.26	0.000109	3.78	31293.67	3021.03	0.15
Upper	123293.4	1%	52000.00	574.40	597.17	588.26	597.33	0.000157	4.45	29331.43	3161.07	0.18
Upper	123870.6	1%	52000.00	574.40	597.25	584.44	597.41	0.000110	3.78	26271.25	2454.36	0.15
Upper	124967.9	1%	52000.00	574.40	597.41	584.34	597.52	0.000085	3.33	31912.89	2989.81	0.13
Upper	126186.8	1%	52000.00	574.40	597.50	583.30	597.62	0.000079	3.30	33324.53	3596.03	0.13
Upper	127351.1	1%	52000.00	574.40	597.60	584.39	597.73	0.000097	3.65	30976.96	3053.44	0.14
Upper	127946.4	1%	52000.00	571.10	597.65	582.42	597.79	0.000087	3.71	30828.04	2860.21	0.14
Upper	128555.8	1%	52000.00	571.10	597.69	582.63	597.85	0.000097	3.94	29398.75	2852.70	0.14
Upper	129055.1	1%	52000.00	571.10	597.76	581.71	597.90	0.000078	3.38	28739.30	2462.72	0.13
Upper	129420.1	1%	52000.00	571.10	597.76	583.82	597.94	0.000119	4.31	27174.24	2533.12	0.16
Upper	129978.8	1%	52000.00	572.40	597.85	582.51	598.00	0.000096	3.92	28693.32	2430.12	0.14
Upper	130589.7	1%	52000.00	574.70	597.92	589.26	598.08	0.000164	4.55	30025.28	3359.74	0.18
Upper	131023.3	1%	52000.00	574.70	597.96	586.34	598.16	0.000155	4.47	27444.74	3237.95	0.18
Upper	131319.*	1%	52000.00	574.95	597.98	585.12	598.21	0.000145	4.36	23796.48	3025.47	0.17
Upper	131617.1	1%	52000.00	575.20	598.05	584.26	598.25	0.000117	3.92	22066.96	2247.61	0.15
Upper	132524.4	1%	52000.00	575.80	598.17	586.59	598.38	0.000158	4.51	25490.30	2881.78	0.18
Upper	133133.3	1%	52000.00	575.80	598.13	586.26	598.56	0.000243	5.57	12247.71	2736.58	0.22
Upper	133515.5	1%	52000.00	575.80	598.36	584.55	598.67	0.000151	4.46	11744.67	2487.34	0.18
Upper	133576.8		Bridge									
Upper	133724.9	1%	52000.00	575.80	598.48	584.55	598.79	0.000147	4.42	11895.82	2490.66	0.17
Upper	134463.9	1%	52000.00	573.12	598.78		598.89	0.000106	3.21	23141.25	2139.91	0.13
Upper	135063.9	1%	52000.00	573.12	598.84		599.00	0.000118	3.70	23270.34	2145.58	0.14
Upper	136913.9	1%	52000.00	573.12	599.09		599.27	0.000136	3.85	23722.99	2265.74	0.15
Upper	138663.9	1%	52000.00	573.12	599.31		599.44	0.000081	3.63	29522.85	2876.76	0.13
Upper	141743.9	1%	52000.00	578.02	599.56		599.69	0.000086	3.45	31831.32	4233.73	0.13
Upper	143823.9	1%	52000.00	572.52	599.70		599.96	0.000157	4.73	22820.88	1769.37	0.18
Upper	147223.9	1%	52000.00	576.02	600.18		600.36	0.000106	3.96	21927.44	2157.62	0.15
Upper	149853.9	1%	52000.00	576.02	600.47		600.68	0.000135	4.25	24324.95	2186.52	0.16
Upper	152203.9	1%	52000.00	569.62	600.82		601.02	0.000158	3.98	22524.41	1840.73	0.16

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	153553.9	1%	52000.00	574.02	601.07		601.20	0.000091	3.29	25065.73	2942.59	0.12
Upper	155083.9	1%	52000.00	568.72	601.14		601.30	0.000055	3.52	24837.78	2132.12	0.11
Upper	157683.9	1%	52000.00	568.72	601.30		601.42	0.000055	3.28	38805.88	3265.79	0.10
Upper	159383.9	1%	52000.00	571.92	601.47		601.56	0.000069	3.20	40747.95	4331.75	0.11
Upper	161233.9	1%	52000.00	572.72	601.58		601.67	0.000072	3.16	36310.60	4051.88	0.12
Upper	162163.9	1%	52000.00	577.02	601.65		601.74	0.000073	3.35	37511.53	4828.37	0.12
Upper	163763.9	1%	52000.00	577.02	601.74		601.84	0.000075	3.26	38924.82	4035.09	0.12
Upper	165443.9	1%	52000.00	575.62	601.88		602.08	0.000120	4.42	25412.47	2720.19	0.16
Upper	167243.9	1%	52000.00	575.42	602.13		602.24	0.000106	3.21	27417.56	2609.48	0.13
Upper	169743.9	1%	52000.00	576.22	602.39		602.58	0.000127	4.41	26616.49	2881.76	0.16
Upper	171243.9	1%	52000.00	577.22	602.57		602.71	0.000092	3.87	27109.19	2331.68	0.14
Upper	172643.9	1%	52000.00	576.62	602.75		602.83	0.000053	2.92	35887.98	3521.02	0.11
Upper	174783.9	1%	52000.00	574.12	602.85		602.98	0.000080	3.72	29512.95	3070.58	0.13
Upper	175383.9	1%	52000.00	574.52	602.88		603.04	0.000117	4.28	24689.21	3782.39	0.16
Upper	176303.9	1%	50000.00	575.02	602.87		603.25	0.000240	6.02	15482.86	1052.30	0.23
Upper	177683.9	1%	50000.00	576.22	603.26		603.51	0.000147	4.73	17654.41	1267.49	0.18
Upper	180133.9	1%	50000.00	574.02	603.58		603.86	0.000129	4.22	11847.67	550.00	0.16
Upper	180134.9	1%	50000.00	574.02	603.56		603.88	0.000261	4.52	11071.75	515.00	0.17
Upper	180162.9		Bridge									
Upper	180190.9	1%	50000.00	574.02	603.58	587.32	603.89	0.000264	4.51	11079.58	515.00	0.17
Upper	180191.9	1%	50000.00	574.02	603.62		603.90	0.000128	4.21	11869.86	550.00	0.16
Upper	180333.9	1%	50000.00	576.42	603.58		603.95	0.000158	5.06	12253.49	1774.11	0.18
Upper	180433.9	1%	50000.00	576.42	603.82		604.10	0.000128	4.53	15227.21	1744.69	0.16
Upper	183733.9	1%	50000.00	574.42	604.29		604.34	0.000041	2.65	45187.54	2976.28	0.09
Upper	190233.9	1%	50000.00	575.12	604.51		604.97	0.000239	6.36	14538.13	1048.48	0.23
Upper	192633.9	1%	50000.00	573.62	605.17		605.38	0.000118	4.54	23891.29	1968.34	0.16
Upper	194983.9	1%	50000.00	572.22	605.43		605.67	0.000118	4.61	19773.96	3670.46	0.16
Upper	195493.9	1%	50000.00	571.92	605.45		605.75	0.000139	5.04	16091.22	2816.18	0.17
Upper	195867.6	1%	50000.00	571.97	605.50	588.23	605.84	0.000197	5.28	17355.80	2462.66	0.18
Upper	195958.1	1%	50000.00	573.97	605.68	592.63	605.87	0.000126	4.05	14812.29	840.00	0.15
Upper	195974.1		Bridge									
Upper	195990.1	1%	50000.00	573.97	605.76	592.63	605.95	0.000124	4.03	14881.36	840.00	0.14
Upper	196113.4	1%	50000.00	574.07	605.62	591.71	606.05	0.000305	6.03	15464.04	2412.20	0.21
Upper	198117.8 XS 1	1%	50000.00	576.31	606.34	589.62	606.53	0.000130	4.43	25344.24	4114.39	0.15
Upper	198346.3	1%	50000.00	575.95	606.34	590.03	606.60	0.000170	5.01	22324.64	3953.27	0.17
Upper	198574.8	1%	50000.00	575.59	606.31	590.54	606.67	0.000218	5.60	19050.69	3808.30	0.19
Upper	198803.4	1%	50000.00	575.23	606.29	591.00	606.76	0.000272	6.17	15810.38	3728.73	0.21
Upper	199031.9 XS 2	1%	50000.00	574.87	606.30	591.64	606.85	0.000313	6.51	13568.85	3539.87	0.23
Upper	199238.3	1%	50000.00	575.52	606.36	591.41	606.92	0.000309	6.48	12684.58	3254.05	0.23
Upper	199444.7	1%	50000.00	576.16	606.47	591.15	606.98	0.000283	6.22	12873.36	3067.86	0.22
Upper	199651.1	1%	50000.00	576.81	606.58	590.92	607.04	0.000259	5.96	13604.65	2936.62	0.21
Upper	199857.4	1%	50000.00	577.45	606.64	590.70	607.10	0.000249	5.86	13358.53	2859.07	0.20

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	200063.8 XS 3	1%	50000.00	578.10	606.69	590.49	607.15	0.000245	5.82	12870.17	2740.72	0.20
Upper	200271.2 I-196 West D/S	1%	50000.00	579.46	606.98	589.59	607.22	0.000134	4.23	16262.50	3032.67	0.15
Upper	200305.2 I-196 West		Bridge									
Upper	200340.0 I-196 West U/S	1%	50000.00	579.31	606.99	589.69	607.24	0.000139	4.30	16213.99	3154.72	0.15
Upper	200408.8 I-196 East D/S	1%	50000.00	579.17	606.99	589.79	607.25	0.000141	4.33	16135.06	3249.02	0.15
Upper	200443.2 I-196 East		Bridge									
Upper	200477.6 I-196 East U/S	1%	50000.00	579.02	607.01	589.88	607.27	0.000144	4.36	16074.16	3352.07	0.15
Upper	200751.0	1%	50000.00	579.44	607.02	589.93	607.32	0.000162	4.67	15116.86	3820.72	0.16
Upper	201024.4 XS 4	1%	50000.00	579.86	607.09	589.86	607.36	0.000154	4.61	18011.35	4113.69	0.16
Upper	201382.2	1%	50000.00	579.84	607.12	590.02	607.43	0.000172	4.86	16061.14	4258.31	0.17
Upper	201740.0	1%	50000.00	579.82	607.15	590.14	607.51	0.000189	5.11	13959.76	4291.87	0.18
Upper	202097.9 XS 5	1%	50000.00	579.80	607.15	590.15	607.62	0.000228	5.60	10754.69	4407.65	0.19
Upper	202531.5	1%	50000.00	579.48	607.23	590.29	607.73	0.000242	5.82	10379.25	2439.81	0.20
Upper	202965.1	1%	50000.00	579.16	607.32	590.40	607.85	0.000255	6.01	10113.36	1958.58	0.21
Upper	203398.8	1%	50000.00	578.84	607.42	590.56	607.97	0.000264	6.17	9877.55	1566.05	0.21
Upper	203832.4 XS 6	1%	50000.00	578.52	607.48	590.71	608.11	0.000296	6.58	9682.54	1168.26	0.22
Upper	204250.5	1%	50000.00	577.54	607.62	590.19	608.23	0.000280	6.50	9915.75	1511.98	0.22
Upper	204668.7 XS 7	1%	50000.00	576.56	607.83	589.74	608.35	0.000238	6.10	10733.50	2303.36	0.20
Upper	205080.5	1%	50000.00	577.23	607.96	589.95	608.45	0.000228	5.93	11124.11	3056.35	0.20
Upper	205492.2	1%	50000.00	577.91	608.10	590.22	608.55	0.000213	5.70	12475.73	3824.13	0.19
Upper	205904.0	1%	50000.00	578.58	608.26	590.75	608.64	0.000191	5.34	14054.63	4787.17	0.18
Upper	206315.8 XS 8	1%	50000.00	579.25	608.33	591.01	608.70	0.000122	5.28	14078.22	4563.20	0.18
Upper	206651.9	1%	50000.00	579.10	608.34	590.71	608.76	0.000129	5.40	11741.09	4291.74	0.18
Upper	206988.0	1%	50000.00	578.96	608.41	590.42	608.80	0.000117	5.13	11859.07	4219.18	0.17
Upper	207324.2 RR1 D/S	1%	50000.00	578.81	608.51	590.21	608.84	0.000103	4.79	12727.12	4243.73	0.16
Upper	207332.5 RR1		Bridge									
Upper	207340.5 RR1 U/S	1%	50000.00	578.81	608.54	590.21	608.88	0.000102	4.78	12746.36	4248.79	0.16
Upper	208327.8 XS 9	1%	50000.00	580.82	608.60	590.63	609.01	0.000124	5.21	10827.30	4406.32	0.18
Upper	208777.1 Wealthy St D/S	1%	50000.00	580.38	608.59	592.83	609.20	0.000195	6.41	9518.47	459.67	0.22
Upper	208814.8 Wealthy St		Bridge									
Upper	208859.8 Wealthy St U/S	1%	50000.00	580.88	608.64	592.84	609.26	0.000197	6.44	9233.99	442.06	0.22
Upper	209175.5 XS 10	1%	50000.00	580.32	608.89	591.35	609.33	0.000135	5.45	10929.15	931.80	0.19
Upper	209422.2 XS 11	1%	50000.00	581.42	609.12	590.21	609.38	0.000077	4.07	12826.16	999.80	0.14
Upper	209656.6 RR2 D/S	1%	50000.00	579.46	609.22	590.02	609.40	0.000065	3.47	15433.87	1047.70	0.12
Upper	209683.8 RR2		Bridge									
Upper	209711.4 RR2 U/S	1%	50000.00	574.98	609.44	589.41	609.62	0.000053	3.47	16824.29	4383.80	0.12
Upper	209996.9 XS 12A	1%	50000.00	579.10	609.45	591.33	609.78	0.000098	4.62	11044.75	3491.04	0.17
Upper	210676.0 XS 12B	1%	50000.00	580.55	609.57	590.77	609.84	0.000070	4.22	13418.07	4692.86	0.15
Upper	210918.9 XS 13	1%	50000.00	580.39	609.57	590.46	609.87	0.000070	4.50	13534.92	5225.22	0.15
Upper	211144.8 US Hwy 131 D/S	1%	50000.00	579.92	609.55	592.27	610.02	0.000112	5.52	11708.13	508.10	0.19
Upper	211242.4 US Hwy 131		Bridge									
Upper	211348.6 US Hwy 131 U/S	1%	50000.00	579.93	609.71	592.41	610.09	0.000120	5.13	11729.07	522.28	0.18

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	211561.3 XS 14	1%	50000.00	579.28	609.80	591.07	610.12	0.000094	4.59	12284.95	5092.07	0.16
Upper	211664.8 XS 15	1%	50000.00	579.11	609.81	591.01	610.13	0.000093	4.56	12013.73	5062.24	0.16
Upper	211868.1 Fulton St D/S	1%	50000.00	583.88	609.91	591.80	610.15	0.000076	3.95	13179.95	534.15	0.14
Upper	211918.1 Fulton St		Bridge									
Upper	211964.7 Fulton St U/S	1%	50000.00	582.95	610.44	592.31	610.68	0.000089	4.00	13255.94	564.53	0.14
Upper	212103.5 XS 16	1%	50000.00	585.58	610.44	593.97	610.79	0.000135	4.79	11083.31	1165.28	0.17
Upper	212334.2 XS 17	1%	50000.00	586.62	610.48	594.68	610.83	0.000140	4.78	11376.96	568.53	0.17
Upper	212414.5 ped bridge D/S	1%	50000.00	586.38	610.48	595.06	610.84	0.000151	4.90	10797.98	487.21	0.18
Upper	212431.8 ped bridge		Bridge									
Upper	212446.8 ped bridge U/S	1%	50000.00	586.06	610.81	594.77	611.16	0.000122	4.82	10972.26	483.42	0.18
Upper	212611.5 XS 18	1%	50000.00	586.59	610.84	595.07	611.18	0.000122	4.77	11714.64	6167.78	0.17
Upper	212980.5 XS 19	1%	50000.00	588.10	610.85	596.08	611.24	0.000146	5.08	10464.52	5549.54	0.19
Upper	213093.7 Pearl St D/S	1%	50000.00	588.27	610.90	596.09	611.26	0.000137	4.86	10708.53	5754.02	0.18
Upper	213128.6 Pearl St		Mult Open									
Upper	213163.8 Pearl St U/S	1%	50000.00	587.58	611.74	595.94	612.07	0.000118	4.65	11127.11	6267.17	0.17
Upper	213213.0 Dam No. 1 D/S	1%	50000.00	587.29	611.76	595.31	612.08	0.000111	4.60	11701.65	6282.95	0.17
Upper	213216.5 Dam No. 1		Inl Struct									
Upper	213220.0 Dam No. 1 U/S	1%	50000.00	589.64	611.80	597.12	612.17	0.000142	4.95	10911.27	6325.02	0.19
Upper	213489.9 ped bridge D/S	1%	50000.00	589.07	611.87	597.04	612.21	0.000130	4.73	11504.10	6501.25	0.18
Upper	213506.2 ped bridge		Mult Open									
Upper	213522.5 ped bridge U/S	1%	50000.00	588.79	611.95	596.67	612.29	0.000125	4.70	11328.38	6428.69	0.18
Upper	213666.4 XS 20	1%	50000.00	588.74	612.02	596.64	612.31	0.000112	4.45	12526.63	6226.18	0.17
Upper	213851.6 Dam No. 2 D/S	1%	50000.00	589.27	612.04	596.60	612.33	0.000111	4.46	12860.91	6660.28	0.17
Upper	213854.3 Dam No. 2		Inl Struct									
Upper	213856.9 Dam No. 2 U/S	1%	50000.00	590.75	612.10	598.17	612.42	0.000137	4.74	12181.41	6695.31	0.18
Upper	214151.6 XS 21	1%	50000.00	590.44	612.12	597.68	612.47	0.000137	4.77	11304.96	6728.53	0.18
Upper	214393.3 Dam No. 3 D/S	1%	50000.00	590.91	612.12	598.30	612.52	0.000160	5.11	10596.23	5914.27	0.20
Upper	214396.4 Dam No. 3		Inl Struct									
Upper	214399.5 Dam No. 3 U/S	1%	50000.00	591.64	612.18	599.30	612.61	0.000186	5.35	10169.93	5926.14	0.21
Upper	214526.8 Bridge St D/S	1%	50000.00	590.28	612.17	599.33	612.66	0.000208	5.69	9176.67	5433.90	0.22
Upper	214566.8 Bridge St		Bridge									
Upper	214608.3 Bridge St U/S	1%	50000.00	589.29	612.34	598.53	612.78	0.000175	5.36	9732.13	5214.89	0.20
Upper	214711.5 Dam No. 4 D/S	1%	50000.00	590.93	612.38	598.72	612.80	0.000171	5.23	9892.52	5149.64	0.20
Upper	214716.2 Dam No. 4		Inl Struct									
Upper	214720.8 Dam No. 4 U/S	1%	50000.00	592.64	612.45	600.75	612.96	0.000234	5.76	9009.23	5167.75	0.23
Upper	214870.9 XS 22	1%	50000.00	591.18	612.57	599.50	613.01	0.000186	5.36	9559.00	5212.98	0.21
Upper	215253.2 I-196 East D/S	1%	50000.00	591.78	612.70	600.39	613.09	0.000181	5.09	10563.13	2336.58	0.21
Upper	215284.2 I-196 East		Bridge									
Upper	215315.2 I-196 East U/S	1%	50000.00	591.81	612.74	600.27	613.13	0.000179	5.08	10389.76	1114.14	0.20
Upper	215330.5 I-196 West D/S	1%	50000.00	589.10	612.74	600.68	613.14	0.000191	5.15	10313.48	1157.62	0.21
Upper	215358.1 I-196 West		Bridge									
Upper	215385.6 I-196 West U/S	1%	50000.00	589.10	612.78	600.70	613.18	0.000191	5.15	10192.47	1323.58	0.21

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	215642.2 XS 23	1%	50000.00	589.43	612.84	599.96	613.23	0.000169	5.03	10635.54	4538.47	0.20
Upper	215862.7 XS 24	1%	50000.00	590.55	612.87	600.46	613.27	0.000180	5.09	10312.62	3633.76	0.21
Upper	216020.2 Dam No. 5 D/S	1%	50000.00	594.62	612.90	601.07	613.30	0.000192	5.08	10017.75	584.00	0.21
Upper	216028.2 Dam No. 5		Inl Struct									
Upper	216034.2 Dam No. 5 U/S	1%	50000.00	595.46	613.81	602.98	614.25	0.000637	5.36	9493.21	584.00	0.23
Upper	216378.8 XS 25	1%	50000.00	595.46	613.96	602.96	614.38	0.000222	5.26	10460.23	1139.90	0.22
Upper	216832.0 Sixth St D/S	1%	50000.00	595.58	614.03	603.66	614.50	0.000256	5.53	9065.39	1204.12	0.24
Upper	216850.9 Sixth St		Bridge									
Upper	216869.4 Sixth St U/S	1%	50000.00	595.17	614.07	603.44	614.53	0.000243	5.44	9280.49	1297.48	0.23
Upper	217611.5 XS 26	1%	50000.00	597.45	614.23	604.93	614.75	0.000308	5.77	8753.04	971.68	0.26
Upper	218588.5 XS 27	1%	50000.00	593.03	614.59	604.31	615.02	0.000240	5.24	9750.89	952.52	0.23
Upper	219354.2 XS 28	1%	50000.00	595.42	614.77	605.14	615.22	0.000265	5.36	9370.45	610.95	0.24
Upper	219767.8 Leonard St D/S	1%	50000.00	595.78	614.85	606.21	615.36	0.000327	5.70	8817.43	603.70	0.26
Upper	219802.8 Leonard St		Bridge									
Upper	219837.8 Leonard St U/S	1%	50000.00	595.94	614.91	606.30	615.43	0.000337	5.82	8693.58	593.04	0.27
Upper	220387.9 XS 29	1%	50000.00	595.96	615.05	606.68	615.65	0.000383	6.26	8589.53	1227.21	0.29
Upper	221221.6 XS 30	1%	50000.00	595.52	615.45	606.56	615.95	0.000311	5.64	8963.05	610.53	0.26
Upper	222516.4 XS 31	1%	50000.00	595.32	615.96	603.44	616.27	0.000171	4.54	11974.24	806.91	0.19
Upper	222717.4 RR3 D/S	1%	50000.00	594.50	615.97	605.95	616.33	0.000245	4.85	10951.84	1578.94	0.22
Upper	222724.2 RR3		Bridge									
Upper	222730.9 RR3 U/S	1%	50000.00	594.27	616.04	605.74	616.39	0.000278	4.73	11065.50	1580.36	0.21
Upper	222995.3 XS 32	1%	50000.00	596.99	616.20	604.67	616.46	0.000194	4.13	12621.10	2170.90	0.18
Upper	223275.7 XS 33	1%	50000.00	596.64	616.24	604.76	616.53	0.000214	4.36	11772.77	2092.65	0.19
Upper	223733.8 Ann St D/S	1%	50000.00	597.26	616.31	604.82	616.66	0.000243	4.72	10963.72	2158.48	0.20
Upper	223766.0 Ann St		Bridge									
Upper	223798.2 Ann St U/S	1%	50000.00	596.09	616.36	604.40	616.69	0.000221	4.58	11220.88	1843.83	0.19
Upper	224424.1 XS 34	1%	50000.00	597.27	616.50	604.73	616.83	0.000225	4.58	11312.55	2487.36	0.19
Upper	225261.3 XS 35	1%	50000.00	597.48	616.71	605.25	617.02	0.000223	4.50	12656.88	2322.81	0.19
Upper	227668.5 XS 36	1%	50000.00	596.58	617.28	605.32	617.45	0.000143	3.62	18326.23	3477.51	0.15
Upper	228851.2 XS 37	1%	50000.00	593.44	617.46	604.82	617.61	0.000122	3.58	21853.89	2667.15	0.14
Upper	231462.9 XS 38	1%	50000.00	591.34	617.75	604.84	617.90	0.000122	3.67	23656.71	2981.84	0.14
Upper	233807.3 XS 39	1%	50000.00	594.85	617.99	606.08	618.29	0.000181	4.67	14209.32	1577.66	0.19
Upper	234410.5 I-96 East D/S	1%	50000.00	596.93	618.12	605.20	618.39	0.000147	4.24	12422.30	718.00	0.17
Upper	234433.5 I-96 East		Bridge									
Upper	234457.4 I-96 East U/S	1%	50000.00	596.95	618.26	605.29	618.54	0.000146	4.25	12426.50	718.77	0.17
Upper	234504.4 I-96 West D/S	1%	50000.00	596.98	618.27	605.37	618.55	0.000150	4.29	12296.08	716.51	0.17
Upper	234529.4 I-96 West		Bridge									
Upper	234551.4 I-96 West U/S	1%	50000.00	597.00	618.34	605.44	618.62	0.000151	4.31	12322.49	718.00	0.17
Upper	234804.6 XS 45	1%	50000.00	597.02	618.36	605.73	618.68	0.000168	4.53	11550.44	2038.68	0.18
Upper	235082.5 N Park St D/S	1%	50000.00	594.55	618.47	604.74	618.73	0.000130	4.10	12762.58	2454.12	0.16
Upper	235119.7 N Park St		Bridge									
Upper	235157.2 N Park St U/S	1%	50000.00	595.31	618.54	604.84	618.79	0.000128	4.07	12798.57	2472.85	0.16

HEC-RAS Plan: Grand Rvr 2017 River: Grand River Reach: Upper Profile: 1% (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper	235474.7 XS 46	1%	50000.00	598.60	618.63	606.06	618.84	0.000123	3.74	14520.75	1822.31	0.16
Upper	236330.2 XS 40	1%	50000.00	599.54	618.74	606.71	618.94	0.000114	3.83	16581.00	1838.06	0.16
Upper	237272.0 XS 41	1%	50000.00	598.02	618.88	606.24	619.05	0.000106	3.56	20492.30	2421.47	0.15
Upper	239160.3 XS 42	1%	50000.00	597.84	619.09	606.30	619.25	0.000105	3.60	23573.72	2375.67	0.15
Upper	241690.0 XS 43	1%	50000.00	599.25	619.35	606.56	619.51	0.000106	3.64	25032.04	2749.73	0.15
Upper	244283.5 XS 44	1%	50000.00	595.51	619.60	605.35	619.79	0.000105	3.89	24816.71	2803.04	0.15

Grand River Flood Protection System
44 CFR 65.10 (b)(4 & 5)
Embankment and Foundation Stability and Settlement Analysis

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

fishbeck
Engineers | Architects | Scientists | Constructors

44 CFR 65.10 (b) (4) Tab

(4) *Embankment and foundation stability.*
Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, ''Design and Construction of Levees'' (EM 1110–2–1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).

P.E. Signature: Todd Munger

Non Applicable: _____

P.E. Name: Todd Munger

P.E. License Number and State: 6201058623, MICHIGAN

44 CFR 65.10 (b) (5) Tab

(5) *Settlement.* Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, ''Soil Mechanics Design— Settlement Analysis'' (EM 1100–2–1904) must be submitted.

P.E. Signature: Todd Munger

Non Applicable: _____

P.E. Name: Todd Munger

P.E. License Number and State: 6201058623, MICHIGAN

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October 28, 2019
Project No. 111266

Fishbeck, Thompson, Carr & Huber, Inc.
1515 Arboretum Drive SE
Grand Rapids, Michigan 49546

Attention: Mr. James E. Smalligan, P.E.
Senior Vice President

Reference: Embankment and Foundation Stability and Settlement Analysis Report
Grand River Floodwall and Embankment Stability
Grand Rapids, Michigan

Dear Mr. Smalligan:

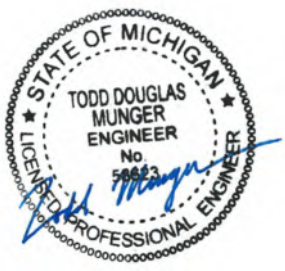
We have completed geotechnical engineering services related to the stability evaluation of the existing floodwalls and embankments in the City of Grand Rapids. Results of the study are presented in the attached report. This report supersedes our report dated March 16, 2018 and addresses comments in the FEMA Completeness Check and Comment letter dated May 3, 2019.

There are no significant indications of global or structural instability, excessive projected settlement or seepage of the existing floodwalls and embankments. Stability evaluations confirm acceptable factors of safety.

We appreciate this opportunity to provide engineering services to you. Please contact our office should you have any questions or require further assistance.

Sincerely,

MATERIALS TESTING CONSULTANTS, INC.



Todd D. Munger, P.E.
Project Manager

Steven M. Elliott, P.E.
President

att: Report

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EMBANKMENT AND FOUNDATION STABILITY AND SETTLEMENT ANALYSIS REPORT GRAND RIVER FLOODWALL AND EMBANKMENT STABILITY GRAND RAPIDS, MICHIGAN

Prepared For:

FISHBECK, THOMPSON, CARR & HUBER, INC.
Grand Rapids, Michigan

Prepared By:

MATERIALS TESTING CONSULTANTS, INC.
Grand Rapids, Michigan

October 2019
MTC Project No. 111266

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Materials Testing Consultants, INC.

EMBANKMENT AND FOUNDATION STABILITY AND SETTLEMENT ANALYSIS REPORT GRAND RIVER FLOODWALL AND EMBANKMENT STABILITY GRAND RAPIDS, MICHIGAN

1.0 INTRODUCTION

The City of Grand Rapids (City) has retained Fishbeck, Thompson, Carr & Huber, Inc. (FTCH) to undertake an assessment of the flood protection system along the Grand River as required by Federal Regulation (44CFR65.10). FTCH has retained Materials Testing Consultants, Inc. (MTC) to perform specific stability evaluations as required by the referenced Federal Regulation. Descriptions of the study methods and results are provided herein for the flood protection system. This work has been performed as described in our proposal dated June 12, 2012. This report supersedes our report dated March 16, 2018 and addresses comments in the FEMA Completeness Check and Comment letter dated May 3, 2019.

The scope of this study, in-general, includes the following:

- Task 1 - Information gathering and review of available existing information. Review available historic information including soil test boring logs, reports and as-built floodwall drawings. Conduct a walkover survey of the floodwalls and embankments to identify indications of global and structural instability.
- Task 2 - Perform foundation stability analyses as required by Paragraph 65.10.b.4 and settlement analyses as required by Paragraph 65.10.b.5 of the referenced Federal Regulation.
- Task 3 - Preparation of this report.

Presented herein are descriptions of background information pertaining to the study, the investigation methodology, investigation results, and conclusions. The Appendices contain boring location plans, boring logs and laboratory test data (Appendix A), engineering evaluations (Appendix B) and historic water level data (Appendix C).

1.1 Background

The Grand River flood protection system was constructed through numerous initiatives dating back to the late 1800's. Since that time and extending into the first two decades of the 1900's, a majority of the existing flood protection was constructed. Numerous modifications and improvements have been made on both private and public properties since the original construction. Flood protection within the system is comprised of both floodwalls and embankments. Floodwalls include gravity walls, cantilever walls, counterfort walls, hybrid walls containing properties of several wall types in addition to an integral floodwall-trunk sewer. A majority of the floodwalls were constructed using concrete, however, several of the gravity walls utilized stone and mortar construction methods as was popular in the late 1800's and early 1900's.

On October 6, 1989, Wade-Trim Associates submitted a report to the City entitled *The Grand River Floodwall/Embankment Study* providing a summary of the flood protection with respect to the 100-year flood elevation, the degree of scour based on wall probing, the structural condition of the floodwalls, outlets requiring back-flow control, areas where permanent or temporary pump facilities were needed as well as freeboard recommendations. In July 1995, FTCH submitted a report to the City entitled *The Grand River Floodwall & Embankment Improvements Implementation Plan* which presented alternatives and recommendations for flood protection improvements based on a review of the 1989 Wade-Trim study and a supplemental field investigation performed by FTCH considering 1982 FEMA 100-year flood elevations. Necessary increases in floodwall and embankment heights were discussed in the FTCH report in addition to recommendations corresponding to maintenance of existing floodwalls and storm water management. Maintenance and improvements to the Grand River flood protection system occurred in the following years based on recommendations in the 1995 FTCH report.

Development of the 2010 FEMA base flood model and subsequent 2015 FEMA base flood model for the Grand River in Grand Rapids has resulted in a general increase in the FEMA Base Flood Elevation (BFE) within the City limits. As a result of the increase, several areas of existing flood protection were deemed to no longer meet freeboard requirements per the referenced Federal Regulation. Certification of the Grand River flood protection system within the City of Grand Rapids based on "freeboard deficient" criteria has prompted the current study.

FTCH performed a comprehensive survey of the pipe penetrations and backflow prevention measures within the Grand River flood protection system and have divided the system into a series of reaches located both west and east of the Grand River which require some level of flood protection (embankment or floodwall) to protect upland areas below the base flood elevation. The reaches are shown on the attached Study Area Location Plan, Figure No. 1 and are summarized below:

East Side of Grand River

- Reach E1 – Knapp Street downstream to Leonard Street
- Reach E2 – Leonard Street downstream to Interstate Route 196 (I-196)
- Reach E3 – Gillett Pedestrian Bridge downstream to U.S. Route 131 (US 131)
- Reach E4 – US 131 downstream to 50% distance to the Water Resource Recovery Facility (WRRF)
- Reach E5 – WRRF Boundary

West Side of Grand River

- Reach W1 – U.S. Route 131 ramp crossing of railroad track in the City of Walker downstream to Indian Mill Creek and then up Indian Mill Creek along the north bank for approximately 2,400 feet to the second railroad bridge
- Reach W2 – Down Indian Mill Creek along the south bank from second railroad bridge crossing for approximately 2,400 feet to the confluence with the Grand River and then downstream to I-196
- Reach W3 – I-196 downstream to Fulton Street
- Reach W4 – Fulton Street downstream to the Butterworth Landfill

2.0 INVESTIGATION METHODOLOGY

2.1 Compilation and Review of Existing Information

Compilation and review of available existing information and conditions included researching our archive files and reviewing the provided existing floodwall and embankment drawings. Relevant boring logs, piezometer data and geotechnical reports were assembled and reviewed for projects performed within the study area. In total, over 600 logs from soil borings performed within the City limits adjacent to the Grand River, Plaster Creek and Indian Mill Creek were reviewed dating back to 1969. Location plans of the borings are included as Figures A-1 through A-14 in Appendix A as well as boring logs specific to stability analysis sections within each reach. We also reviewed drawings of the floodwall system, dating from 1909 to 1998, from City archives provided by FTCH as well as drawings pertaining to recent flood protection improvements prepared by FTCH in 2016.

2.2 Walkover Survey

Upon review of the available existing information, a walkover survey was conducted of the flood protection system to identify flood protection systems and representative sections for stability analyses and apparent indications of structural or global instability. The walkover survey was conducted by Mr. Steven M. Elliott, P.E. and Mr. Todd D. Munger, P.E. of MTC between October 23, 2012 and November 8, 2012. Our walkover survey did not include an assessment of internal structural stability, such as concrete strengths or size and spacing of reinforcing steel. Modifications to the flood protection system were designed by FTCH to address areas with protection below the base flood elevation as well as O&M issues. These modifications are reflected in the 2016 flood protection improvement drawings.

2.3 Subsurface Conditions

During the development of the area in the late 1800's and early 1900's, placement of available miscellaneous material was common to raise low-lying riverbank levels, to create additional property for development as well as flood protection for nearby residences and businesses, defining what is now the current river boundary. A majority of the existing riverbanks are therefore composed of miscellaneous fill material extending to depths up to 20 or 30 ft.

The miscellaneous fill material is composed of a primarily granular soil with occasional cohesive soil, boulder and cobble, organic material (topsoil, peat and wood), building debris, cinders, brick and the like. Directly adjacent to and within the river channel, granular glacial outwash and post-glacial alluvium are present below the miscellaneous fill material below which relatively shallow bedrock is present as previously discussed. Native cohesive soil is also encountered adjacent to and within the river channel most often in the form of highly weathered shale above more competent shale and gypsum. The bedrock is typically highly weathered near the top of rock with frequent fractures which transitions to more competent (massive) rock with depth.

Six supplemental conventional soil test borings (Borings B-1 through B-6, MTC Project No. 111266) were performed along with one hand auger boring (Boring B-5HA) within Reaches E1, W1, W2 and W4. In addition, 22 supplemental soil test borings (B-1 through B-22, MTC Project No. 111266.2) were completed around the perimeter of the embankment protecting the WRRF within Reach E5. These borings were completed where historical subsurface data was lacking and supplemental subsurface information was required. Flood protection improvements, including modifications described in Section 3.2, were completed following the completion of supplemental borings, however, the soil boring information utilized, and associated analyses are appropriately representative of the existing condition of the flood protection system.

A select number of representative samples collected from the borings were subjected to laboratory testing to approximate or confirm the engineering properties of the soil. Laboratory testing performed included the following:

- ASTM D 422 "Test Method for Particle-Size Analysis of Soils"
- ASTM D 4318 "Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils"
- ASTM D 2216 "Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures"
- ASTM D 1140 "Test Method for Material in Soils Finer than the No. 200 (75-µm) Sieve"
- ASTM D 2974 "Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils"
- ASTM D 3080 "Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions"
- USACE Method EM 1110-IV-1906 “Falling-Head Permeability Test with Permeameter Cylinder”

Index testing including particle size analysis, Atterberg Limits, moisture content and organic matter content were performed on a select number of samples to revise the field classification (ASTM D 2488) to the more refined ASTM D 2487 Standard Practice Classification of Soils for Engineering Purposes where appropriate. A summary of the laboratory test results and the individual laboratory test reports are provided in Appendix A.

2.4 Stability Analyses

The stability of the flood protection system was evaluated through the selection of representative embankment and floodwall sections within each reach with well documented geometries. With stability analysis sections selected, FTCH surveyed floodwall and embankment geometries at each section and provided the collected information to MTC including the 2015 BFE. Analyzed cross-sections represent existing conditions as described herein. The following table provides a summary of the location and flood protection type at stability evaluation sections.

Table 2.4.1 - Embankment and Floodwall Stability Section Summary

Reach	Section	Flood Protection Type	Address	2015 BFE (ft)	Top of Flood Protection (ft)
E1	E1A	Embankment	60 Ann St NW	616.4	618.3
	E1B	Embankment	1529 Monroe Ave NW	615.0	616.1
E2	E2A	Embankment	905 Monroe Ave NW	614.2	615.3
	E2B	Embankment / Floodwall	647 Monroe Ave NW	612.9	613.0
E3	E3	Counterfort Floodwall	21 Market Ave SW	610.0	610.3
E4	E4	Floodwall and Trunk Sewer	577 Market Ave SW	608.5	610.1
E5	E5	Embankment	1550 Market Ave SW	607.3	610.4
W1	W1	Cantilever Floodwall	400 Ann St NW	616.1	617.5
W2	W2A	Embankment	1930 Alpine Ave NW	616.1	624.0
	W2B	Gravity / Cantilever Floodwall	1300 Front Avenue NW	615.3	616.1
	W2C	Gravity Floodwall	750 Front Ave NW	614.2	616.4
W3	W3	Embankment	220 Front Ave SW	611.9	612.5
W4	W4A	Counterfort Floodwall	50 Front Ave NW	609.7	609.7
	W4B	Embankment	850 Wealthy St SW	608.5	609.3

Embankment and foundation stability analyses are required by Paragraph 65.10.b.4 of the referenced Federal Regulation. Specifically, the regulation requires seepage analyses and stability

evaluations during loading cases associated with the base flood. U.S. Army Corps of Engineers (COE) Manual "Design and Construction of Levees" (EM 1110-2-1913), Chapter 6, Section 2 is referenced by the regulation which provides required factors of safety associated with the loading cases under consideration. The loading cases and the corresponding required factors of safety are provided in Table 2.4.2.

Table 2.4.2 - Levee Stability Criteria (EM 1110-2-1913)

Case	Loading Description	Required Factor of Safety
Case I	Existing Condition	1.3
Case II	Sudden Drawdown	1.0 to 1.2
Case III	Steady State Seepage (BFE)	1.4
Case IV	Earthquake	> 1.0

For the Case I loading, effective stress parameters were utilized for both granular and cohesive soils while for Case II, III and IV loading, total stress parameters were used for cohesive soil to reflect the shear strength of the soil under short-term loading conditions.

In consideration of the presence of both embankment protection as well as floodwall protection within the flood protection system, the U.S. Army Corps of Engineers (COE) Manual "Retaining and Flood Walls" (EM 1110-2-2502) was reviewed for inland floodwall stability criteria. Required factors of safety and minimum eccentricities associated with four loading cases are provided in Table 4-2 of the manual and are summarized below in Table 2.4.3.

Table 2.4.3 - Inland Floodwall Stability Criteria (EM 1110-2-2502)

Case	Loading Description	Sliding and Global FS	Minimum Base Area in Compression, % (soil)	Minimum Base Area in Compression, % (rock)	Bearing Capacity FS
Case I1	Design Flood	1.50	100	75	3.0
Case I2	Water to top of wall	1.33	75	50	2.0
Case I3	Earthquake	1.10	Resultant within base	Resultant within base	>1.0
Case I4	Construction	1.33	75	50	2.0

Embankment and Floodwall Global Slope Stability

Global slope stability was evaluated considering failure towards the river for each of the four loading cases stipulated in EM 1110-2-1913 for both embankments and floodwalls. Slope failure away from the river (landside) was also evaluated considering steady state seepage conditions during the base flood and was found to not control given the relatively high landside elevation with respect to the top of flood protection.

Computer software SLIDE 6.0 was utilized to perform limit equilibrium slope stability analyses at the section locations. The Modified Bishop Method was utilized to compute the factor of safety against global slope stability failure for the four loading cases considered.

Earthquake Load Case

ER 1110-2-1806 is referenced by EM 1110-2-1913 for earthquake design and evaluation. Although no specific factor of safety is provided in the reference regarding earthquake loading, the reference states that the project "team is responsible for establishing the earthquake engineering requirements for the project, planning and executing the seismological and engineering investigations, and evaluating the results." The reference also describes that detailed site explorations, site-specific ground motion studies, and structural analyses are not necessary for projects located in Zones 0 and 1 and that preliminary values of the ground motions obtained from published seismic zone maps may be used to determine if seismic loading controls the design and to set the scope of any proposed site-specific studies. The study area is in Zone 0 with a very low risk for seismic activity and, therefore, it is considered that a detailed site exploration and determination of site-specific ground motions will not be necessary and a pseudostatic analysis will be sufficient.

The pseudostatic method is an inertial analysis method originally applied by Terzaghi (1950) where the cyclic nature of the earthquake is ignored, and the earthquake loading is applied as an additional static force acting through the centroid of the mass under consideration. The horizontal pseudostatic force (F_h) acts to decrease stability while the vertical pseudostatic force (F_v) typically has less impact on stability and is frequently neglected. The horizontal pseudostatic force acting upon the mass is equal to the product of the total weight of the mass (W) and the horizontal

pseudostatic coefficient (k_h) where k_h is equal to the maximum horizontal acceleration (a_{max}) divided by the acceleration due to gravity (g).

Per Kramer (*Geotechnical Earthquake Engineering*, Prentice Hall, 1996), psuedostatic coefficients used in practice generally correspond to acceleration values well below a_{max} because the body of mass is typically not rigid, and the peak acceleration occurs only for a very short time period. Kramer references a study performed by Hynes-Griffin and Franklin (1984) which concluded that earth dams with pseudostatic factors of safety greater than 1.0 using $k_h = 0.5a_{max}/g$ should not develop "dangerously large" deformations.

Conservatively, the peak ground acceleration (PGA) can be selected for a_{max} if the maximum horizontal acceleration is unknown. United States Geological Survey (USGS) 2008 Earthquake Hazard Maps of the Central/Eastern United States were used to select a PGA for the study area corresponding to an earthquake with a 10 percent probability of exceedance in 50 years (CEUS PGA 10%/50 years, 2008). A PGA of 2% g (0.02g) was selected. The PGA associated with 2 percent probability of exceedance in 50 years in the study area is also very near 2% g. The pseudostatic coefficient was then computed as follows:

$$k_h = 0.5 \times \frac{a_{max}}{g} = 0.5 \times \frac{0.02g}{g} = 0.01 .$$

Therefore, significant deformations are not anticipated when using a horizontal pseudostatic coefficient of 0.01 and where static stability safety factors are greater than 1.0.

Floodwall External Stability

With respect to floodwall stability, sudden drawdown is expected to represent the most critical load case due to the potential instability created by unbalanced hydrostatic pressure behind the floodwall, however, EM 1110-2-2502 makes no reference to the specific evaluation of a sudden drawdown load case for inland floodwalls. Due to the stabilizing effect of the hydrostatic pressure acting on the waterside of the floodwall during the design flood and the inconsequential impact of earthquake loading considering a factor of safety of 1.0 or greater is estimated, the suggested floodwall stability analysis procedure was modified to analyze the stability associated with the following load cases: (1) existing condition and (2) sudden drawdown.

As no specific "existing condition" or "sudden drawdown" analysis criteria are provided for floodwalls, floodwall stability was evaluated based on the criteria summarized below in Table 2.4-4, incorporating stability components of both EM 1110-2-1913 and EM 1110-2-2502.

Table 2.4.4 - Modified Inland Floodwall Stability Criteria

Case	Loading Description	Sliding and Global FS	Minimum Base Area in Compression (soil), Percent	Minimum Base Area in Compression (rock), Percent	Bearing Capacity FS
Case I	Existing Condition	1.3	75	50	2.0
Case II	Sudden Drawdown	1.0	Resultant within base	Resultant within base	>1.0

Sudden Drawdown

Per EM 1110-2-1913, sudden drawdown represents an analysis condition whereby a prolonged flood stage saturates at least a major part of the upstream embankment (or floodwall backfill) and then falls faster than the soil can drain, resulting in full-height unbalanced water head conditions which occur instantaneously without consideration of expected drawdown rates. Federal Regulation (44CFR65.10) states levee embankment stability analyses must be submitted based on ***expected*** seepage during loading conditions associated with the base flood. Based on historic water level measurements and observations during drawdown events, we conclude, as described herein, it is unrealistic to apply full-height sudden drawdown parameters when evaluating floodwall stability as this condition is not applicable to the Grand River flood protection system.

In order to estimate expected drawdown rates and the corresponding expected drawdown loading condition upon embankments and floodwalls, Grand River level data was collected and reviewed against landside groundwater level data collected from piezometers installed behind floodwalls as well as within flood protection embankments. Piezometer locations are summarized in Table 2.4.5.

Table 2.4.5 - Historical Piezometer Location Summary

Project/Event	Year	Purpose
Convention Center	2000	Monitor groundwater immediately behind floodwall
Plaza Towers	2013	Monitor groundwater during 2013 Grand River flood event
GVSU Eberhard	2017	Monitor groundwater levels within embankment protection

Piezometer locations are provided in Figure C-1 located within Appendix C. Figures C-2, C-3 and C-4 (Appendix C) provide a graphical representation of landside groundwater and Grand River water levels as a function of time and provide insight into the groundwater behavior adjacent to the river during river flood and drawdown events. Of particulate importance, Figure C-3 includes data collected during the 2013 Grand River flood event where the river crested at a historic high of 21.85 ft (el 607.55) in downtown Grand Rapids.

Each high river event was prompted by significant regional precipitation resulting in prolonged high river levels with the peak river crest followed immediately by negligible regional precipitation resulting in drawdown. River level data confirms that instantaneous drawdown does not occur within the system but, rather, river levels decrease at a maximum drawdown rate of 1 to 2 ft per day when considering weather conditions which would facilitate maximum drawdown. Piezometer data concludes landside groundwater elevations immediately behind floodwalls and within embankments closely follow adjacent Grand River water levels. Landside groundwater levels were found to react to river level drawdown almost immediately with groundwater elevations measured to be within approximately 1 to 3 ft of adjacent river levels at each measurement interval.

Considering the similarity in subsurface conditions and associated drainage properties throughout the system and historical water level data presented, we conclude full-height sudden drawdown loading conditions are not applicable to the Grand River flood protection system as expected seepage during river drawdown results in a “controlled” drawdown rate with a maximum head differential of 3 ft. As a result, a more appropriate “controlled” drawdown condition was evaluated whereby a maximum allowable head differential was calculated for each floodwall section required to maintain a stable condition and compared to the expected maximum head differential of 3 ft to confirm minimum stability requirements.

Steady State Seepage – Embankments, Floodwalls

Steady state seepage was analyzed during the base flood event at each section with the exception of floodwalls bearing upon or within bedrock where excessive seepage is not expected. At locations where seepage faces were predicted to form on the landside of the flood protection, the critical hydraulic gradient (i_{cr}) was analyzed to evaluate the likelihood of piping or heave. Computer software SLIDE 6.0 was utilized to perform finite element steady state seepage analyses (where appropriate) at the section locations. Steady state seepage analyses were performed for the base flood which evaluated the steady state groundwater surface behind the floodwall or embankment, the hydraulic gradient and the presence of potential seepage faces where applicable.

Steady State Seepage – Outfalls

Per Paragraph 65.10.b.2 of the referenced Federal Regulation, "all outfalls must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice." In the City of Grand Rapids flood protection system, all outfalls with inlets below the base flood elevation have backflow prevention (closure devices) in the form of flap gates, valves, duckbills or sluice gates, most of which are mounted to a floodwall or headwall on the riverside of the flood protection. Headwalls have wing walls designed to protect flap gates from ice damage that has commonly been experienced in the past. When it is not feasible to construct a headwall, backflow prevention is provided in manhole structures on the landside of the flood protection. This has proven to be an effective measure against ice damage while allowing for more efficient inspection and maintenance.

It has been the City's practice to not install backflow prevention (closure devices) on outfalls with inlets above the BFE. These outfalls serve either upland areas above the BFE, roof drains or have inlets only on the riverside of the levee. Prior to 1980, it was standard practice to grout sealed pipe joints to prevent leakage. Since 1980, rubber O-ring gasketed joints have been used. The flood protection at these outfall locations are either floodwalls or broad earthen embankments with a protected landside ground surface less than 4 ft below the BFE. No instability related to seepage from these pipes has been reported in the past.

To demonstrate potential seepage associated with outfalls which do not contain riverside closure devices will not jeopardize the stability of the flood protection system, four steady state seepage

outfall analysis locations were evaluated (Outfalls 29, 48, 56 and 112). Analysis locations were originally numbered by FTCH and were selected to evaluate large diameter pipes which do not contain modern rubber gasketed joints with limited ground cover relative to the adjacent BFE. FTCH provided cross sections and pipe diameters to assist in the development of each seepage model. A total water head equal to the adjacent river BFE was considered within each pipe extending from the outlet to landward of the flood protection (embankment or floodwall) to model a pipe hydraulically connected to the river. Although a structurally sound pipe with intact joints is not expected to result in excessive seepage forces, the risk of instability was evaluated by modeling a failure at the pipe crown consisting of a 6-inch wide opening and the corresponding exit hydraulic gradient at the ground surface adjacent to the flood protection system was analyzed using SLIDE 6.0 software. The risk of instability (piping or heave) was evaluated by comparing the estimated exit hydraulic gradient (i) to the critical hydraulic gradient (i_{cr}). A summary of analysis locations is provided in Table 2.4.6.

Table 2.4.6 - Outfall Steady State Seepage Analysis Section Summary

Reach	Section	Pipe Type	Flood Protection Type
E1	Outfall 56	48-inch RCP Storm Sewer (1936)	Embankment
W2	Outfall 112	42-inch RCP Storm Sewer (1963)	Floodwall
E2	Outfall 48	54-inch RCP Storm Sewer (1962)	Embankment / Floodwall
E3	Outfall 29	60-inch RCP Storm Sewer (1991)	Embankment

Settlement

Settlement analyses are required by Paragraph 65.10.b.5 of the referenced Federal Regulation. Specifically, the regulation requires an assessment of the potential and magnitude of future losses of freeboard as a result of settlement based on guidance referenced in COE Manual "Engineering and Design – Settlement Analysis" (EM 1110-1-1904).

At each stability evaluation section, settlement and the potential impact due to loss of freeboard was evaluated considering total settlement (immediate settlement, primary consolidation, secondary consolidation and decomposition of organic material where applicable) based on the subsurface conditions encountered in adjacent soil borings or supplemental borings which can be found in Appendix A for reference. Immediate settlement in granular soil was estimated utilizing

the Hough Method while consolidation settlement in cohesive soil was estimated utilizing one-dimensional consolidation theory. Cohesive soil was conservatively considered to be normally consolidated. Where organic soil was encountered, settlement associated with secondary consolidation and decomposition of organic material was estimated considering a 100-year design life. The load increase considered at each stability evaluation section is summarized in Table 2.4.7 and is based on information contained in provided flood protection improvement drawings provided by FTCH and described in Section 3.2

Table 2.4.7 – Settlement Analysis Summary

Reach	Section	Flood Protection Type	Recent Flood Protection Improvements	Proposed Load Increase (psf)
E1	E1A	Embankment	None	0
	E1B	Embankment	None	0
E2	E2A	Embankment	None	0
	E2B	Embankment / Floodwall	Increase embankment height by 2 ft	240
E3	E3	Counterfort Floodwall	None	0
E4	E4	Floodwall and Trunk Sewer	None	0
E5	E5	Embankment	Increase embankment height by average of 1.5 ft	180
W1	W1	Cantilever Floodwall	None	0
W2	W2A	Embankment	None	0
	W2B	Gravity / Cantilever Floodwall	None	0
	W2C	Gravity Floodwall	None	0
W3	W3	Embankment	Increase embankment height by 1.5 ft	180
W4	W4A	Counterfort Floodwall	Increase top of floodwall by 1 ft	12
	W4B	Embankment	None	0

3.0 INVESTIGATION RESULTS

3.1 Walkover Survey

In general, no obvious signs of structural or global instability were identified during our walkover survey of the existing floodwalls and embankments. Based on observations during the survey, a brief description of observed flood protection within each reach is summarized in Table 3.1.1.

Table 3.1.1 - Reach Flood Protection Summary

Reach	Flood Protection
E1	Embankments along the east bank of the Grand River
E2	Combination of embankments north of the 6th Street Dam and a cantilever and gravity retaining wall south of the 6th Street Dam to immediately south of I-196
E3	Floodwalls including concrete cantilever and counterfort walls and gravity stone and mortar walls. A 300 ft length of the river's edge located immediately north of the Blue Bridge is protected by the west exterior concrete foundation and masonry building wall of 55 and 85 Campau Avenue NW.
E4	Embankments provide most the flood protection within the northern half of Reach E3 with the southern half protected by an integral floodwall and trunk sewer structure
E5	Embankments provide flood protection around the perimeter of the WRRF with respect to the adjacent Grand River and Plaster Creek with additional groundwater control provided by groundwater pumping within the WRRF property
W1	Embankments and concrete cantilever retaining walls
W2	Counterfort, gravity and cantilever retaining walls. The southern and northern extents of the reach are protected by embankments.
W3	Natural ground elevations as well as embankments
W4	A counterfort retaining wall provides flood protection within the northern half of the reach with the southern half protected by embankments.

3.2 Flood Protection Modifications

Following the walkover survey, flood protection modifications and improvements were designed and implemented by FTCH and the City to provide freeboard equal to or above the base flood elevation, repair aging infrastructure and install backflow prevention onto existing storm sewer penetrations. A summary of individual flood protection improvement contracts is provided:

- Improvements to berms at the Wastewater Treatment Plant
- Contract No. 1 – Backflow prevention improvements throughout flood protection system
- Contract No. 2 – Freeboard and Embankment Protection Improvements
  - Concrete retaining wall construction at 700 Wealthy Street, 624 Front Avenue, 2204 to 2280 Turner Avenue, 509 Wealthy Street, 201 Market and 647 Monroe Avenue

  - Sheet pile wall installation at 509 Wealthy Street
  - Increase embankment height up to approximately 2 ft at 647 Monroe Avenue and 1781 Broadway Avenue
  - Floodwall cap construction up to approximately 15-inches in height placed at 50 and 210 to 240 Front Street, 417 Watson Street, 449 Market and 201 Market
  - Storm sewer and flap gate installation at 1781 Broadway Avenue
- Contract No. 3 – Freeboard and embankment protection improvements at 58 and 220 Front Avenue and 272 Pearl Street including concrete retaining wall construction, reconstruction of Indian Mounds Park and increasing the embankment height by 1.5 ft at Ah Nab Awen Park.

In addition to the described flood protection modifications to satisfy freeboard deficient criteria, FTCH has updated the Grand Rapids Flood Protection System Emergency Action Plan containing provisions for strategic permanent closures during flood stage above the BFE. Although supplemental soil borings were performed prior to flood protection modifications, the soil boring information utilized, and associated analyses reflect the existing condition of the flood protection system as described herein.

3.3 Regional Geology

The *Map of the Surface Formations of the Southern Peninsula of Michigan*, published by the State of Michigan, indicates the site is in an area of glacial outwash. The Grand River valley is known to have been a major channel of glacial water flows. Near-surface soil conditions typically are found to be primarily granular with numerous cobbles and boulders. Several areas along the west and east riverbanks are known to have been low-lying areas prior to development of the area and have been filled with a variety of uncontrolled urban fill materials.

Relatively shallow bedrock is present below the Grand River within Grand Rapids which includes a limestone and sandstone cap of the Bayport Formation north of the Lyon Street alignment. Near the Lyon Street alignment, the Bayport Formation ends, and the underlying weathered shale and gypsum of the Michigan Formation continues south below overburden soil. Near Pearl Street and south where the Bayport Limestone is absent, the Michigan Formation Shale is approximately 10 to 30 ft below the riverbed.

3.4 Supplemental Test Borings

The subsurface conditions in the supplemental soil borings confirm the presence of miscellaneous fill material along floodwalls and within embankments overlying granular and cohesive soil and bedrock. The miscellaneous fill material typically consists of variable granular soil with occasional cinders, wood fragments, brick and topsoil-like material. The most commonly encountered granular soils included *poorly graded sand* (SP), *poorly graded sand with silt* (SP-SM), *poorly graded sand with clay* (SP-SM), *silty sand* (SM) and *clayey sand* (SC) while the most commonly encountered cohesive soil was *lean clay* (CL).

Reaches E1, W1, W2 and W3

Six conventional soil test borings, Borings B-1 through B-6 (MTC Project No. 111266), were performed behind floodwalls and near the top of embankments to obtain subsurface information at Sections W3, W2C, E1B, E1A, W2A and W1, respectively, where existing subsurface information was not available or was incomplete for stability analysis purposes. A hand auger boring (Boring B-5HA) was performed to evaluate the material near a railroad embankment (Section W2A) where drill rig access was not possible.

Borings B-1 through B-3 and B-6 were extended to refusal at depths varying from 13.5 to 25.1 ft on bedrock or possible boulder/cobble while Borings B-4 and B-5 were performed to a depth of 40 ft below existing grade. The very dense gravel and silt material encountered near the explored depth at Borings B-1 and B-4 may represent a stratum of highly weathered bedrock material overlying more competent bedrock.

At Boring B-3, approximately 5.5 ft of black loose *poorly graded sand* (SP), anticipated to be composed primarily of cinders, was encountered overlying approximately 7.5 ft of dark brown to black very loose *silty sand with gravel* (SM) topsoil. Bedrock was encountered at approximately 13 ft. The cinder material was likely placed as railroad embankment over the topsoil fill material prior to track placement.

Table 3.4.1 provides a summary of the subsurface conditions encountered at supplemental boring locations performed within Reaches E1, W1, W2 and W3.

Table 3.4.1 - Supplemental Soil Boring Summary

Boring No.	Stability Section No.	Ground Surface Elev. (ft)	Boring Depth (ft)	Groundwater Elev. (ft)	Fill Depth (ft)	Bedrock Elev. (ft)
B-1	W3	611.29	25.1	596.3	17	NA
B-2	W2C	611.73	14.1	606.2	11	598.7
B-3	E1B	614.73	13.5	606.8	13	601.7
B-4	E1A	618.42	40.0	604.4	12	NA
B-5	W2A	613.79	40.0	605.8	8	NA
B-5HA	W2A	NA	8.7	NA	NA	NA
B-6	W1	614.44	18.5	606.4	5.5	NA

Reach E5

Twenty-two conventional soil test borings, Borings B-1 through B-22 (MTC Project No. 111266.2) were performed along the perimeter of the embankment protecting Reach E5, encountering variable layers of uncontrolled fill overlying layers of native clay, silt and sand, in-turn overlying shale and gypsum bedrock. Intermediate strata of silt, peat, and gravel were occasionally encountered. The peat deposits were encountered in Borings B-18 and B-22 near the southeast corner of the property at a depth close to the normal water level of the Grand River and the original ground surface elevation of the site prior to development. Wood fragments and roots were noted in the fill. Wood (presumably a fallen tree beneath the fill) was found in Boring B-13 between the 12 and 15 ft depth.

Bedrock, varying from weathered shale to fragmented gypsum, was encountered at elevations between el 564 and el 589. Most borings had some samples with poor recovery, possibly due to the presence of coarse gravel or cobbles. Boring B-3 experienced auger refusal at 26.5 ft deep, in a gravel stratum. Boring B-4A, completed with a hand auger, was abandoned at 4.5 ft due to auger refusal, likely caused by cobbles. Boring B-8 experienced auger refusal at 5 ft and cobble was present in the auger cuttings at the point of refusal.

Groundwater was encountered between el 576 and el 595 ft. It should be noted that groundwater levels measured during drilling are influenced by the amount of pumping within the WRRF property, adjacent river and creek levels and other factors.

The described relative density of the granular soil is based on the SPT N-values while the estimated unconfined compressive strength of cohesive soil (provided in the logs) is based on calibrated penetrometer readings. The boring logs located in Appendix A should be reviewed for detailed soil descriptions as deviations from the provided descriptions do exist.

Groundwater levels measured during drilling are influenced by adjacent river and creek levels which vary with several factors. Water levels will vary with time.

3.5 Laboratory Test Results

Laboratory testing was performed on select soil samples to validate soil properties utilized in stability analyses. A summary of notable laboratory results is provided herein. A comprehensive summary of laboratory data is provided in Appendix A.

Reaches E1, W1, W2 and W3

Direct Shear Testing (ASTM D 3080) was performed on samples of granular fill material collected at Borings B-1, B-3 and B-4. Effective friction angles and effective cohesion through Direct Shear Testing ranged from approximately 44 to 51 degrees and 0.063 to 0.182 tsf.

Organic Content Testing (ASTM D 2974) confirmed the presence of organic material at Borings B-3 and B-4. The dark brown to black *silty sand with gravel* (SM) fill encountered at Boring B-3 was determined to have an organic content of 8.5 percent and likely represents an assortment of miscellaneous material including topsoil and granular soil which was used to fill the area. At Boring B-4, the gray *sandy organic clay* (OH) was determined to have an organic content of 9.4 percent and likely was once near or at the former ground surface prior to fill placement.

Reach E5

Permeability testing on 15 soil samples yielded hydraulic conductivities ranging from $1.1x10^{-5}$ to $1.2x10^{-2}$ cm/s. Direct Shear Testing on two samples of granular fill material collected from Borings B-12 and B-14 yielded effective friction angles and effective cohesion ranging from approximately 28.2 to 43.4 degrees and 0.176 to 0.375 tsf.

The laboratory effective friction angles were significantly higher than the effective friction angles utilized in our stability analyses. Effective cohesion within the granular fill material was not considered in our stability analyses.

3.6 Stability Analyses

Results of stability analyses are provided herein with comprehensive results for slope stability, floodwall stability, steady state seepage and settlement as well as geotechnical parameters considered organized by reach provided in Appendix B.

Global Slope Stability

A summary of estimated global slope stability factors of safety is provided in Table 3.6.1.

Table 3.6.1 - Global Slope Stability Summary

Reach	Section	Flood Protection Type	Global Factor of Safety			
			Case I Existing Condition	Case 2 Sudden Drawdown	Case 3 Steady State Seepage	Case 4 Earthquake
E1	E1A	Embankment	1.31	1.72	5.83	2.15
	E1B	Embankment	2.43	1.07	2.35	2.22
E2	E2A	Embankment	2.44	1.90	3.43	2.25
	E2B	Embankment / Floodwall	1.99	1.21	2.54	1.94
E3	E3	Counterfort Floodwall	1.79	1.09	2.42	1.76
E4	E4	Floodwall and Trunk Sewer	2.80	>10	>10	>10
E5	E5	Embankment	1.70	1.50	1.80	1.70
W1	W1	Cantilever Floodwall	2.15	1.00	3.44	2.08
W2	W2A	Embankment	2.76	1.75	2.72	2.63
	W2B	Gravity / Cantilever Floodwall	2.32	1.78	4.98	2.27
	W2C	Gravity Floodwall	2.54	2.03	5.33	2.48
W3	W3	Embankment	3.42	1.77	4.06	3.42
W4	W4A	Counterfort Floodwall	1.78	1.08	5.11	1.74
	W4B	Embankment	2.23	1.25	2.67	2.14

Global slope stability evaluations confirm acceptable factors of safety considering existing conditions, sudden drawdown, steady state seepage and earthquake loading cases. The minimum global factor of safety for sudden drawdown at Section W1 is equal to 1.00 which meets the minimum recommended factor of safety for existing levees per Table 6.1b of EM 1110-2-1913 and captures the most critical factor of safety for the existing conditions in Reach W1.

Floodwall External Stability

Results of floodwall external stability evaluations are provided below in Table 3.6.2.

Table 3.6.2 - Floodwall External Stability Summary

Reach	Section	Flood Protection Type	Load Case	Hydro. Head Diff. (ft)	Base Area In Comp. (%)	FS Bearing	FS Over-turning	FS Sliding
E2	E2B	Embankment and Cantilever Floodwall	EC	0.0	100	>3	5.10	2.68
			SD	8.0	Resultant within Base	>3	1.00	1.14
E3	E3	Counterfort Floodwall	EC	0.0	100	>3	5.91	2.16
			SD	14.0	64	>3	1.42	1.05
E4	E4	Floodwall and Trunk Sewer	EC	0.0	100	>3	3.02	2.00
			SD	6.7	100	>3	1.48	1.00
W1	W1	Cantilever Floodwall	EC	0.0	100	>3	17.88	9.05
			SD	5.5	100	>3	4.77	3.00
W2	W2B	Gravity / Cantilever Floodwall	EC	0.0	90	>3	6.35	2.44
			SD	7.5	Resultant within Base	>3	1.01	1.19
	W2C	Gravity Floodwall	EC	0.0	89	>3	1.57	2.06
			SD	3.0	Resultant within Base	>3	1.00	1.56
W4	W4A	Counterfort Floodwall	EC	0.0	100	>3	4.55	1.86
			SD	8.3	71	>3	1.61	1.00

Existing floodwalls meet stipulated factors of safety associated with slope stability (Table 3.6.1), bearing and sliding as well as the percent of base area in compression considering the existing condition (EC) load case.

The calculated maximum allowable head differential required to maintain a stable floodwall condition meets or exceeds the maximum measured head differential of 3 ft based on historic water level measurements with justification for a "controlled" drawdown rate analysis provided in Section 2.4. Existing floodwalls are judged to be stable with respect to sudden drawdown.

Steady State Seepage – Embankments, Floodwalls and Outfalls

Steady state seepage conclusions are provided in Table 3.6.3.

Table 3.6.3 - Steady State Seepage Summary

Reach	Section	Flood Protection Type	Seepage Analysis Performed	Seepage Faces Present on Landside of Protection	i / i_{cr}	Piping/ Heave Expected
E1	E1A	Embankment	Yes	Yes	0.12 / 0.84	No
	E1B	Embankment	Yes	No		No
	Outfall 56	Embankment	Yes	Yes	0.39 / 0.84	No
E2	E2A	Embankment	Yes	No		No
	E2B	Embankment / Floodwall	Floodwall Bears on Bedrock			No
	Outfall 48	Embankment / Floodwall	Yes	Yes	0.25 / 0.84	No
E3	E3	Counterfort Floodwall	Yes	No	0.50 / 0.84	No
	Outfall 29	Embankment	Yes	No		No
E4	E4	Floodwall and Trunk Sewer	Floodwall Bears on Bedrock			No
E5	E5	Embankment	Yes	Yes	0.15 / 0.84	No
W1	W1	Cantilever Floodwall	Yes	No		No
W2	W2A	Embankment	Yes	No		No
	W2B	Gravity / Cantilever Floodwall	Floodwall Bears on Bedrock			No
	W2C	Gravity Floodwall	Floodwall Bears on Bedrock			No
	Outfall 112	Gravity Floodwall	Yes	Yes	0.20 / 0.84	No
W3	W3	Embankment	Yes	Yes	0.17 / 0.84	No
W4	W4A	Counterfort Floodwall	Yes	No		No
	W4B	Embankment	Yes	No		No

Steady state seepage evaluations conclude piping and heave is not expected to occur as a result of excessive seepage forces. The seepage analyses performed are judged to be applicable to all pipe penetrations not equipped with flag gates and which have outlet elevations below the BFE and invert elevations above the BFE. Based on our understanding of the conditions as described, pipe penetrations within the system will not jeopardize the stability of the flood protection system.

Settlement

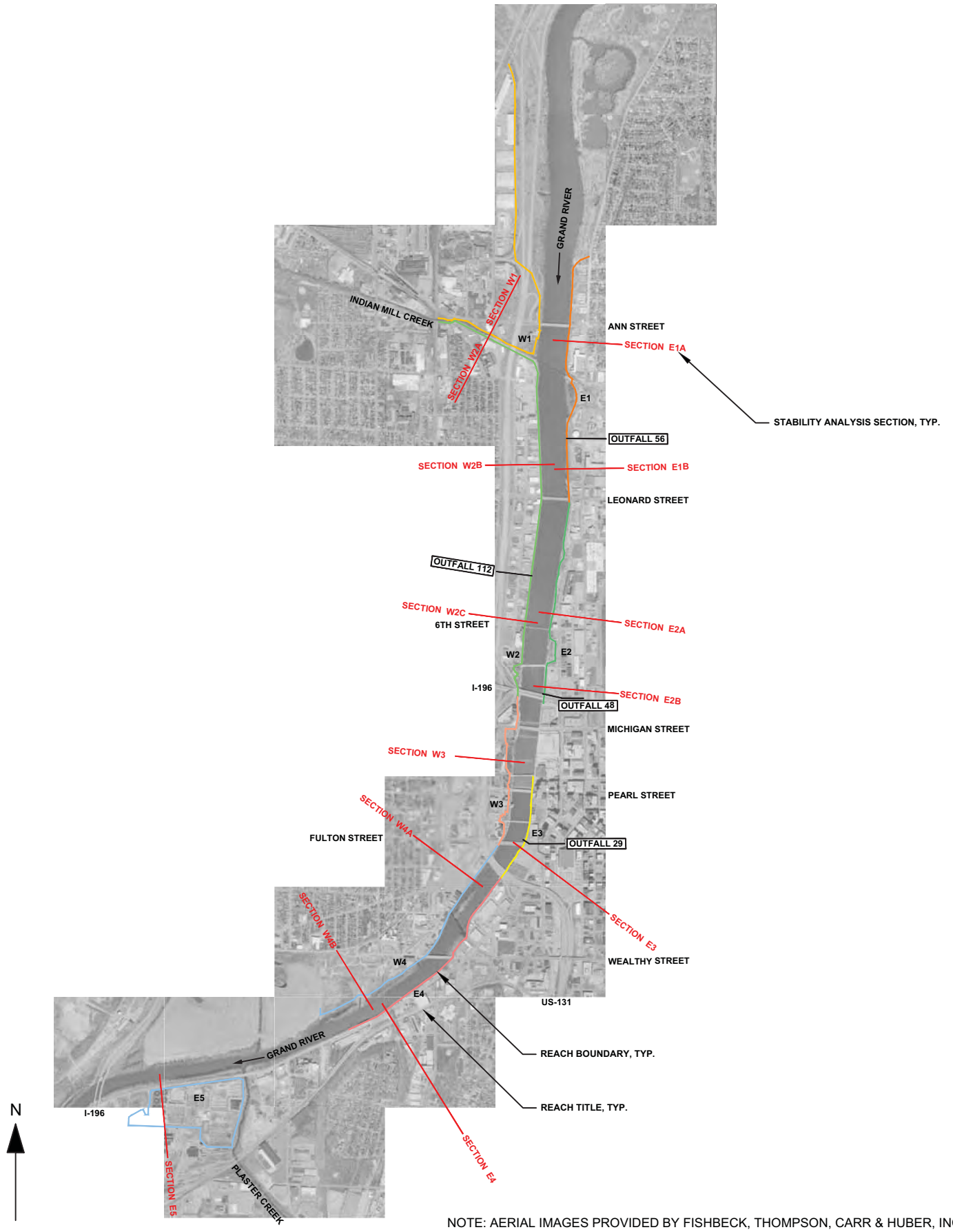
Table 3.6.4 provides a summary of the magnitude of future losses of freeboard as a result of settlement at each analysis section. A stress increase corresponding to flood protection improvements completed or planned in the future was utilized to evaluate the magnitude of future settlement (immediate settlement, primary consolidation, secondary consolidation and decomposition of organic material). A design life of 100 years was considered for secondary consolidation calculations.

Table 3.6.4 - Settlement Summary

Reach	Section	Flood Protection Type	Estimated Future Settlement (in)
E1	E1A	Embankment	2.9
	E1B	Embankment	4.1
E2	E2A	Embankment	0.0
	E2B	Embankment / Floodwall	0.7
E3	E3	Counterfort Floodwall	0.0
E4	E4	Floodwall and Trunk Sewer	1.5
E5	E5	Embankment	1.9
W1	W1	Cantilever Floodwall	0.0
W2	W2A	Embankment	0.0
	W2B	Gravity / Cantilever Floodwall	0.0
	W2C	Gravity Floodwall	0.0
W3	W3	Embankment	0.6
W4	W4A	Counterfort Floodwall	0.1
	W4B	Embankment	4.4

The soil borings utilized, and associated analyses reflect the existing conditions of the flood protection system. Although some future settlement of embankments and floodwalls is expected, our analyses conclude minimum freeboard requirements will be maintained.

Figures



NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

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SCALE: 1" = 3000'	DATE: 2-27-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: 1	DR. BY: TM	REV. BY: SE	

APPENDIX A – Geotechnical Data

- **Boring Location Plans (Figures A-1 through A-14) p**
- **Boring Logs at Stability Analysis Sections p**
- **Boring Log Terminology p**
- **oil Classification pharts p**
- **ummary of Laboratory Test Data** H

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LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-1	DR. BY: TM	REV. BY: SE	



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TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
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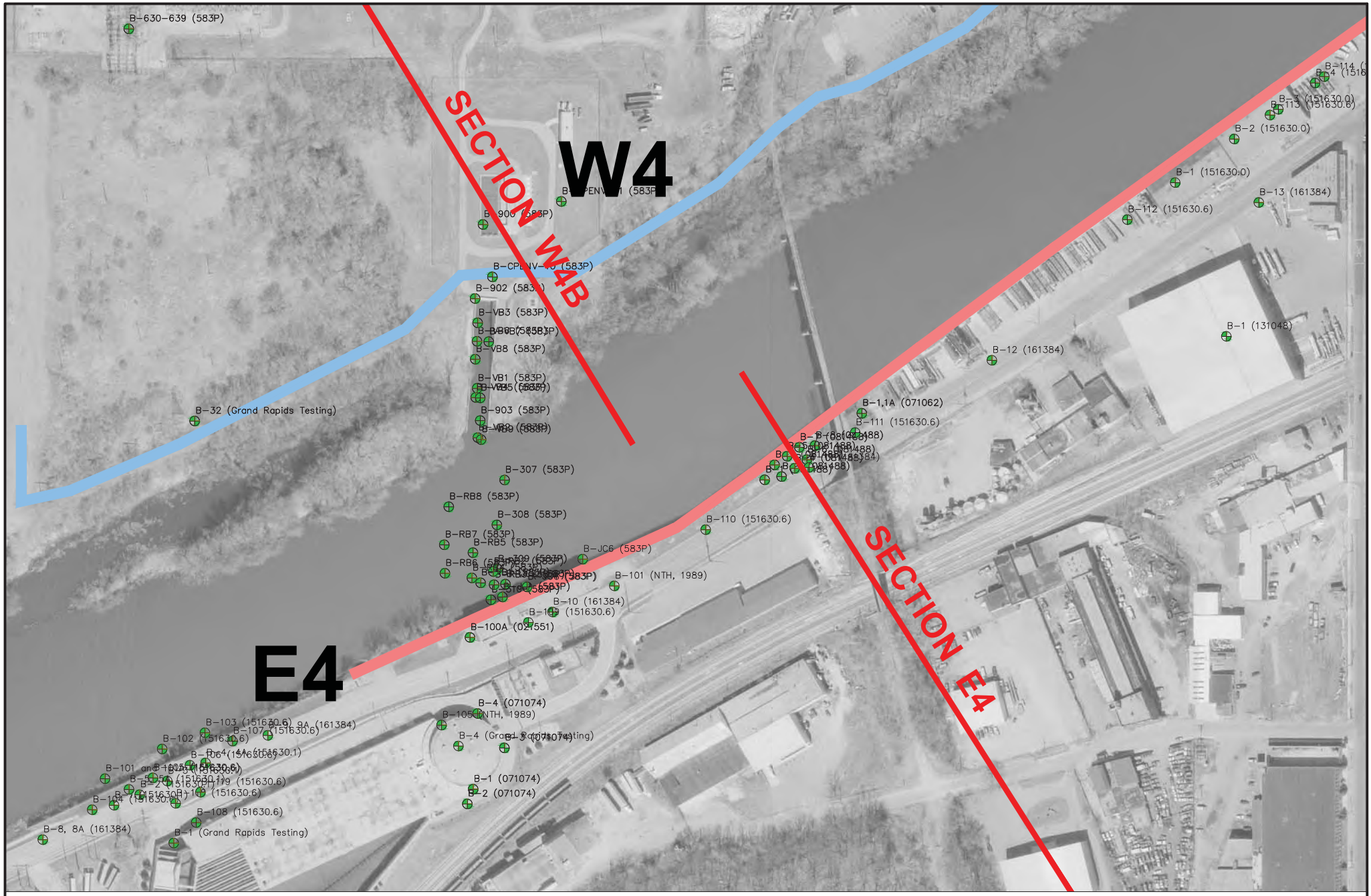

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NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

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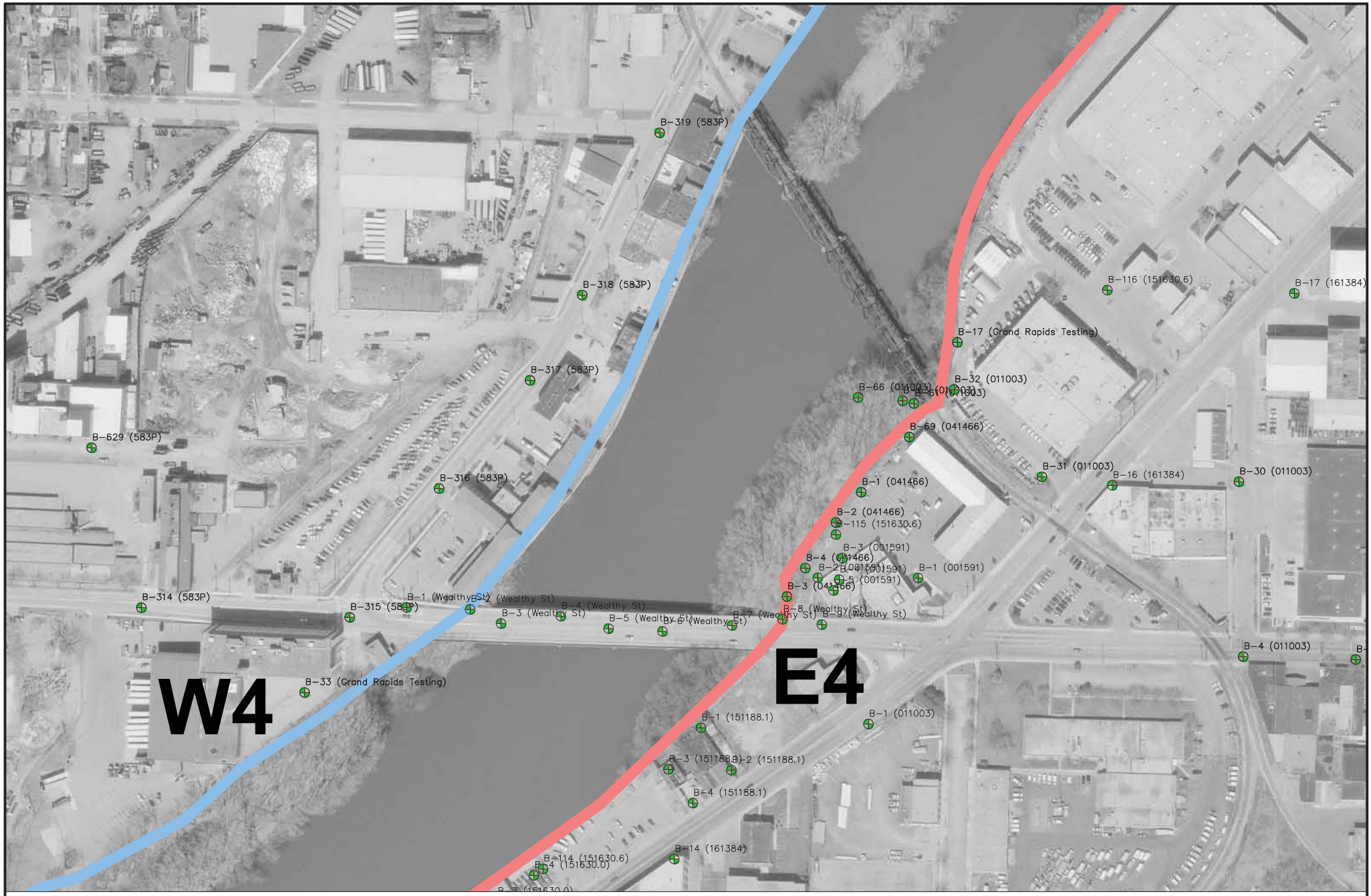
FIG. NO.: A-3	DR. BY: TM	REV. BY: SE	



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NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

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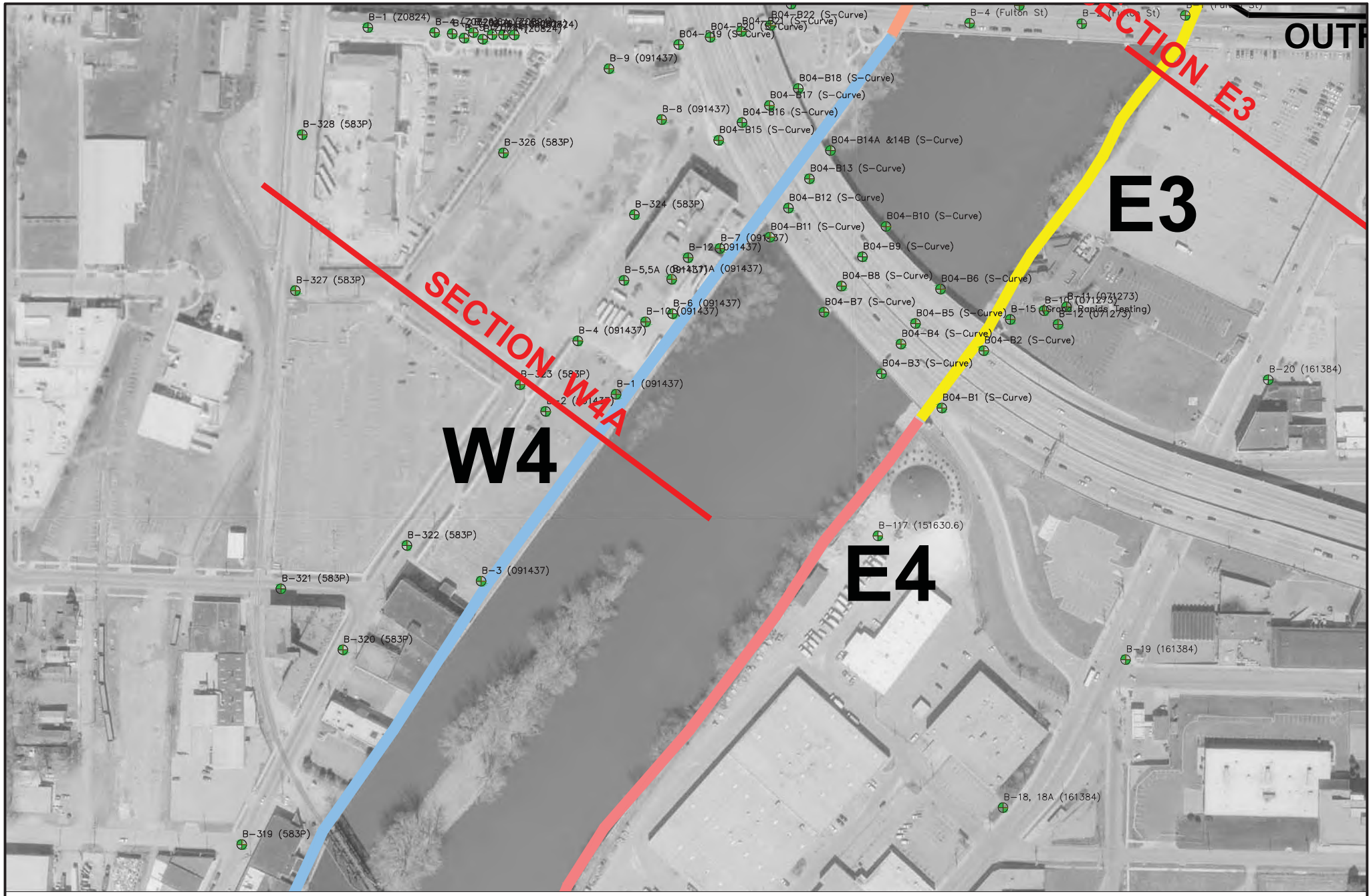

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= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

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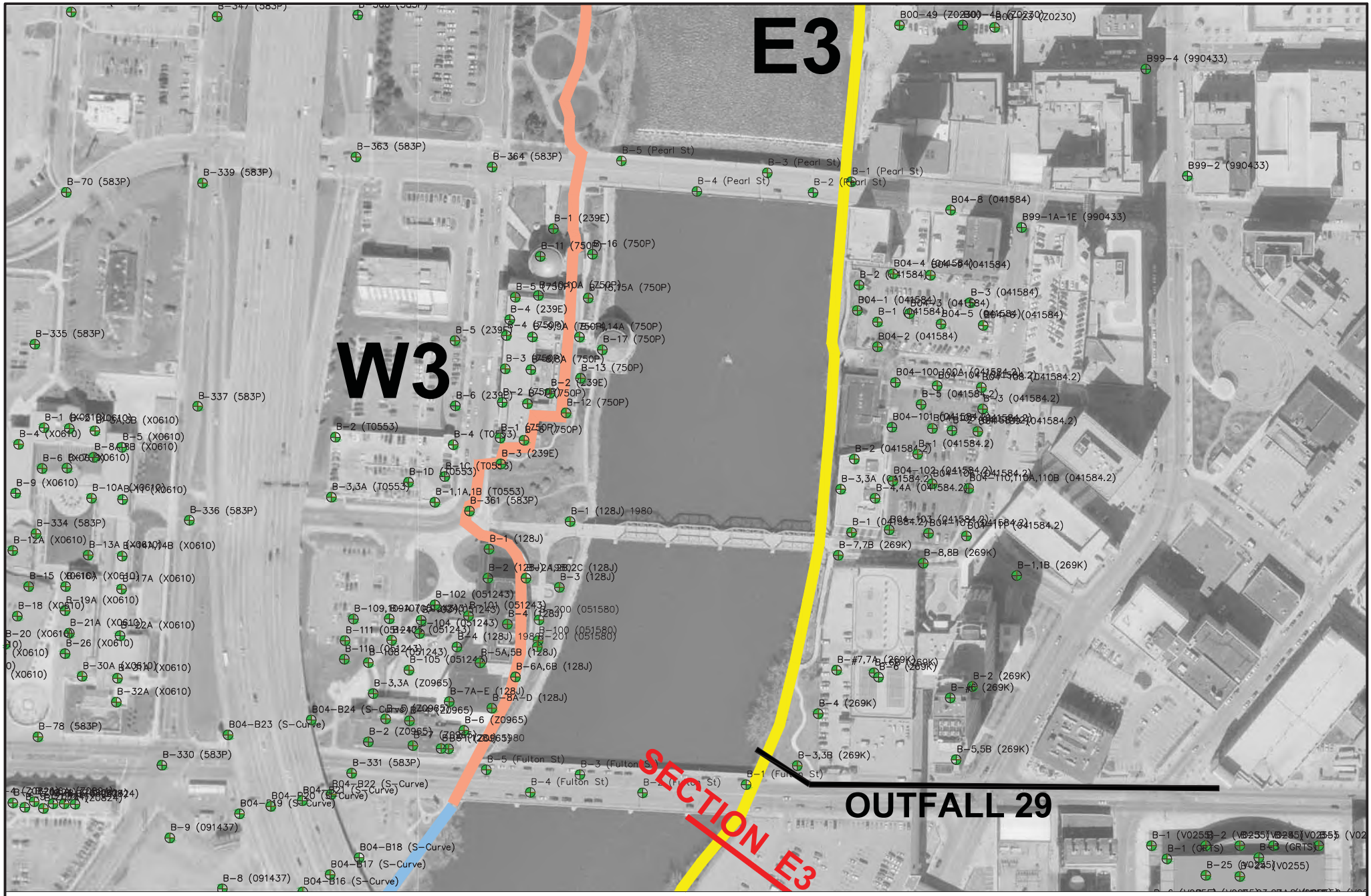

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

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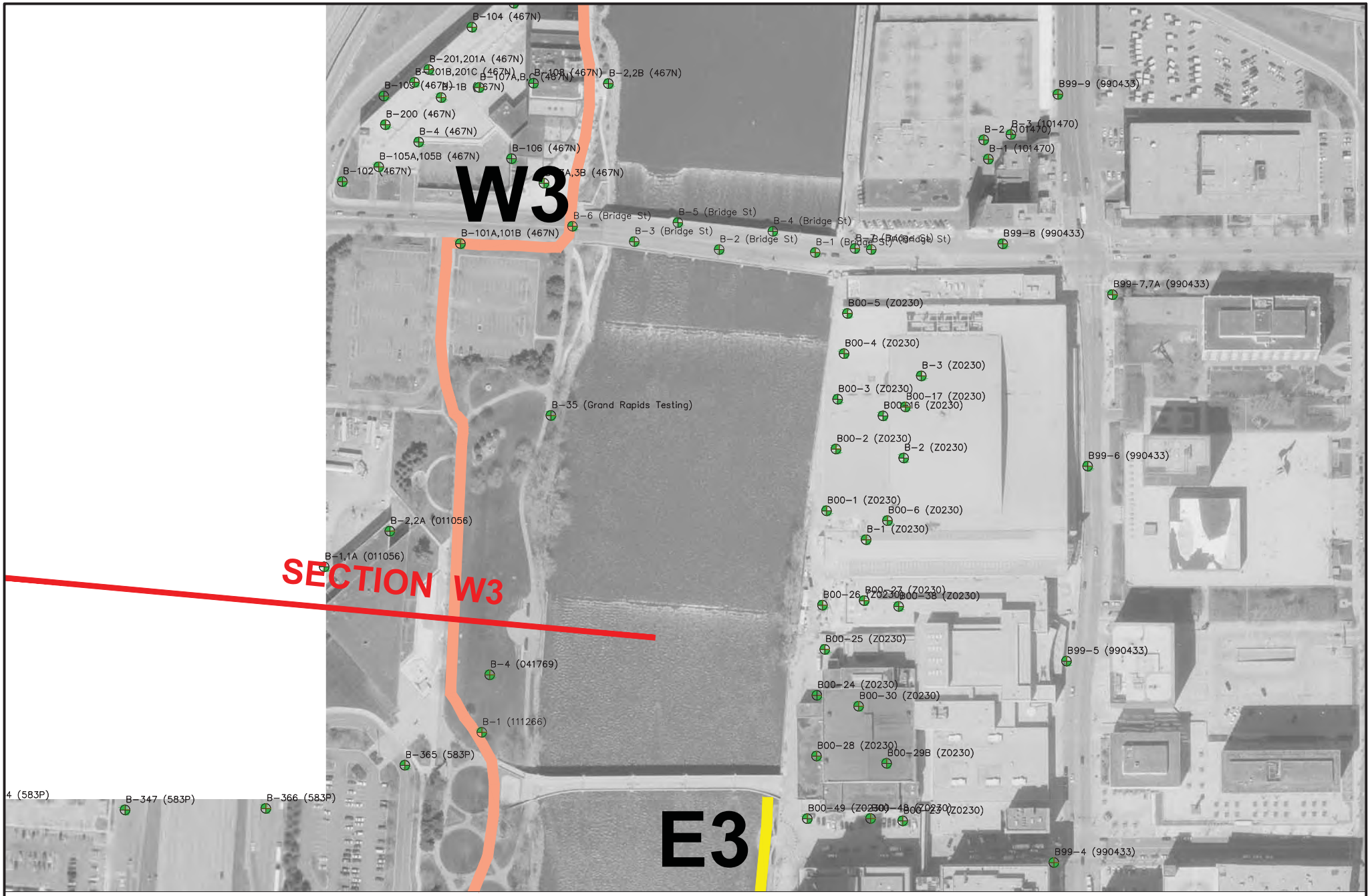

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

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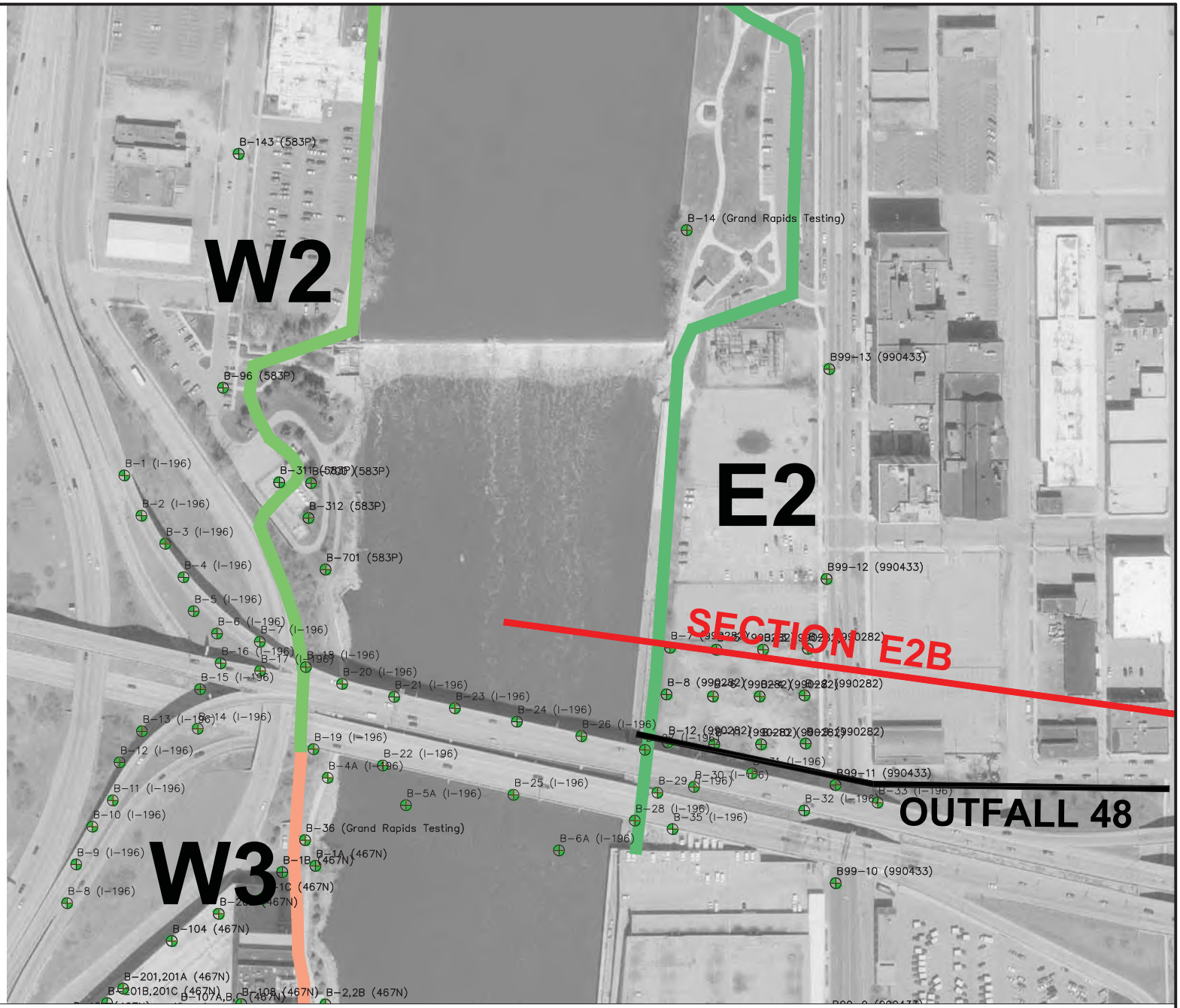
LEGEND

= HISTORIC SOIL BORING (TYP)

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-7	DR. BY: TM	REV. BY: SE	



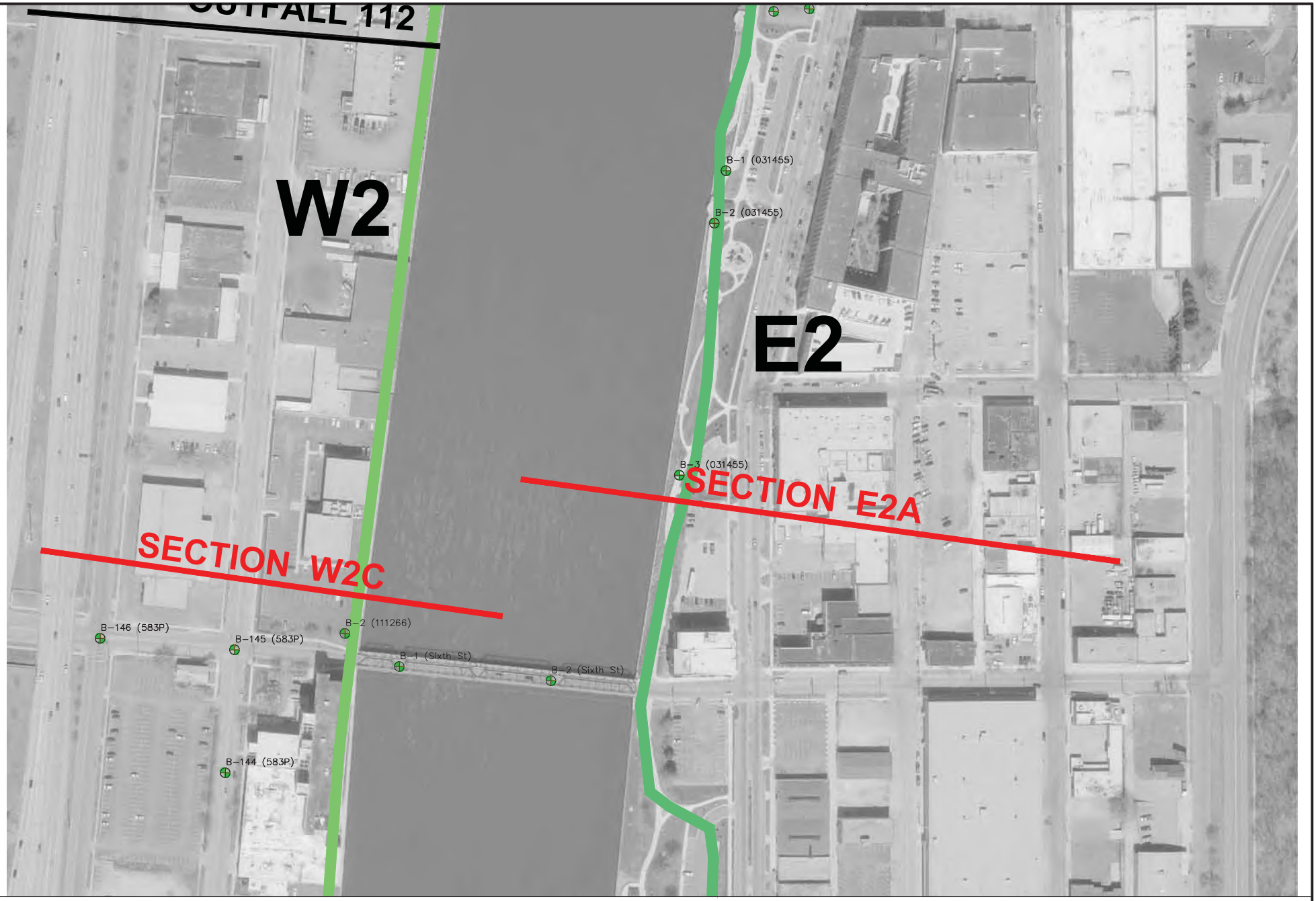
N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-8	DR. BY: TM	REV. BY: SE	



N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-9	DR. BY: TM	REV. BY: SE	



N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-10	DR. BY: TM	REV. BY: SE	



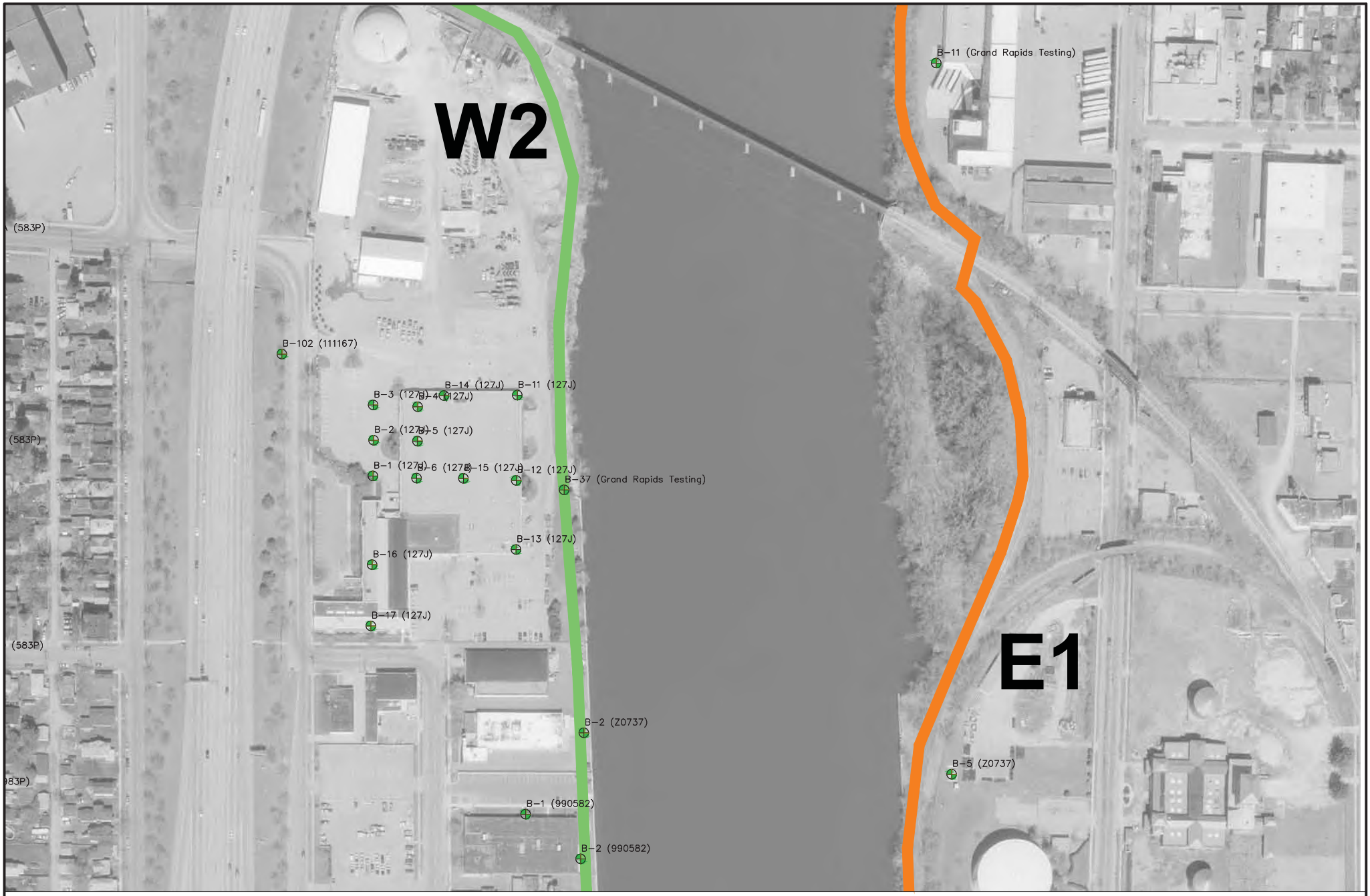
N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-11	DR. BY: TM	REV. BY: SE	



N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-12	DR. BY: TM	REV. BY: SE	



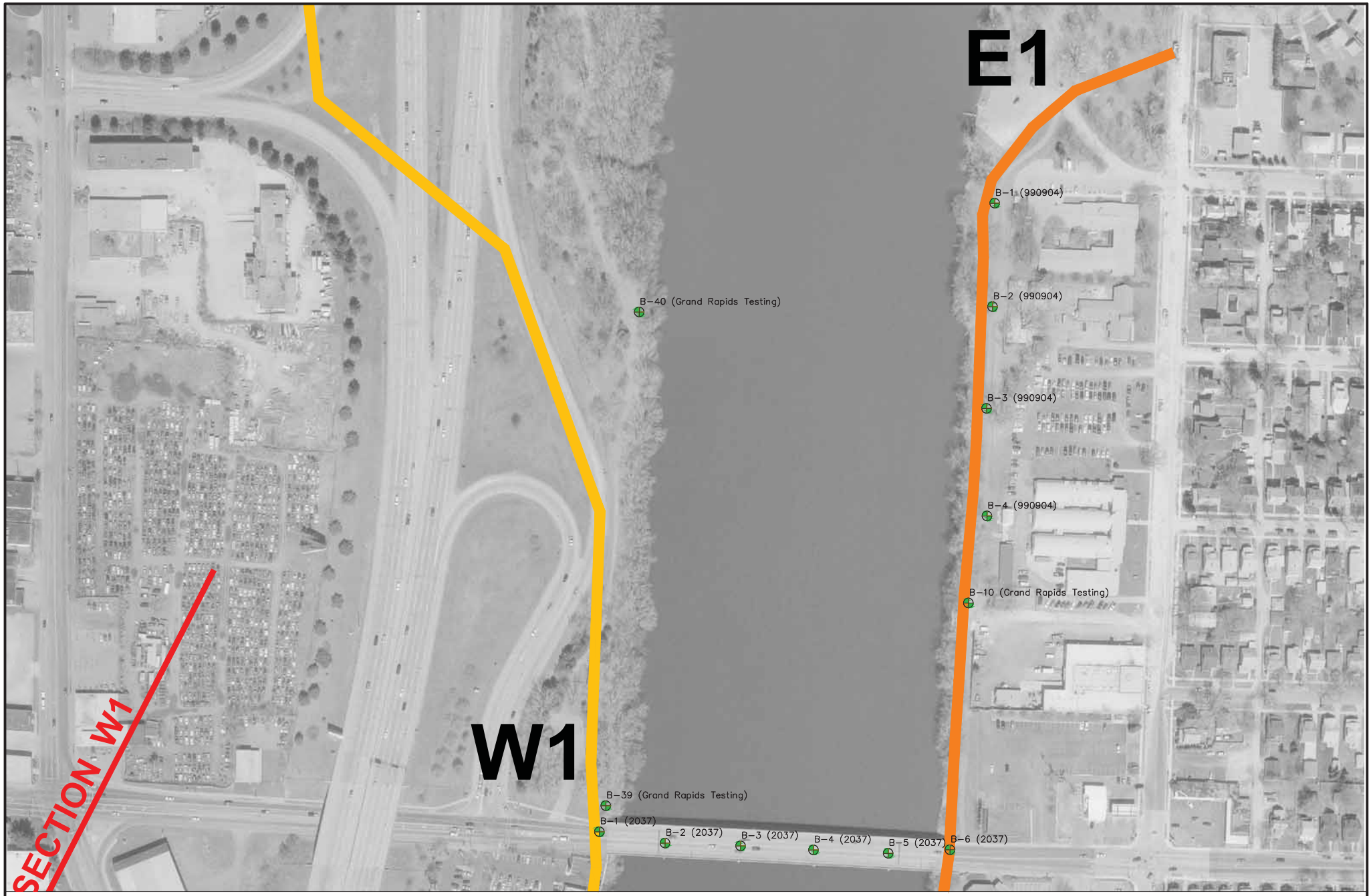
N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-13	DR. BY: TM	REV. BY: SE	



N

LEGEND

= HISTORIC SOIL BORING (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: BORING LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 250'	DATE: 1-11-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: A-14	DR. BY: TM	REV. BY: SE	

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-4 Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55 LC
Crew Chief: RC
Field Eng.: AV
Rev. By: TM
Elevation: 618.42 ft.
Datum:
Notes: Section 6E

Date Begin: 10/31/12 Date End: 10/31/12

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	17 +/-
Sampler	SPT	2"	End	14
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 40.0 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 25.0'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%

QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
617.4	1	S-1	1.0	2-3-4	SM	6 to 12" Topsoil Brown silty SAND with gravel; mostly fine to coarse sand, little fine gravel, little silty fines, moist, Fill	Fill 0' to 12' +/- S-1, S-3: Poor recovery, possible coarse gravel/ COBBLE.	
616.4	2							
615.4	3	A-2						
614.4	4							
613.4	**5**	S-3	1.5	4-12-14	CL	Brown lean CLAY with sand; mostly clayey fines, little fine to coarse sand, moist, Fill	4.2' +/-	4.5+
612.4	6							
611.4	7	S-4	0.3	14-15-18	CL	Grades with some fine to coarse sand		4.5+
610.4	8						Difficult drilling from 4.2' to 12'.	
609.4	9							
608.4	**10**	S-5	1.5	9-12-12	CL	Grades with trace fine gravel		4.5+
607.4	11							
606.4	12						12' +/-	
605.4	13							
604.4	14							
603.4	**15**	S-6	1.5	2-2-3	OH	Gray Sandy ORGANIC CLAY, mostly clayey fines, some medium to fine sand, moist		
602.4	16							
601.4	17						17' +/-	
600.4	18							
599.4	19							
598.4	**20**	S-7	1.5	1-2-3	SM	Light gray silty SAND; mostly fine sand, some silty fines, wet with trace shells and silt lenses, possible marl		
597.4	21							
596.4	22						22' +/-	
595.4	23						Difficult drilling, coarse gravel/ COBBLE from 22' to 40'.	
594.4	24							
593.4	**25**	S-8	1.5	5-7-9	SP	Brown poorly graded SAND; mostly fine to coarse sand, trace silty fines, moist, wet		
592.4	26							
591.4	27						*Charged augers with water from 25'.	
590.4	28							
589.4	29							
588.4	**30**	S-9	1.5	9-17-19	SP	Grades with some coarse to fine gravel		
587.4	31							
586.4	32							
585.4	33							
584.4	34							
583.4	**35**	S-10	1.3	10-26-50/5"	SP			
582.4	36							
581.4	37						37' +/-	
580.4	38							
579.4	39					Brown sandy SILT; mostly silty fines, some fine sand,		
578.4	**40**	S-11	1.5	16-24-50/5"	ML	wet	End of Boring at 40.0'	

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION E1A

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-3 Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55 LC
Crew Chief: RC
Field Eng.: AV
Rev. By: TM
Elevation: 614.73 ft.
Datum:
Notes: Section 5E

Date Begin: 10/31/12 Date End: 10/31/12

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	NA
Sampler	SPT	2"	End	7.9
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 13.5 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 10.8'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%

QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
613.7	1	S-1	0.9	2-6-6	SP-SM	Black poorly graded SAND with silt and gravel; mostly fine to coarse sand, some fine to coarse gravel, few silty fines, moist, cinders with frequent roots, Fill	Fill 0' to 13' +/- S-1, S-2, S-4 and S-5: Poor recovery, possible coarse gravel/COBBLE.	
612.7	2							
611.7	3	A-2						
610.7	4							
609.7	**5**	S-3	0.1	2-2-3	SP-SM			
608.7	6						5.5' +/-	
607.7	7	S-4	1.5	1-1-1	SM	Dark brown to black silty SAND with gravel, mostly fine to coarse sand, little fine to coarse gravel, little silty fines, moist, topsoil, Fill	A-1: 2' to 2.5' A-2: 7' to 7.5'	
606.7	8	A-5						
605.7	9							
604.7	**10**	S-6	0.8	1-1-1	SM	Grades with glass fragments		
603.7	11							
602.7	12							
601.7	13						13' +/- Coarse gravel/ COBBLE 12' to 13'.	
600.7	14	S-7	0.5	31-50/1"	-	Fractured Sandstone		
	15					End of Boring at 13.5'	Auger refusal on bedrock at 13'. Sampler refusal at 13.5'.	
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							
	27							
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	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION E1B

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 031455 Boring No.: B-3 Sheet: 1 of 1

Project: Canal Park
Client: City of Grand Rapids
Location: Canal Park, Grand Rapids, MI
Drill Type: CME 45T
Crew Chief: DF
Field Geo.: JTM
Rev. By: _____
Elevation: 615.0 ft. +/-
Datum:
Notes:

Date Begin: 5/26/2004 Date End: 5/26/2004

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	8
Sampler	SPT	2"	End	11
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 14.1 ft.
Plugging Rcrd: Excavated Soil.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% PID = Photoionization Detector (ppm)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	PID
614.0	1				-	Concrete	0.25' Fill 0 to 13.3'	
613.0	2	S-1	0.8	2-3-3	SP	Yellowish brown poorly graded SAND; medium to fine grained, trace silty fines, moist	0.4'	0
612.0	3							
611.0	4	S-2	1.3	3-4-3	SC	Dark brown to black clayey SAND, trace gravel, moist, fill		0
610.0	5							
609.0	6	S-3	0.4	4-2-3	SC			0
608.0	7						6.3'	
607.0	8							
606.0	9	S-4	1.1	2-2-3	CL	Dark grayish brown lean CLAY; some silty fines, trace fine sand, trace gravel, moist to wet, fill		0
605.0	10							
604.0	11							
603.0	12							
602.0	13							
601.0	14	S-5	0.9	3-13-50/1"	SP	Dark gray poorly graded SAND; medium grained, wet	13.3'	0
	15				-	Fractured Limestone	13.7'	
	16							
	17					End of Boring at 14.1'		
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							
	27							
	28							
	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION E2A

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 990282 Boring No.: B-7 Sheet: 1 of 1

Project: 555 Monroe LLC
Client: Craig Architects, Inc.
Location: Grand Rapids, Michigan
Drill Type: CME 95
Crew Chief: G.S.
Field Eng.: S.T.
Rev. By: S.M.T
Elevation: 612.1 ft.
Datum:
Notes:

Date Begin: 6/16/99 Date End: 6/17/99

	Type	Dia.	Groundwater, ft.	
Casing	HSA	6 1/4"	During	14 +/-
Sampler	SPT	2"	End	NA
Core			Seepage	
Tube			Date	Depth, ft.
Depth Drilled:	30.0 ft.			

Plugging Rcrd: Grouted rock with cement bentonite slurry.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
611.1	1	S-1	1.0	2-2-1	SM	3" of asphalt Brown to black silty SAND with gravel; moist with concrete fragments (fill)	Fill 0' to 19'.	
610.1	2							
609.1	3							
608.1	4							
607.1	5	S-2	1.1	4-7-2	SM			
606.1	6						5.5' +/-	
605.1	7	S-3	1.5	4-3-3	ML	Black sandy SILT; moist with cinders (fill)		
604.1	8							
603.1	9							
602.1	10	S-4	0.4	2-2-2	ML	Grades with plant and wood fragments		
601.1	11							
600.1	12							
599.1	13							
598.1	14							
597.1	15	S-5	0.0	3-2-3	ML	Grades wet		
596.1	16							
595.1	17							
594.1	18					Black sandy SILT; some coarse to fine sand, few coarse to		
593.1	19	S-6	0.3	3-50/0"	ML	fine gravel; wet with plant fragments and brick fragments	19'	Auger refusal at 19'.
592.1	20				-	Gray LIMESTONE; fine to very fine grained, hard, moderately		Set 4" casing to 20'.
591.1	21					to slightly weathered, intensely to closely fractured with		Run 1: 21'-
590.1	22					horizontal and vertical fractures		22'-8 min.
589.1	23	R-1	100%	RQD=32	-			23'-5 min.
588.1	24							24'-4 min.
587.1	25							25'-4 min.
586.1	26					Grades to slightly weathered, closely to moderately fractured		Run 2: 26'-5 min.
585.1	27							27'-4 min.
584.1	28	R-2	100%	RQD=66	-	Grades to little fractured		28'-3 min.
583.1	29							29'-2 min.
582.1	30					4" of sandstone at 30'		30'-2 min.
581.1	31					End of Boring at 30.0'		Rock core recovery is in percent of run.
580.1	32							
579.1	33							
578.1	34							
577.1	35							
576.1	36							
575.1	37							
574.1	38							
573.1	39							
572.1	40							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION E2B AND OUTFALL 48

Materials Testing Consultants, Inc.
693 PLYMOUTH N.E.,
GRAND RAPIDS, MICH. 49505
PHONE 616/456-5469

LOG OF BORING

Project No. 269K
Boring No. B-3
Sheet 1 of 1

Project East Bank Project
Client United Development Corp.
Location Fulton & Campau Streets, Grand Rapids, MI
Crew Chief D. Taylor
Inspector S. Thompson
Reviewed By
Elevation 609
Datum NGVD
Drill Type CME-45
Plugging Record: Excavated Soil
Depth Drilled 29.8'
Notes:

Contractor Mateco Drilling Company
Date Begin 10/20/86 Date End 10/22/86

	TYPE	DIA.	NO.
Casing	HSA	3-3/4"	6
Sampler	SBS	2"	7
Core			
Tube			

GROUNDWATER
During 22
End 16' in auger
Seepage
Date / Depth

DEPTH FT.	SAMPLE NO.	REC. FT.	PENETRATION (BLOWS PER 6") ASTM D 1586	UNIF. SOIL CLASS.	DESCRIPTION	REMARKS
					FILL	2" of asphalt
	S1	1.2	4-3-4	SP	light brown medium to fine SAND, trace silt, moist	
5	S2	0.5	7-7-R		brick and concrete (5.5-6.0')	hit concrete unable to cont. driving sampler
						wood brought up on auger
10	S3	0.5	5-5-10	SM	brown medium to fine SAND, little silt, some fine gravel; moist (broken up bricks and concrete)	
					change approximate	
15	S4	1.0	5-3-16	SM	brown coarse to fine SAND, some clayey silt, trace fine gravel, wet, with clean wet sand seams	
20	S5 S6	1.5	1½-1½-2	SC	gray medium to fine SAND, and silty clay, trace fine gravel, wet black silty SAND seam 20.5-21' (SM)	
25	S7	1.5	10-11-10	SP	gray coarse to fine SAND, trace silt, little fine gravel, trace shells, wet	End 10/20 5:45 Start 10/21 8:30
30	S8	1.0	16-50-50/3"	GW/GC	gray coarse to fine GRAVEL, coarse to fine sand, little silty clay, wet	Hard drilling from 26' - boulders 10/21
					End of Boring @ 29.8'	10/22 10:00 drill rig broke down 10:00-7:00 repaired rig pulled out of hole 10/22
35						

SECTION E3

Materials Testing Consultants, Inc.
693 PLYMOUTH N.E.,
GRAND RAPIDS, MICH. 49505
PHONE 616/456-5469

LOG OF BORING

Project No. 269K
Boring No. B-3B
Sheet 1 of 1

Project East Bank Project
Client United Development Corp.
Location Fulton & Campau Streets, Grand Rapids, MI
Crew Chief D. Taylor
Inspector S. Thompson
Reviewed By
Elevation 609
Datum NGVD
Drill Type CME-45
Plugging Record: Grouted Hole to 31', backfilled with excavated soil
Depth Drilled 47.8'
Notes:
Contractor Mateco Drilling Company
Date Begin 11/3/86 Date End 11/3/86

	TYPE	DIA.	NO.
Casing	HSA	3-3/4"	6
Sampler			
Core	NX	2"	15.0'
Tube			
Casing	Adv.	3"	

GROUNDWATER	
During	
End	
Seepage	
Date	Depth
11/4	12'

DEPTH FT.	SAMPLE NO.	REC. FT.	PENETRATION (BLOWS PER 6") ASTM D 1586	UNIF. SOIL CLASS.	DESCRIPTION	REMARKS
					See Log B-3 for Soil Drescriptions	redrilled B-3 to 31', augered to 30', set casing to 31'
25				SP		
				GW/GC	Boulders	cleaned out hole w/ roller bit to 31.5'
30					gray coarse to fine SAND, and coarse to fine gravel, little silty clay, wet	
				CL	gray silty CLAY (weathered shale)	
35	NX Core Run 1	Rec-90%	RQD-41.7		gray SHALE, very fine grained, soft to friable, deeply weathered, closely fractured in gray shale matrix	8-16 m/ft
	NX Core Run2	Rec-50%	RQD-0		soft gray SHALE	loss circulation @ 34.5'
40	NX Core Run 3	93.3%	RQD-56.7		white and clear GYPSUM, very fine grained friable to low hardness, deeply weathered, closely fractured in gray shale matrix	9-12 m/ft
45	NX Core Run4	77.7%	RQD-62.5		gray SHALE Gypsum, very fine grained, low to mod.hardness, mod.weathered, closely fractured in gray shale matrix	8-10 m/ft
50					End of Boring @ 47.8'	
55						

SECTION E3

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 071062 Boring No.: B-1A Sheet: 1 of 1

Project: MAPS Diversion Chamber
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, Michigan
Drill Type: CME 55LC
Crew Chief: GS
Field Eng.: ST
Rev. By: DS
Elevation: 600 ft.
Datum:
Notes:

Date Begin: 10/19/07 Date End: 10/19/07

	Type	Dia.	Groundwater, ft.	
Casing	HSA	4 1/4"	During	9.6
Sampler	SPT	2"	End	26.0
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 40.0 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 37'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
599.0	1					See boring log B-1 for soil descriptions from 0' to 5'	Fill 0' to 8'	
598.0	2							
597.0	3							
596.0	4							
595.0	5							
594.0	6							
593.0	7	S-1	1.0	7-5-3	CL	Brown sandy lean CLAY; moist, Fill		
592.0	8						8'+/-	
591.0	9							
590.0	10	S-2	1.5	1-1-2	OL	Brown mottled organic SILT; wet with trace decomposed plant matter and shells		
589.0	11						11'+/-	
588.0	12	S-3	0.8	4-4-11	CL	Gray brown mottled lean CLAY; moist with coarse to fine sand seams (weathered shale)		2.5
587.0	13							
586.0	14							
585.0	15	S-4	1.2	2-5-7	CL	Grades with brown silt seams (possible weathered limestone)		4.0
584.0	16							
583.0	17						17'+/-	
582.0	18						Harder drilling from 18'	
581.0	19							
580.0	20	S-5	0.8	10-10-14	CL	Gray lean CLAY; moist (weathered shale)		4.5+
579.0	21							
578.0	22							
577.0	23						S-6: Limestone and granite fragments in sampler	
576.0	24	S-6	0.3	50/5"	CL	Limestone/gravel lens, wet		-
575.0	25						Easier drilling from 25' to 27'	
574.0	26							
573.0	27							
572.0	28							
571.0	29							
570.0	30	S-7	1.0	7-7-14	CL	Gray lean CLAY; moist (weathered shale) with wet fractured limestone lenses		4.5+
569.0	31						Easier drilling from 32'	
568.0	32							
567.0	33						S-8: No recovery, drove second sampler	
566.0	34		0.0					
565.0	35	S-8	0.6	4-6-5	CL		S-9: Lost tip of sampler, drove second sampler to recover sample	2.5
564.0	36							
563.0	37							
562.0	38							
561.0	39					Gray lean CLAY; moist (weathered shale) with		
560.0	40	S-9	0.3	20-10-15	CL	weathered gypsum lenses	End of Boring at 40.0'	4.0

Visual estimate following ASTM D 2488 unless laboratory testing has been performed

SECTION E4

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266.2 Boring No.: B-5 Sheet: 1 of 1

Project: GRWWTP - Embankment Stability
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55
Crew Chief: RC
Field Eng.: NS
Rev. By: AV
Elevation: 610.2 ft.
Datum:
Notes:

Date Begin: 10/04/2013 Date End: 10/04/2013

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	27 +/-
Sampler	SPT	2"	End	**NA
Core			Seepage	
Tube	Shelby	3"	Date	Depth, ft.

Depth Drilled: 38.5 ft.

Plugging Rcrd: **Full depth grout with cement/bentonite. Backfilled with asphalt cold patch.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%

QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
609.2	1					13" Asphalt	Fill 0' to 22' +/-	
608.2	2	S-1	1.0	9-10-10	GP	Poorly graded GRAVEL; mostly coarse to fine gravel,	1.5' S-1, S-2, S-3, S-9	
607.2	3				CL	moist, Fill	S-10, S-11	2.5
606.2	4					Brown sandy lean CLAY with gravel; mostly clayey fines,	Poor Recovery	-
605.2	**5**	S-2	1.0	5-11-16	CL	some medium to fine sand, little coarse to fine gravel,	possible coarse	
604.2	6					moist, Fill	gravel/COBBLE	
603.2	7	S-3	1.0	18-19-19			6.5'	
602.2	8				SP	Brown poorly graded SAND; mostly medium to fine		
601.2	9					sand, trace silty fines, moist		
600.2	**10**	S-4	1.5	3-5-5	SP	Grades with occasional clay seams		
599.2	11							
598.2	12							
597.2	13							
596.2	14							
595.2	**15**	S-5	1.5	1-1-2	SC	Grades with sandy clay lens from 13.5' to 13.7'		
594.2	16							
593.2	17						17' +/-	
592.2	18							
591.2	19							
590.2	**20**	S-6	1.5	2-3-4	SM	Brown silty SAND; mostly fine sand, some silty fines,		
589.2	21					moist		
588.2	22						22' +/-	
587.2	23							
586.2	24						Fine sand lens 24' to	
585.2	**25**	S-7	1.5	1-2-2	CL	Gray lean CLAY; mostly clayey fines, trace fine sand, trace	24.1'	1.5
584.2	26					wood fibers, moist		
583.2	27	U-8	1.7	-			27' +/- Driller noted possible	
582.2	28					Brown poorly graded SAND; mostly coarse to medium	coarse gravel/	
581.2	29				SP	sand, few fine gravel, wet	29' COBBLE at 27'	
580.2	**30**	S-9	1.0	2-3-4	SM	Brown silty SAND with gravel; mostly fine sand, little		
579.2	31					silty fines, little fine gravel, wet		
578.2	32						32' +/-	
577.2	33							
576.2	34							
575.2	**35**	S-10	1.0	10-18-28	GP	Poorly graded GRAVEL; mostly coarse to fine gravel, few		
574.2	36					medium to coarse sand, wet	35' +/-	
573.2	37							
572.2	38							
571.2	39	S-11	1.0	10-20-42	-	Gray weathered Shale		
570.2	**40**					End of Boring at 38.5'		

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION E5

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-6 Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55 LC
Crew Chief: BD
Field Eng.: AV
Rev. By: TM
Elevation: 614.44 ft.
Datum:
Notes: Section 7N

Date Begin: 11/05/12 Date End: 11/05/12

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	8 +/-
Sampler	SPT	2"	End	11*
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 18.5 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 11'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%

QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
613.4	1	S-1	1.2	3-3-3		5" HMA	Fill 0' to 5.5' +/-	
612.4	2				SP-SM	Brown poorly graded SAND with silt; mostly fine to coarse		
611.4	3					sand, few silty fines, trace fine gravel, moist, Fill	2.5' +/-	
610.4	4							
609.4	**5**	S-2	1.5	2-2-2	SC	Brown clayey SAND; mostly fine sand, some clayey fines,		
608.4	6					moist, Fill	5.5' +/-	
607.4	7	S-3	1.5	2-2-2	SP	Brown poorly graded SAND; mostly fine sand, trace silty		
606.4	8					fines, moist		
605.4	9						*Charged augers	
604.4	**10**	S-4	1.5	1-3-3	SP	Grades wet	with water from 8.5'.	
603.4	11							
602.4	12						12' +/-	
601.4	13							
600.4	14							
599.4	**15**	S-5	1.5	4-4-4	ML	Gray SILT, mostly silty fines, few fine	Difficult drilling,	
598.4	16					sand, wet	16' +/- possible coarse	
597.4	17						gravel/COBBLE from	
596.4	18	S-6	0.7	12-50/6"	GP	Poorly graded GRAVEL; mostly fine to coarse gravel, wet	16' to17.5'.	
595.4	19							
	20					End of Boring at 18.5'	Auger refusal on	
	21						suspected boulder	
	22						or cobble at 17.5'.	
	23						Sampler refusal at	
	24						18.5'.	
	25							
	26							
	27							
	28							
	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W1

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-5 Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55 LC
Crew Chief: BD
Field Eng.: AV
Rev. By: TM
Elevation: 613.79 ft.
Datum:
Notes: Section 7S

Date Begin: 11/05/12 Date End: 11/05/12

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	8 +/-
Sampler	SPT	2"	End	10*
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 40.0 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 10'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%

QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
612.8	1	S-1	1.4	4-6-7		3" HMA	Fill 0' to 8' +/-	
611.8	2				SP-SM	Brown/Dark brown poorly graded SAND with silt; mostly fine to coarse sand, few silty fines, moist, Fill		
610.8	3						2.5' +/-	
609.8	4							
608.8	**5**	S-2	1.5	3-2-3	SP	Brown poorly graded SAND; mostly fine sand, trace silty fines, moist, Fill		
607.8	6							
606.8	7	S-3	1.5	5-5-5	SP			
605.8	8						8' +/-	
604.8	9							*Charged augers with water from 8.5'.
603.8	**10**	S-4	1.5	2-2-2	SP	Gray poorly graded SAND; mostly fine to coarse sand, wet with wood lens from 8.5' to 8.7'		
602.8	11							
601.8	12							
600.8	13						12.5' +/-	
599.8	14							
598.8	**15**	S-5	1.5	3-3-3	SM	Gray silty SAND; mostly fine sand, some silty fines, wet		
597.8	16							
596.8	17							
595.8	18						18' +/-	Difficult drilling, coarse gravel/ COBBLE from 18' to 21' +/-.
594.8	19							
593.8	**20**	S-6	1.2	10-26-40	GP	Gray poorly graded GRAVEL; mostly fine to coarse gravel, trace fine to coarse sand, wet		
592.8	21						21' +/-	
591.8	22							
590.8	23							
589.8	24							
588.8	**25**	S-7	0.5	10-28-30	SP	Gray poorly graded SAND; mostly fine to coarse sand, trace fine gravel, wet		S-7: Poor recovery, drove tip of sampler on gravel.
587.8	26							
586.8	27							
585.8	28							
584.8	29							
583.8	**30**	S-8	1.5	8-17-26	SP	Grades mostly fine sand, trace silty fines, without gravel		
582.8	31							
581.8	32						32' +/-	
580.8	33							
579.8	34							
578.8	**35**	S-9	1.5	15-28-30	ML	Brown SILT; mostly silty fines, few fine sand, wet		
577.8	36							
576.8	37						37' +/-	
575.8	38							
574.8	39					Brown poorly graded SAND with silt; mostly fine sand, few		
573.8	**40**	S-10	1.5	8-10-17	SP-SM	silty fines, wet	End of Boring at 40.0'	

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W2A

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-5HA Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: Hand Auger
Crew Chief:
Field Eng.: AV
Rev. By: TM
Elevation: ft.
Datum:
Notes: Performed 12 ft Below Top of RR Berm Along N Side of Berm, Section 7S

Date Begin: 11/02/12 Date End: 11/02/12

	Type	Dia.	Groundwater, ft.	
Casing	HA	3 1/4"	During	None
Sampler			End	None
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 8.7 ft.
Plugging Rcrd: Backfilled with compacted cuttings.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%
QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
-1.0	1					10" Topsoil	Fill 0' to 8.7'	
-2.0	2	A-1			SP-SM	Dark brown poorly graded SAND with silt; mostly fine sand, few silty fines, moist, Fill	2' +/-	
-3.0	3							
-4.0	4	A-2			SP	Brown poorly graded SAND; mostly fine sand, moist, Fill		
-5.0	5	A-3				Grades with coarse sand and fine gravel	Auger refusal on	
-6.0	6						5.5' +/- coarse gravel/	
-7.0	7	A-4			SP-SM	Dark brown poorly graded SAND with silt; mostly fine	COBBLE at 8.7'	
-8.0	8					sand, few silty fines, moist, Fill		
-9.0	9							
	10					End of Boring at 8.7'		
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							
	27							
	28							
	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W2A

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: Z0737 Boring No.: B - 1 Sheet: 1 of 1

Project: Grand River Floodwall
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, Michigan
Drill Type: CME 45
Crew Chief: M.D.
Field Eng.:
Rev. By:
Elevation: ft.
Datum:
Notes:

Date Begin: 12/2/1998 Date End: 12/2/1998

	Type	Dia.	Groundwater, ft.	
Casing	HSA	2 1/4"	During	6 +/-
Sampler	SPT	2"	End	NA
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 11.8 ft.

Plugging Rcrd: Backfilled with excavated soil and cold patch.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
######	1					1" of asphalt		
######	2	S-1	0.6	8-8-10	SM	Brown silty SAND with gravel; mostly coarse to fine sand,	frequent coarse	
######	3					little silty fines, little coarse to fine gravel, moist with concrete	gravel and cobble	
######	4					fragments (fill		
######	**5**	S-2	0.1	6-5-4	SM			
######	6							
######	7	S-3	0.3	3-4-3	SM	Brown silty SAND with gravel; wet (fill)		
######	8							
######	9					Brown silty GRAVEL with sand; wet with weathered	8' +/-	
######	**10**	S-4	0.8	12-50/5"	GM	limestone fragments in tip of sampler		
######	11							
######	12	S-5	0.2	50/3"	LS	Weathered Limestone		
######	13						Auger and sampler	
######	14					End of Boring at 11.8'	refusal at 11.8'.	
######	**15**							
######	16							
######	17							
######	18							
######	19							
######	**20**							
######	21							
######	22							
######	23							
######	24							
######	**25**							
######	26							
######	27							
######	28							
######	29							
######	**30**							
######	31							
######	32							
######	33							
######	34							
######	**35**							
######	36							
######	37							
######	38							
######	39							
######	**40**							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W2B AND OUTFALL 112

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-2 Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55 LC
Crew Chief: RC
Field Eng.: AV
Rev. By: TM
Elevation: 611.73 ft.
Datum:
Notes: Section 4W

Date Begin: 11/01/12 Date End: 11/01/12

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	5.5 +/-
Sampler	SPT	2"	End	6.5*
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 14.1 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 7.2'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%

QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS		QP
610.7	1	S-1	1.5	3-3-4		6" Topsoil	1.0' +/-	Fill 0' to 8' +/-	
609.7	2				SP-SM	Brown poorly graded SAND with silt; mostly fine sand, few		Possible fill to 11' +/-	
608.7	3					silty fines, trace fine gravel, moist, Fill	2.5' +/-	S-3, S-4, S-5, S-6:	
607.7	4				SP	Brown poorly graded SAND; mostly fine sand, moist, Fill		Poor recovery,	
606.7	**5**	S-2	1.5	4-5-8	SP-SM	Dark brown/black poorly graded SAND with silt; mostly		possible coarse	
605.7	6					fine to coarse sand, few silty fines, trace wood fragments,		gravel/COBBLE.	
604.7	7	S-3		8-2-2	SP-SM	possible topsoil lenses, moist, Fill			
603.7	8					Grades with little fine gravel, wet at 5.5' +/-	8' +/-	Difficult drilling on	
602.7	9							coarse gravel/	
601.7	**10**	S-4	0.7	5-6-7	GP	Poorly graded GRAVEL with sand; mostly fine gravel, few		COBBLE from 2.5' to	
600.7	11					fine to coarse sand, wet, possible Fill	11' +/-	11' +/-, 13 to 13.5'.	
599.7	12				SP	Gray poorly graded SAND; mostly fine to medium sand,			
598.7	13					wet	13' +/-	*Charged auger with	
597.7	14	S-5	0.6	18-50/1/2"	-	Fractured Sandstone		water from 10'.	
596.7	**15**	S-6	0.1	50/1/2"	-				
	16							Auger refusal on	
	17					End of Boring at 14.1'		bedrock at 14'.	
	18							Sampler refusal at	
	19							14.1'.	
	20								
	21								
	22								
	23								
	24								
	25								
	26								
	27								
	28								
	29								
	30								
	31								
	32								
	33								
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	35								
	36								
	37								
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** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W2C

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 111266 Boring No.: B-1 Sheet: 1 of 1

Project: Grand Rapids Floodwalls and Embankments Study
Client: Fishbeck, Thompson, Carr & Huber
Location: Grand Rapids, MI
Drill Type: CME 55 LC
Crew Chief: RC
Field Eng.: AV
Rev. By: TM
Elevation: 611.29 ft.
Datum:
Notes: Section 3W

Date Begin: 11/01/12 Date End: 11/01/12

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	20.0
Sampler	SPT	2"	End	15*
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 25.1 ft.

Plugging Rcrd: Backfilled with compacted cuttings. Cave-in at 18'.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
610.3	1			Hand Dug		6" Topsoil	Fill 0' to 17' +/-	
609.3	2				SM	Dark brown silty SAND with gravel; mostly fine to coarse	Hand dug to 2'	
608.3	3	A-1				sand, little silty fines, little fine gravel, moist, Fill	S-2, S-4, S-5, S-7,	
607.3	4						S-8: Poor recovery,	
606.3	**5**	S-2	0.6	15-47-46	SM		possible coarse	
605.3	6						5.5' +/- gravel/COBBLE.	
604.3	7	S-3	1.5	3-5-6	CL	Brown sandy lean CLAY; mostly clayey fines, some fine		
603.3	8					to coarse sand, moist, Fill	8' +/- Two large angular	2.0
602.3	9						concrete pieces	
601.3	**10**	S-4	0.5	8-11-5	SP-SC	Brown poorly graded SAND with clay; mostly fine to	(9"x5"x3") +/-	
600.3	11					coarse sand, few clayey fines, moist, Fill	were removed while	
599.3	12						hand digging at 1'	
598.3	13							
597.3	14						Difficult drilling	
596.3	**15**	S-5	1.0	7-7-34	SP-SC	Grades with few fine gravel	coarse gravel/	
595.3	16						COBBLE 2' to 6';	
594.3	17						17' +/- 8' to 25'	
593.3	18							
592.3	19						Very difficult drilling	
591.3	**20**	S-6	1.3	7-4-4	SP	Black poorly graded SAND; mostly fine sand, trace wood	at 16' to 17' +/-	
590.3	21					fragments, trace shells, moist, possible former ground	*Charged augers	
589.3	22					surface, grades wet at 20'	22' +/- with water from	
588.3	23						23.6'	
587.3	24	S-7	0.3	50/5"	GP	Poorly graded GRAVEL; mostly fine gravel, wet		
586.3	**25**	S-8	0.1	50/2"	GP			
585.3	26					End of Boring at 25.1'	Auger refusal on	
	27						bedrock or possible	
	28						boulder/cobble at	
	29						25'. Sampler refusal	
	30						at 25.1'.	
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W3

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 091437 Boring No.: B-1 Sheet: 1 of 2

Project: GVSU - New Academic Building
Client: Facilities Planning Services
Location: Grand Rapids, MI
Drill Type: CME 750
Crew Chief: RC
Field Eng.: ST
Rev. By: NF
Elevation: 605.8 ft.
Datum:
Notes:

Date Begin: 11/24/09 Date End: 12/01/09

	Type	Dia.	Groundwater, ft.	
Casing	HSA	3 1/4"	During	17.6
Sampler	SPT	2"	End	*NA
Core			Seepage	7 +/-
Tube			Date	Depth, ft.
Drill Bit				

Depth Drilled: 80.5 ft.

Plugging Rcrd: Cement grouted bedrock. Backfilled with excavated soil/bentonite holeplug

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
604.8	1					3" of topsoil	Fill 0' to 17' +/-	
603.8	2	S-1	1.5	9-5-3	SC	Brown clayey SAND with gravel; moist, Fill		
602.8	3						2.5' +/- S-3, S-4 and S-5: Poor recovery, possible coarse gravel or COBBLE	
601.8	4							
600.8	**5**	S-2	1.5	3-5-7	SP	Light brown poorly graded SAND; mostly fine sand, moist with black silty sand seams, Fill		
599.8	6							
598.8	7	S-3	0.6	4-5-7	SP	Grades wet	7' +/- Perched water at 7'	
597.8	8						Possible gravels, COBBLE or rubble at 7'	
596.8	9							
595.8	**10**	S-4	0.2	2-2-2	SM	Brown to dark brown silty SAND; moist with concrete fragments, clay lenses, Fill		
594.8	11							
593.8	12						Brick fragment in cuttings	
592.8	13							
591.8	14							
590.8	**15**	S-5	0.1	1-1-2	SM	Dark brown silty SAND; mostly fine sand, little silty fines, moist, Fill		
589.8	16							
588.8	17						17' +/-	
587.8	18						*Charged augers with water from 18.5'	
586.8	19							
585.8	**20**	S-6	1.4	1-2-3	ML	Dark gray brown sandy SILT; mostly silty fines, some fine sand, wet with sand seams and wood fragments, possible Fill	Gravels, possible COBBLES from 21' to 32'	
584.8	21							
583.8	22						22' +/-	
582.8	23							
581.8	24							
580.8	**25**	S-7	0.7	12-10-10	SP	Brown poorly graded SAND; mostly medium to fine sand, trace silty fines, wet	S-7, S-8 and S-9: Poor recovery, possible coarse gravel or COBBLE	
579.8	26							
578.8	27							
577.8	28							
576.8	29							
575.8	**30**	S-8	0.2	5-7-10	SP	Grades with trace roots	30' +/- Difficult drilling from 30' to 38.5'	
574.8	31							
573.8	32	S-9	0.5	60/6"	GM	Brown silty GRAVEL with sand; wet	32' +/- S-9, S-10: Blow in drillers had to pull up 5' and knock out plug	
572.8	33							
571.8	34							
570.8	**35**	S-10	1.2	4-8-10	CL	Gray lean CLAY; moist (weathered shale with limestone fragments)		3.7
569.8	36							
568.8	37							
567.8	38							
566.8	39							
565.8	**40**	S-11	1.0	37-50/6"		Gray SHALE, deeply weathered	Set 3" casing to 40'	4.5+

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W4A

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 091437 Boring No.: B-1 Sheet: 2 of 2

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
564.8	41	R-1	0.6	RQD = NA		Gray SHALE, deeply weathered	R-1: Cored through	
563.8	42					White GYPSUM lens at 42'	COBBLE in shale	
562.8	43						run time = 10 min	
561.8	44	R-2	3.5	RQD = 35		Gray SHALE; low hardness to friable, little fractured,	Driller reset 3" casing	4.5
560.8	45					deeply weathered	to 42'	
559.8	46					45' Pink GYPSUM; slightly weathered 45.6'		
558.8	47					Gray SHALE; low hardness to friable, little fractured,		
557.8	48					deeply weathered		4.5+
556.8	49	R-3	5.0	RQD = 29		48.5'	R-3: 20 min/5 ft	
555.8	50					Pink GYPSUM, low hardness, little to closely fractured, soft	Based on weathering	
554.8	51					shale lenses 48.8', 50.5' 50.3'	of rock, possible	
553.8	52						solution activity at	
552.8	53						50.2'	
551.8	54	R-4	5.0	RQD = 33		Gray SHALE, low hardness to friable, little fractured,	R-4: 13 min/4.9 ft	4.5+
550.8	55					moderate to deeply weathered with sandstone lens 54.4'	Gray shale stuck in	
549.8	56					to 54.8'	barrel	
548.8	57							
547.8	58					Small vug in shale at 57.4'	R-5: 15 min/5 ft	4.5+
546.8	59	R-5	5.1	RQD = 50		58.2'		
545.8	60					Pink GYPSUM; moderate to low hardness, little fractured,		
544.8	61					slightly weathered		
543.8	62						R-6: 15 min/5 ft	
542.8	63					62.8'	Based on weathering	
541.8	64	R-6	5.0	RQD = 60		Pink GYPSUM/gray SHALE; friable, deeply weathered	of rock, possible	
540.8	65					64.4'	solution activity 62.8'	
539.8	66					Pink GYPSUM; slightly weathered 65.1'	to 64.4', did not lose	3.8
538.8	67					Gray SHALE; deeply weathered 66.4'	circulation	
537.8	68					Pink GYPSUM; moderate to low hardness, little fractured,		
536.8	69	R-7	5.0	RQD = 63		slightly weathered with fractures 67.8' to 68' and 69.1' to	R-7: 22 min/5 ft	
535.8	70					69.2'		
534.8	71							
533.8	72							
532.8	73					Pink GYPSUM; moderate to low hardness, little fractured,	R-8: 22 min/5 ft	
531.8	74	R-8	5.0	RQD = 88		slightly weathered with fracture 75.0 to 75.2'		
530.8	75							
529.8	76							
528.8	77					Fracture 76.3' to 76.9'		
527.8	78					77.9'	R-9: 24 min/5 ft	
526.8	79	R-9	4.9	RQD = 47		Gray SHALE; low hardness to friable, little fractured,		
525.8	80					deeply weathered		4.5+
524.8	81							
	82					End of Boring at 80.5'	Did not lose	
	83						circulation during	
	84						coring.	
	85							
	86							
	87							
	88							
	89							
	90							

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

SECTION W4A

Materials Testing Consultants, Inc.
PHONE 616/456-5469

LOG OF BORING

Project No. 583P
Boring No. B-900
Sheet 1 of 1

Project: Combined Sewer Separation Study
Client: Black and Veatch
Location: Wealthy Street Substation
Crew Chief: S. Taylor
Inspector: S. Thompson
Reviewed By: SMT
Elevation: 599.6
Datum: NGVD
Notes:

Drill Type: CME 850
Plugging Record: Bentonite holeplug
Depth Drilled: 34.0'

Contractor: Mateco Drilling Company
Date Begin: 10-3-92 Date End: 10-3-92

	TYPE	DIA.	NO.
Casing	HSA	4¼"	
Sampler	SPT	2"	
Core			
Tube			

GROUNDWATER: During 21'±; End NA; Seepage; Date / Depth

SOIL TYPE: Coarse Grained (Cohesionless)
Boulder (> 12") Cobbles (12" to 3") Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4) Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)
Fine-Grained (Cohesive): Silt PI < 1; Clayey Silt 1 < PI < 5; Silt and Clay 5 < PI < 10; Clay and Silt 10 < PI < 20; Silty Clay 20 < PI < 40; Clay PI > 40

Minor Component: Trace 1-10%, Little 10-20%, Some 20-35%, And 35-50% QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	PID	QP
				SM	Dark brown coarse to fine SAND, some coarse to fine+ gravel, some silt, moist with tile ± wood gragments (fill)		Air/Sample	
5	S-1	0.7	4-3-3	SM			0/0	
				SM		9.5'±	0/0	
10	S-2	0.1	3-2-1	ML	Light brown SILT, and+ fine sand, wet	13'±		
15	S-3	1.5	WOH-2 12"	SM	Gray fine SAND, and organic silt, wet shell fragment and seams of organic silt (Sandy MARL)		0/0	
20	S-4	1.5	2-2-2	OL	Gray sandy MARL, wet with shell fragments and frequent medium to fine sand seams	22'±	0/0	
				SP-SM	Gray medium to fine SAND, trace silt, wet 4" of coarse to fine SAND with shell fragment at 24.8'	24.8'±		
25	S-5	1.0	15-6-6	CL	Gray silty CLAY, moist (weathered shale) with limestone fragment at 24.8'±	3' of blow-in, washed auger before sampling S-6. No recovery drove 2nd spoon. Driller noted changed at 31.5'. Auger refusal at 32'.	0/0	
30	S-6	0.0 0.2	3-4-7	CL				
	S-7	0.9	10-25-12-12	CL	Dark gray silty CLAY, moist (weathered shale) with limestone fragments			
35					End of Boring at 34.0'			

SECTION W4B AND OUTFALL 29

* Visual estimate unless laboratory testing has been performed.

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 061489 Boring No.: B-1 Sheet: 1 of 1

Project: Monroe Ave, Palmer St. to Frank St.
Client: City of Grand Rapids
Location: Grand Rapids, Michigan
Drill Type: CME 55LC
Crew Chief: GS
Field Eng.: ST
Rev. By: ST
Elevation: 614.1 ft.
Datum: BM 4 = 615.30
Notes: Sta 13+73, 36'LT, Riverside Printing, 1375 Monroe Ave., S. of Caledonia St.

Date Begin: 10/18/07 Date End: 10/18/07

	Type	Dia.	Groundwater, ft.	
Casing	HSA	4 1/4"	During	8.5
Sampler	SPT	2"	End	NA
Core			Seepage	
Tube			Date	Depth, ft.

Depth Drilled: 20.0 ft.
Plugging Rcrd: Backfilled with cement bentonite grout.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100% QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
613.1	1	S-1	0.6	2-2-2	ML/CL	6" of Silty Topsoil Dark brown to black sandy SILT; moist with frequent brown clay lenses, cinders, Fill	Fill 0' to 6'+/-	-
612.1	2							
611.1	3							
610.1	4							
609.1	**5**	S-2	1.5	2-2-2	CL	Brown lean CLAY; moist with black sandy silt lenses, moist, Fill		1.0
608.1	6						6'+/-	
607.1	7	S-3	1.2	3-3-5	CL	Gray lean CLAY; moist with sandy clay lenses, trace gravel (deeply weathered shale)		0.8
606.1	8							
605.1	9						8.5'	
604.1	**10**	S-4	0.6	3-3-50/2"	ML	Brown mottled SILT with fine sand; wet (weathered limestone)		
603.1	11							
602.1	12							
601.1	13	R-1	4.8	RQD=20		Light gray LIMESTONE, hard, slightly weathered, moderately to closely fractured (deeply weathered at fractures) some vertical fractures, brown clay in fractures 10' to 12'	R-1: 5,3,2,3,2 min/ft	
600.1	14							
599.1	**15**							
598.1	16							
597.1	17							
596.1	18	R-2	4.0	RQD=31			R-2: 2,3,3,13,7 min/ft	
595.1	19							
594.1	**20**							
	21					End of Boring at 20.0'		
	22							
	23							
	24							
	25							
	26							
	27							
	28							
	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

OUTFALL 56

** Visual estimate following ASTM D 2488 unless laboratory testing has been performed*

MATERIALS TESTING CONSULTANTS, INC.	LOG OF BORING	Project No.: 061489 Boring No.: B-2 Sheet: 1 of 1

Project: Monroe Ave, Palmer St. to Frank St.
Client: City of Grand Rapids
Location: Grand Rapids, Michigan
Drill Type: Hand Auger
Crew Chief:
Field Eng.: ST
Rev. By: ST
Elevation: 614.2 ft.
Datum: BM 4 = 615.30
Notes: Sta 13+85, 34'LT, Riverside Printing, 1375 Monroe Ave., S. of Caledonia St.

Date Begin: 11/18/07 Date End: 11/18/07

	Type	Dia.	Groundwater, ft.	
Casing			During	8.5
Sampler			End	8
Core			Seepage	
Tube			Date	Depth, ft.
			2.0 hrs	7

Depth Drilled: 9.0 ft.
Plugging Rcrd: Backfilled with bentonite holeplug, cuttings and asphalt cold patch.

Component Percentages: Trace < 5%, Few 5-10%, Little 15-25%, Some 30-45%, Mostly 50-100%
QP = Calibrated Penetrometer Reading (tons/sq.ft.)

Elev. FT.	Depth FT.	Sample Number	Recov. FT.	Penetration (Blows Per 6") ASTM D 1586	*Unified Soil Class.	*DESCRIPTION	REMARKS	QP
613.2	1					5" of silty SAND Topsoil	Fill 0' to 6'+/-	
612.2	2				SP	Brown poorly graded SAND with silt; mostly medium	2'+/-	
611.2	3					to fine sand, few coarse to fine gravel, few silty fines,		
610.2	4					moist, Fill		
609.2	5				SP-SM	Light brown poorly graded SAND with silt; mostly		
608.2	6					fine sand, few silty fines, moist, Fill	6'	
607.2	7				OL	Dark brown organic CLAY; moist with decomposed		
606.2	8					wood fragments	7.5'	
605.2	9				CL	Gray mottled lean CLAY; moist (weathered shale)	8.5'	*0.8
	10				ML	Brown mottled sandy SILT; wet		
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
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	26							
	27							
	28							
	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

End of Boring at 9.0'

OUTFALL 56

*Visual estimate following ASTM D 2488 unless laboratory testing has been performed

Materials Testing Consultants, INC.

Boring Log Terminology

Soil Classification Systems:

ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488 Standard Practice for Description and Identifications of Soils (Visual-Manual Procedure)

Minor Component Quantifying Terms:

Trace (less than 5%); Few (5 to 10%); Little (15 to 25%); Some (30 to 45%); Mostly (50 to 100%)

Sample Types and Numbering:

S	SPT, split-barrel sample, ASTM D1586	**U**	Shelby tube sample, ASTM D1587
***S**	Other than 2" split barrel sample	**A**	Auger cuttings
L	SPT with liner, ASTM D1586	**R**	Rock core run
		G	Geoprobe liner

Grain Size:

Boulder	>12"
Cobble	12" to 3"
Coarse Gravel	3" to 0.75"
Fine Gravel	0.75" to No. 4
Coarse Sand	No. 4 to No. 10
Medium Sand	No. 10 to No. 40
Fine Sand	No. 40 to No. 200

Clay - Soil passing a No. 200 sieve that can be made to exhibit plasticity (putty-like properties) and exhibits considerable strength when air dry (ASTM D2487).
Silt - Soil passing a No. 200 sieve that is nonplastic or very slightly plastic and exhibits little or no strength when air dry (ASTM D2487).
Peat - A soil composed of decomposed vegetable tissue with organic odor, dark brown to black color, spongy consistency, and a fibrous to amorphous texture.

"Grades with" or "Grades without" may be used to describe soil when characteristics vary within a stratum.

Moisture Condition:. Dry (absence of visible moist.); Moist (damp but no visible water); Wet (visible free water)

Compactness (Coarse Grained Soils) and Consistency (Fine Grained Soils):

N-value	Relative Density	Compactness	N-value	Approx. Shear Strength, ksf	Consistency
0 - 4	0 - 20%	Very Loose	0 - 2	0.25	Very Soft
5 - 10	20 - 40%	Loose	3 - 4	0.25 - 0.5	Soft
11 - 30	40 - 70%	Med. Dense	5 - 8	0.5 - 1	Med. Stiff
31 - 50	70 - 90%	Dense	9 - 16	1 - 2	Stiff
>50	90 - 100%	Very Dense	17 - 32	2 - 4	Very Stiff
			>32	>4	Hard

Groundwater Observations:

During - indicates water level encountered during the boring
End - indicates water level immediately after drilling
Date and Depth - Measurements at indicated date

Water observations in pervious soils are considered reliable for the date. Water observations in impervious soils may not be accurate groundwater measurements unless records are made over several days time. Groundwater levels will fluctuate for both pervious and impervious soils.

Materials Testing Consultants, INC.

ASTM D2488 Soil Classification Chart - Coarse Grained Soil:

Primary Soil Type	Group Name and (Group Symbol)	Criteria
GRAVEL	Well-graded GRAVEL (GW) Poorly graded GRAVEL (GP)	<5% fines, <15% sand
	Well-graded GRAVEL with sand (GW) Poorly-graded GRAVEL with sand (GP)	<5% fines, >15% sand
	Well-graded GRAVEL with silt (GW-GM) Poorly graded GRAVEL with silt (GP-GM) Well-graded GRAVEL with clay (GW-GC) Poorly-graded GRAVEL with clay (GP-GC)	10% fines, <15% sand
	Well-graded GRAVEL with silt and sand (GW-GM) Poorly graded GRAVEL with silt and sand (GP-GM) Well-graded GRAVEL with clay and sand (GW-GC) Poorly graded GRAVEL with clay and sand (GP-GC)	10% fines, >15% sand
	Silty GRAVEL (GM) Clayey GRAVEL (GC)	>15% fines, <15% sand
	Silty GRAVEL with sand (GM) Clayey GRAVEL with sand (GC)	>15% fines, >15% sand
SAND	Well-graded SAND (SW) Poorly-graded SAND (SP)	<5% fines, <15% gravel
	Well-graded SAND with gravel (SW) Poorly-graded SAND with gravel (SP)	<5% fines, >15% gravel
	Well-graded SAND with silt (SW-SM) Poorly-graded SAND with silt (SP-SM) Well-graded SAND with clay (SW-SC) Poorly-graded SAND with clay (SP-SC)	10% fines, <15% gravel
	Well-graded SAND with silt and gravel (SW-SM) Poorly-graded SAND with silt and gravel (SP-SM) Well-graded SAND with clay and gravel (SW-SC) Poorly-graded SAND with clay and gravel (SP-SC)	10% fines, >15% gravel
	Silty SAND (SM) Clayey SAND (SC)	>15% fines, <15% gravel
	Silty SAND with gravel Clayey SAND with gravel	>15% fines, >15% gravel

Materials Testing Consultants, INC.

ASTM D2488 Soil Classification Outline - Fine Grained Soil:

Primary Soil Type	Group Name and (Group Symbol)	Criteria
SILT	SILT (ML) Elastic SILT (MH)	<15% plus No. 200
	SILT with sand (ML) Elastic SILT with sand (MH)	15-25% plus No. 200, % sand > % gravel
	SILT with gravel (ML) Elastic SILT with gravel (MH)	15-25% plus No. 200, % gravel >% sand
	Sandy SILT (ML) Sandy Elastic SILT (MH)	>30% plus No. 200, % sand > % gravel, <15% gravel
	Sandy SILT with gravel (ML) Sandy Elastic SILT with gravel (MH)	>30% plus No. 200, % sand > % gravel, >15% gravel
	Gravelly SILT (ML) Gravelly Elastic SILT (MH)	>30% plus No. 200, % gravel > % sand, <15% sand
	Gravelly SILT with sand (ML) Gravelly Elastic SILT with sand (MH)	>30% plus No. 200, % gravel > % sand, >15% sand
CLAY	Lean CLAY (CL) Fat CLAY (CH)	<15% plus No. 200
	Lean CLAY with sand (CL) Fat CLAY with sand (CH)	15-25% plus No. 200, % sand > % gravel
	Lean CLAY with gravel (CL) Fat CLAY with gravel (CH)	15-25% plus No. 200, % gravel >% sand
	Sandy lean CLAY (CL) Sandy fat CLAY (CH)	>30% plus No. 200, % sand > % gravel, <15% gravel
	Sandy lean CLAY with gravel (CL) Sandy fat CLAY with gravel (CH)	>30% plus No. 200, % sand > % gravel, >15% gravel
	Gravelly lean CLAY (CL) Gravelly fat CLAY (CH)	>30% plus No. 200, % gravel > % sand, <15% sand
	Gravelly lean CLAY with sand (CL) Gravelly fat CLAY with sand (CL)	>30% plus No. 200, % gravel > % sand, >15% sand

Note: Percentages are based on estimated amounts of fines, sand and gravel to the nearest 5%

SUMMARY OF LABORATORY TEST DATA

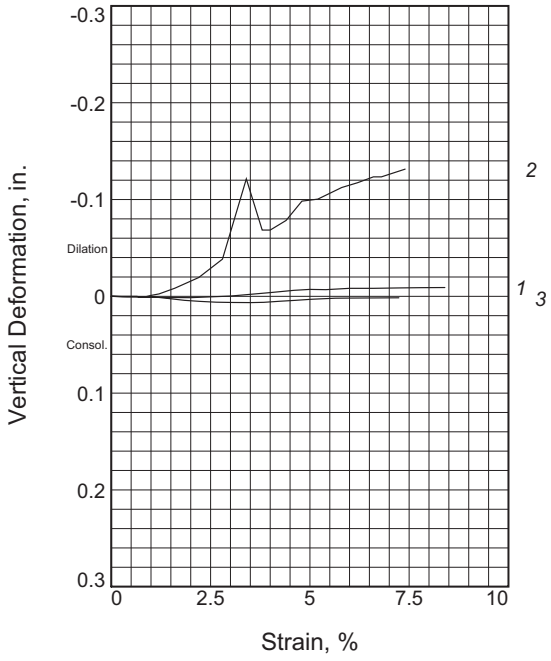
Boring Number	Sample No. *	Sample Depth (ft)	Sample Description and USCS Classification	Effective Friction Angle (degrees)	Effective Cohesion (tsf)	Natural Moisture Content (%)	Organic Content (%)	Atterberg Limits		
								LL	PL	PI
B-1	A-1	2 - 3	Dark Brown Silty Sand with Gravel	46.2	0.182	16.4				
B-3	A-2	2 – 2.5	Black Poorly Graded Sand with Silt and Gravel							
B-3	A-5	7 – 7.5	Dark Brown to Black Silty Sand with Gravel	51.7	0.063	34.0	8.5	45	34	11
B-4	A-2	2 – 2.5	Brown Silty Sand with Gravel	44.7	0.121	7.9				
B-4	S-6	13.5 – 15	Gray Sandy Organic Clay				9.4	69	40	29
B-4	S-7	18.5 - 20	Light Gray Silty Sand							

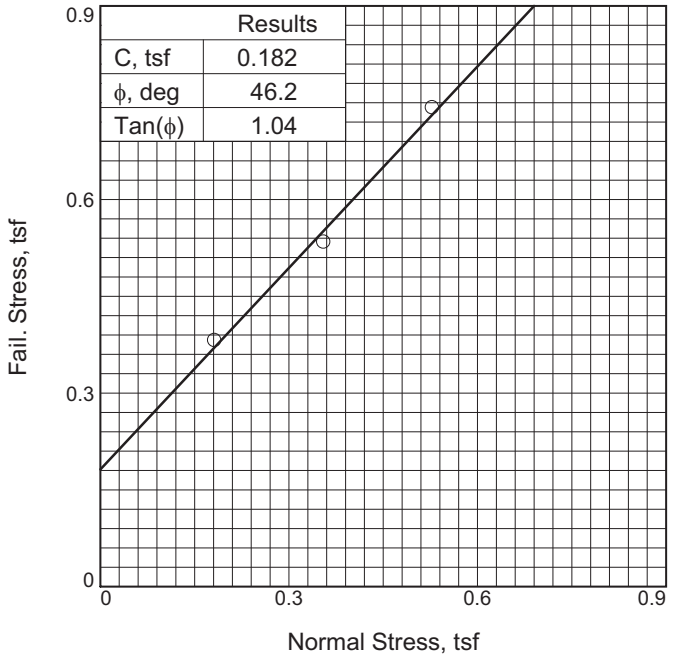
Note: Graphic Presentations of Results of Grain Size and Direct Shear Testing follow this summary

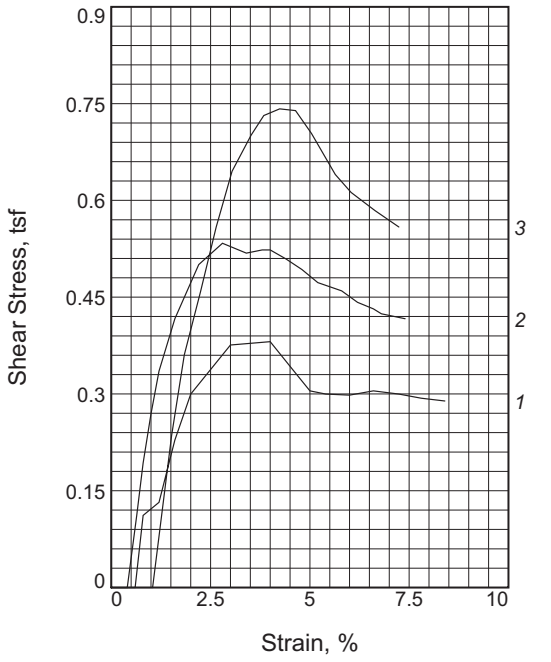
MATERIALS TESTING CONSULTANTS, INC.
693 PLYMOUTH NE, GRAND RAPIDS, MICH. 49505 - PHONE 616/456-5469

* S - Split Spoon Sample (ASTM D 1586)
L - Split Spoon Sample with Liners (ASTM D 1586)
U - Thin-walled tube sample (ASTM D 1587)
R - Rock Core (ASTM D 2113)

PROJECT NO.: 111266
PAGE: 1 OF 1







Sample No.		1	2	3
Initial	Water Content, %	16.4	14.6	13.8
	Dry Density, pcf	111.9	112.6	116.9
	Saturation, %	91.0	82.5	88.2
	Void Ratio	0.4783	0.4694	0.4146
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.96	1.10	1.05
At Test	Water Content, %	16.4	14.6	13.8
	Dry Density, pcf	115.6	114.0	117.7
	Saturation, %	101.0	85.8	90.2
	Void Ratio	0.4309	0.4514	0.4054
	Diameter, in.	2.50	2.50	2.50
	Height, in.	0.93	1.09	1.05
Normal Stress, tsf		0.182	0.356	0.529
Fail. Stress, tsf		0.381	0.533	0.742
Strain, %		4.0	2.8	4.2
Ult. Stress, tsf				
Strain, %				
Strain rate, %/min.		0.30	0.67	0.20

Sample Type: Re-compacted
Description: Dark Brown Silty Sand with Gravel

Assumed Specific Gravity= 2.65
Remarks: Percent Passing No. 200 Sieve = 16.4%

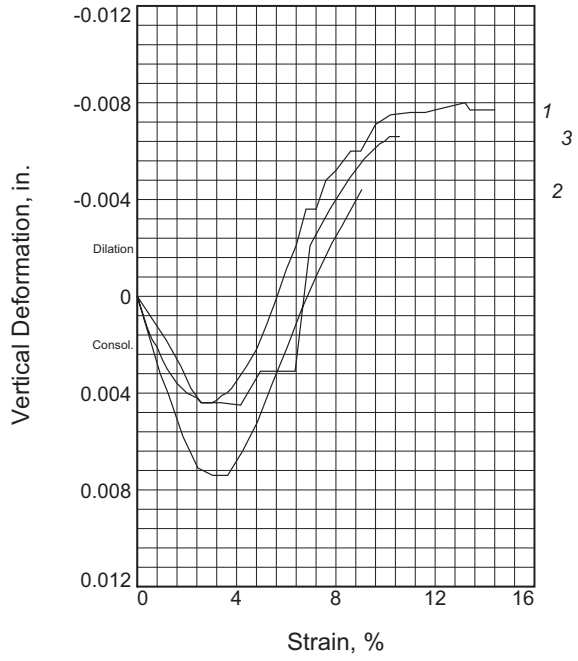
Figure _____

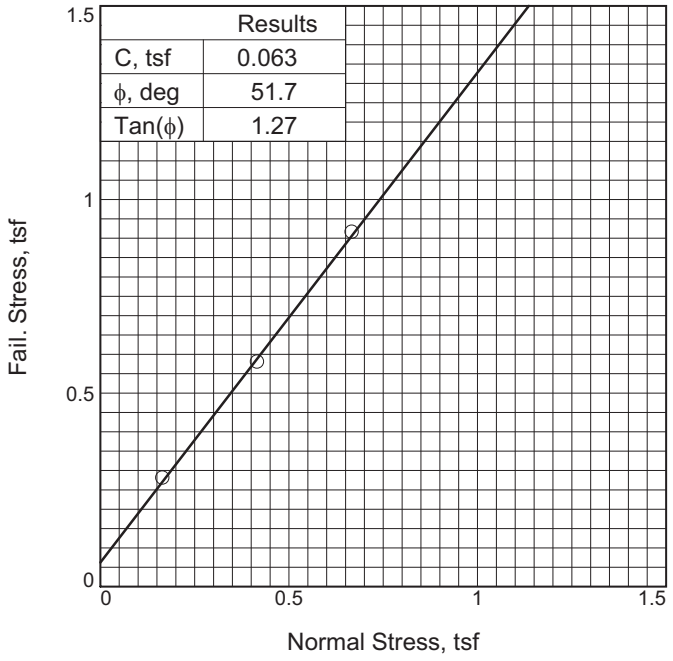
Client: Fishbeck, Thompson, Carr & Huber, Inc.

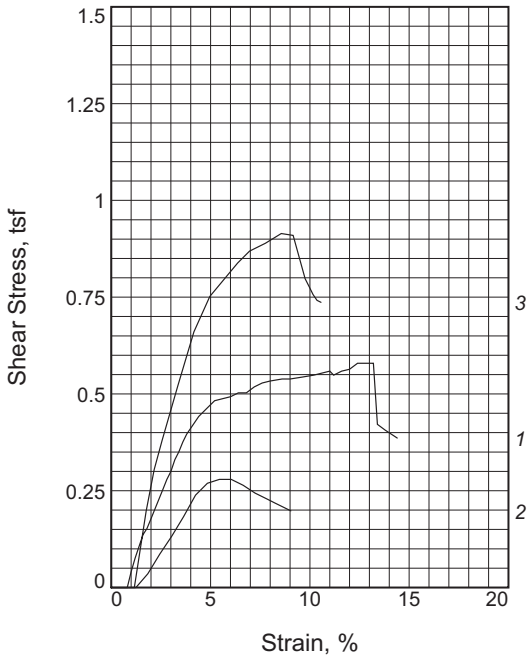
Project: Grand Rapids Floodwalls and Embankments Study

Location: Boring B-1, Sample A-1
Depth: 2 to 3 ft
Proj. No.: 111266 **Date Sampled:**

DIRECT SHEAR TEST REPORT
MATERIALS TESTING CONSULTANTS, INC.
Grand Rapids, MI







Sample No.		1	2	3
Initial	Water Content, %	34.0	31.4	31.9
	Dry Density, pcf	80.7	82.5	84.3
	Saturation, %	85.7	82.7	87.8
	Void Ratio	1.0512	1.0058	0.9616
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.16	1.14	1.10
At Test	Water Content, %	30.5	31.4	29.0
	Dry Density, pcf	84.4	84.0	88.0
	Saturation, %	84.1	85.9	87.3
	Void Ratio	0.9602	0.9693	0.8789
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.11	1.12	1.06
Normal Stress, tsf		0.417	0.167	0.669
Fail. Stress, tsf		0.579	0.279	0.914
Strain, %		12.4	5.4	8.6
Ult. Stress, tsf				
Strain, %				
Strain rate, %/min.		0.20	0.33	0.33

Sample Type: Re-compacted

Description: Dark Brown to Black Silty Sand with Gravel

LL= 45 **PL=** 34 **PI=** 11

Assumed Specific Gravity= 2.65

Remarks: Percent Passing No. 200 Sieve = 23%
Organic Content = 8.5%

Figure _____

Client: Fishbeck, Thompson, Carr & Huber, Inc.

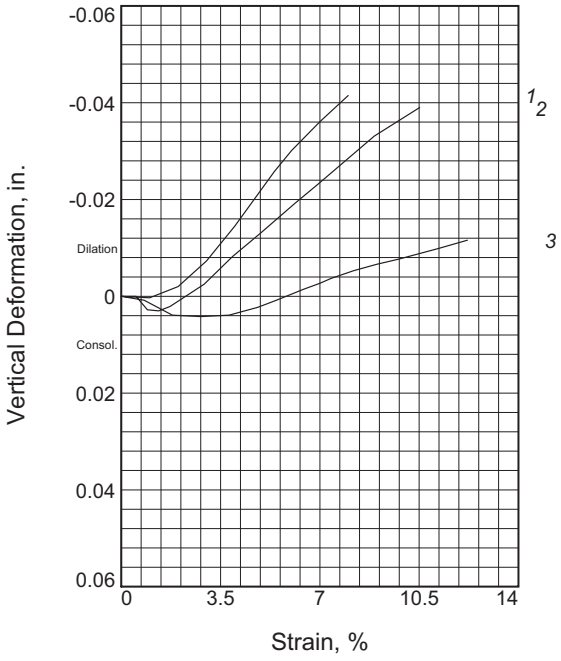
Project: Grand Rapids Floodwalls and Embankments Study

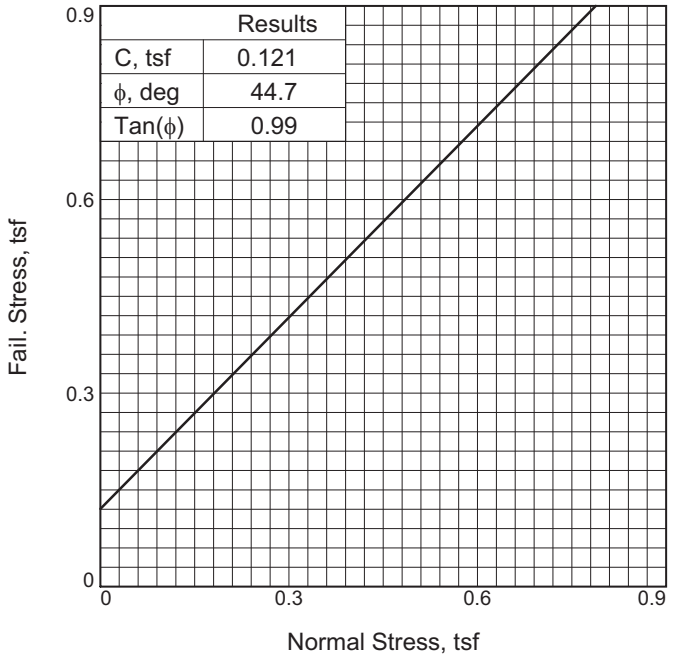
Location: Boring B-3, Sample A-5

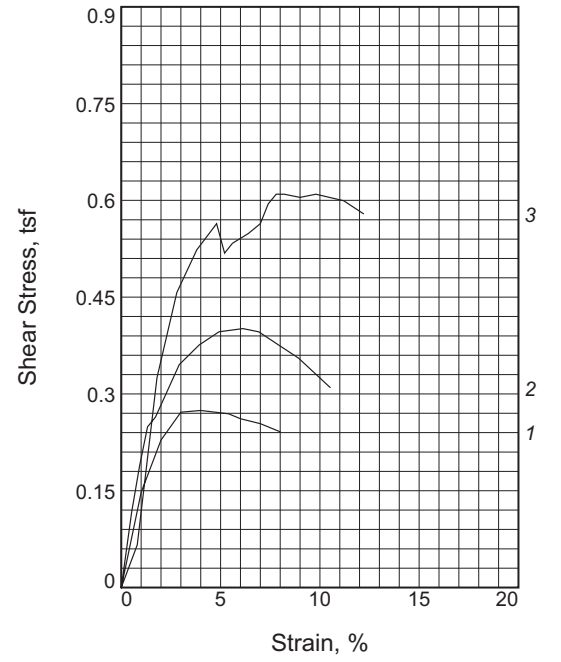
Depth: 7 to 7.5 ft

Proj. No.: 111266 **Date Sampled:**

DIRECT SHEAR TEST REPORT
MATERIALS TESTING CONSULTANTS, INC.
Grand Rapids, MI







Sample No.		1	2	3
Initial	Water Content, %	7.7	7.6	7.9
	Dry Density, pcf	105.7	106.3	103.2
	Saturation, %	36.1	36.2	34.7
	Void Ratio	0.5651	0.5562	0.6036
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.25	1.13	1.21
At Test	Water Content, %	7.7	7.6	7.9
	Dry Density, pcf	107.0	107.8	104.5
	Saturation, %	37.4	37.6	35.9
	Void Ratio	0.5460	0.5351	0.5833
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.24	1.11	1.19
Normal Stress, tsf		0.140	0.317	0.477
Fail. Stress, tsf		0.274	0.401	0.610
Strain, %		4.0	6.1	7.8
Ult. Stress, tsf				
Strain, %				
Strain rate, %/min.		0.39	0.39	0.40

Sample Type: Re-compacted
Description: Brown Silty Sand with Gravel

Assumed Specific Gravity= 2.65
Remarks: Percent Passing No. 200 Sieve = 14.5%

Figure _____

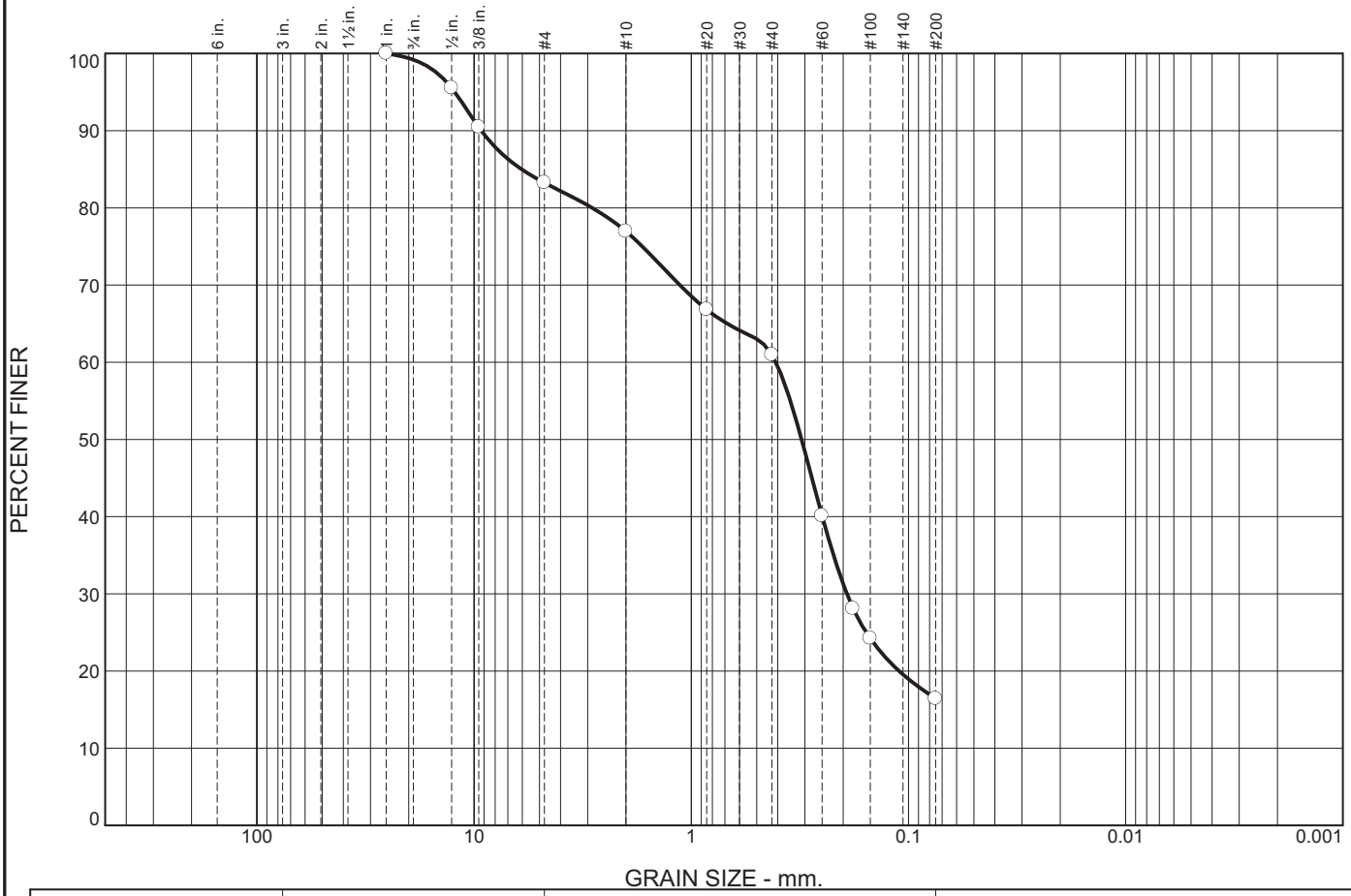
Client: Fishbeck, Thompson, Carr & Huber, Inc.

Project: Grand Rapids Floodwalls and Embankments Study

Location: Boring B-4, Sample A-2
Depth: 2 to 2.5 ft
Proj. No.: 111266 **Date Sampled:**

DIRECT SHEAR TEST REPORT
MATERIALS TESTING CONSULTANTS, INC.
Grand Rapids, MI

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.8	15.9	6.3	16.0	44.6	16.4	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			6.0497	0.4076	0.3106	0.1923				

	Material Description	USCS	AASHTO
○	Dark Brown Silty Sand with Gravel	SM	

Project No. 111266 **Client:** Fishbeck, Thompson, Carr & Huber, Inc.

Project: Grand Rapids Floodwalls and Embankments Study

○ **Location:** Boring B-1, Sample A-1 **Depth:** 2 to 3 ft

Remarks:

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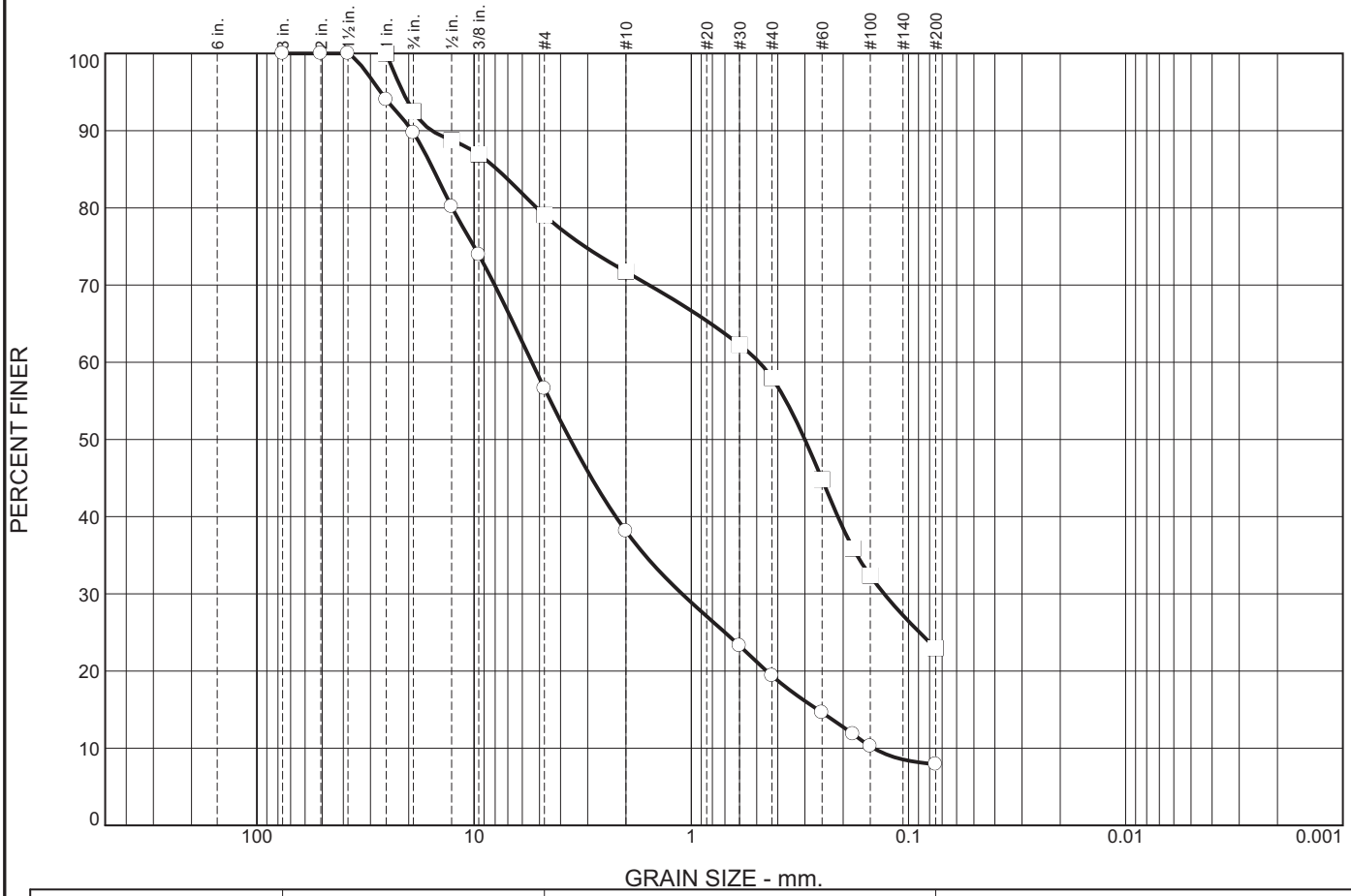
Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	10.3	33.1	18.5	18.7	11.5	7.9	
□	0.0	7.5	13.4	7.4	13.7	35.0	23.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			15.4218	5.4232	3.6125	1.1039	0.2620	0.1448	1.55	37.46
□	45	34	7.8335	0.4870	0.3001	0.1294				

Material Description	USCS	AASHTO
○ Black Poorly Graded Sand with Silt and Gravel	SP-SM	
□ Dark Brown to Black Silty Sand with Gravel	SM	

Project No. 111266 **Client:** Fishbeck, Thompson, Carr & Huber, Inc.

Project: Grand Rapids Floodwalls and Embankments Study

○ **Location:** Boring B-3, Sample A-2 **Depth:** 2 to 2.5 ft

□ **Location:** Boring B-3, Sample A-5 **Depth:** 7 to 7.5 ft

Remarks:

□Sample A-5: Organic Content = 8.5%

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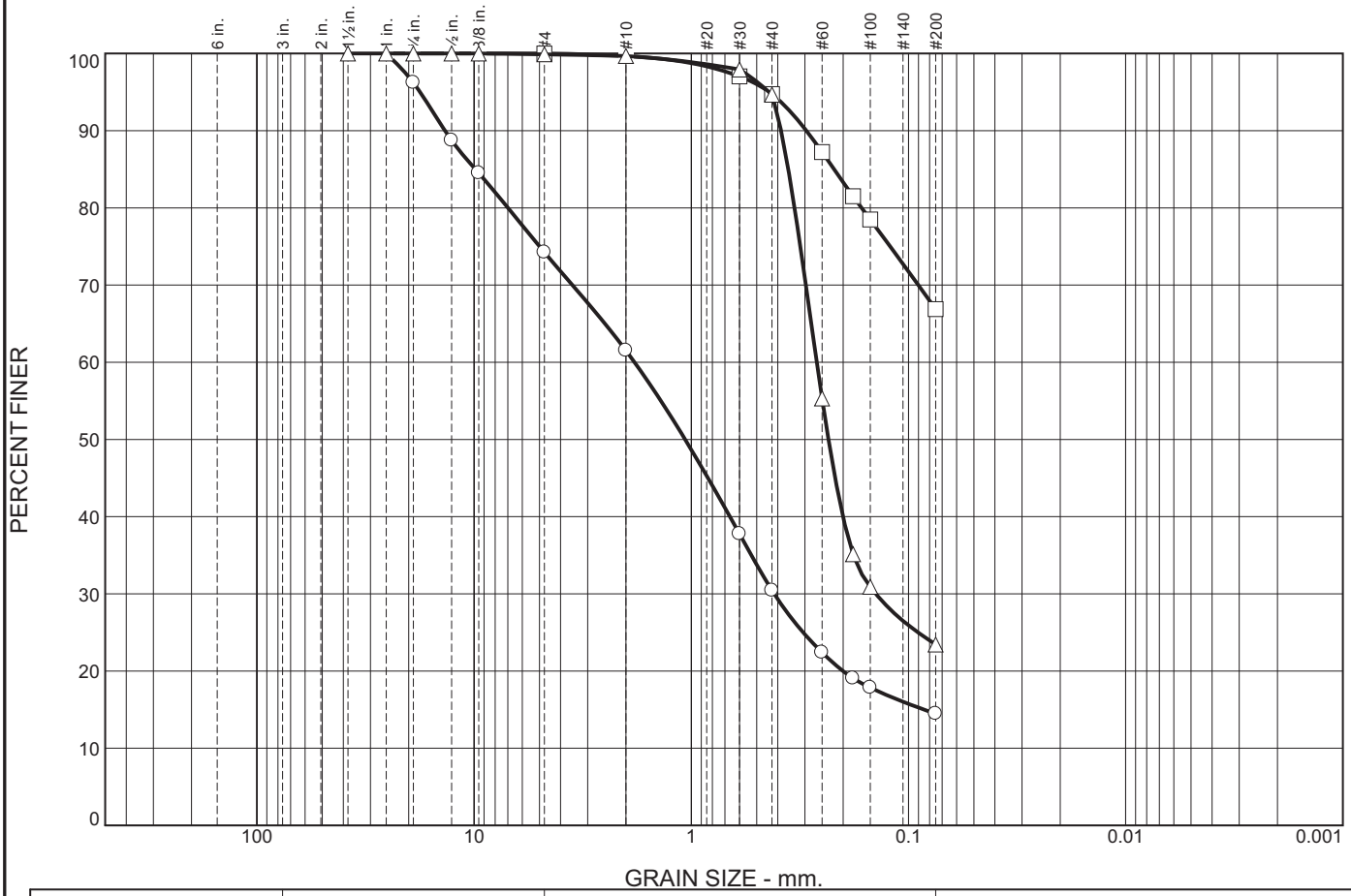
Grand Rapids, MI

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	3.8	22.0	12.7	31.1	15.9	14.5	
□	0.0	0.0	0.0	0.3	5.0	27.8	66.9	
△	0.0	0.0	0.1	0.2	5.0	71.3	23.4	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			9.8640	1.8256	1.0680	0.4153	0.0848			
□	69	40	0.2200							
△			0.3575	0.2645	0.2336	0.1413				

Material Description	USCS	AASHTO
○ Brown Silty Sand with Gravel	SM	
□ Gray Sandy Organic Clay	OH	
△ Light Gray Silty Sand	SM	

Project No. 111266 **Client:** Fishbeck, Thompson, Carr & Huber, Inc.

Project: Grand Rapids Floodwalls and Embankments Study

○ **Location:** Boring B-4, Sample A-2 **Depth:** 2 to 2.5 ft

□ **Location:** Boring B-4, Sample S-6 **Depth:** 13.5 to 15 ft

△ **Location:** Boring B-4, Sample S-7 **Depth:** 18.5 to 20 ft

Remarks:

□Sample S-6: Organic Content = 9.4%

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Grand Rapids, MI

Figure

SUMMARY OF LABORATORY TEST DATA

Boring Number	Sample No. *	Sample Depth (ft)	Sample Description and USCS Classification	Unit Weight (pcf)		Hydraulic Conductivity (cm/s)	Percent Finer No. 200 Sieve	Natural Moisture Content (%)	Direct Shear		Atterberg Limits		
				Wet	Dry				C (tsf)	Phi (deg)	LL	PL	PI
B-1	S-5	13.5-15	Brown poorly graded SAND with Silt (SP-SM)	123.5	101.9	$2.2x10^{-4}$	5.1	21.1					
B-3	S-5	13.5-15	Brown silty SAND (SM)	126.5	102.9	$2.4x10^{-4}$	20.1	23.0					
B-5	S-4	8.5-10	Brown poorly graded SAND (SP)	105.5	96.4	$1.4x10^{-3}$	4.6	9.5					
B-6	S-4	8.5-10	Brown poorly graded SAND with Clay and Gravel (SP-SC)	104.6	98.4	$1.2x10^{-2}$	6.2	6.3					
B-7	S-4	8.5-10	Brown poorly graded SAND with Gravel (SP)	114.5	107.3	$8.3x10^{-4}$	3.5	6.7					
B-7	S-6	18.5-20	Brown clayey SAND (SC)	126.5	104.5	$3.3x10^{-4}$	49.8	21.1					
B-8	S-2	3.5-5	Brown clayey SAND with Gravel (SC)	103.9	96.0	$1.1x10^{-5}$	16.2	8.2					
B-10	S-5	13.5-15	Brown clayey SAND (SC)	91.3	75.0	$1.9x10^{-3}$	29.5	21.7					
B-11	S-3	6-7.5	Brown silty SAND (SM)	78.0	69.6	$1.2x10^{-4}$	34.8	12.0					
B-12	S-4	8.5-10	Brown silty SAND (SM)	93.9	87.3	$1.6x10^{-3}$	12.2	7.6					
B-12	S-6	18.5-20	Brown poorly graded SAND with Silt and Gravel (SP-SM)	106.4	104.3	$1.0x10^{-3}$	7.4	2.1					
B-12/B-14	S-3/S-3	6-7.5	Brown poorly graded SAND with Silt (SP-SM)		103.2			5.3	0.375	28.2			
B-14	S-3/S-4	6-10	Brown silty SAND (SM)		98.2			4.0	0.176	43.4			

Note: Graphic Presentations of Results of Unconfined Compression Strength, Consolidation, and Grain Size follow this summary

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* S - Split Spoon Sample (ASTM D 1586)
L - Split Spoon Sample with Liners (ASTM D 1586)
U - Thin-walled tube sample (ASTM D 1587)
R - Rock Core (ASTM D 2113)

PROJECT NO.: 111266.2

SUMMARY OF LABORATORY TEST DATA

Boring Number	Sample No. *	Sample Depth (ft)	Sample Description and USCS Classification	Unit Weight (pcf)		Unconfined Compressive Strength (ksf)	Percent Finer No. 200 Sieve	Natural Moisture Content (%)	Direct Shear		Atterberg Limits		
				Wet	Dry				C (tsf)	Phi (deg)	LL	PL	PI
B-14	S-5	13.5-15	Brown silty SAND (SM)	90.7	84.0	$9.2x10^{-4}$	39.2	8.1					
B-16	S-4	8.5-10	Brown silty SAND (SM)	88.0	80.5	$7.5x10^{-4}$	28.8	9.3					
B-18	S-4	8.5-10	Brown silty SAND (SM)	89.6	83.5	$3.9x10^{-4}$	41.0	7.3					
B-19	S-3/S-4	6-10	Brown poorly graded SAND with Clay (SP-SC)				8.7	18.6			40	21	19
B-22	S-4	8.5-10	Brown poorly graded SAND with Silt (SP-SM)	106.9	101.8	$1.4x10^{-3}$	9.2	5.0					

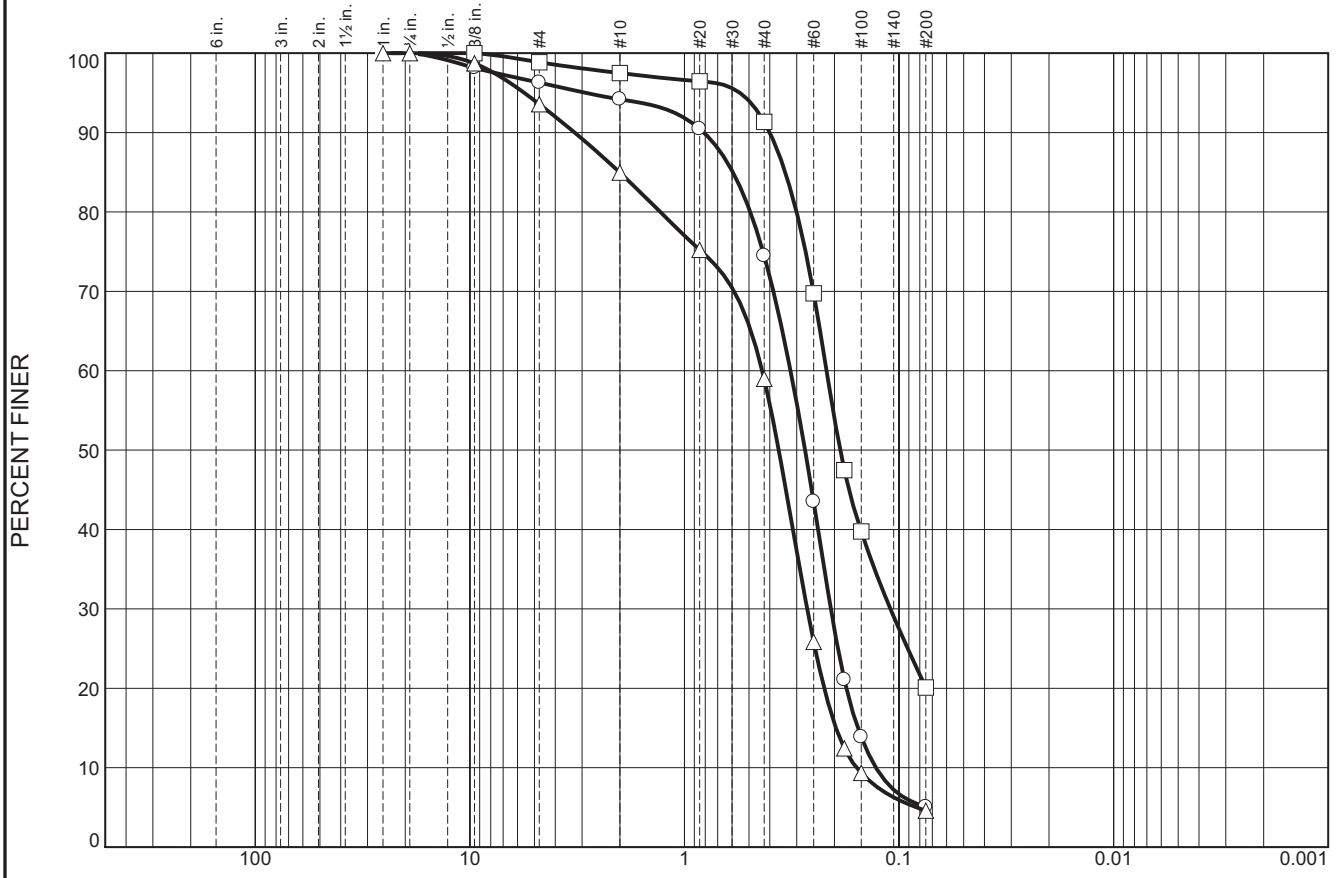
Note: Graphic Presentations of Results of Unconfined Compression Strength, Consolidation, and Grain Size follow this summary

* S - Split Spoon Sample (ASTM D 1586)
L - Split Spoon Sample with Liners (ASTM D 1586)
U - Thin-walled tube sample (ASTM D 1587)
A - Auger Sample

MATERIALS TESTING CONSULTANTS, INC.
693 PLYMOUTH NE, GRAND RAPIDS, MICH. 49505 - PHONE 616/456-5469

PROJECT NO.: 111266.2
PAGE: 2 OF 2

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	3.7	2.1	19.7	69.4	5.1	
□	0.0	0.0	1.1	1.4	6.2	71.2	20.1	
△	0.0	0.0	6.4	8.6	26.0	54.4	4.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.5946	0.3204	0.2742	0.2078	0.1555	0.1281	1.05	2.50
□			0.3389	0.2176	0.1880	0.1097				
△			2.0082	0.4340	0.3635	0.2681	0.1968	0.1577	1.05	2.75

Material Description	USCS	AASHTO
○ Poorly Graded Sand with Silt	SP-SM	
□ Silty Sand	SM	
△ Poorly Graded Sand	SP	

Project No. 111266.2 **Client:** Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

○ **Loc.:** Boring B1 Sample S5 **Depth:** 13.5-15 ft **Sample No.:** 36317-1

□ **Loc.:** Boring B3 Sample S5 **Depth:** 13.5-15 ft **Sample No.:** 36317-2

△ **Loc.:** Boring B5 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-3

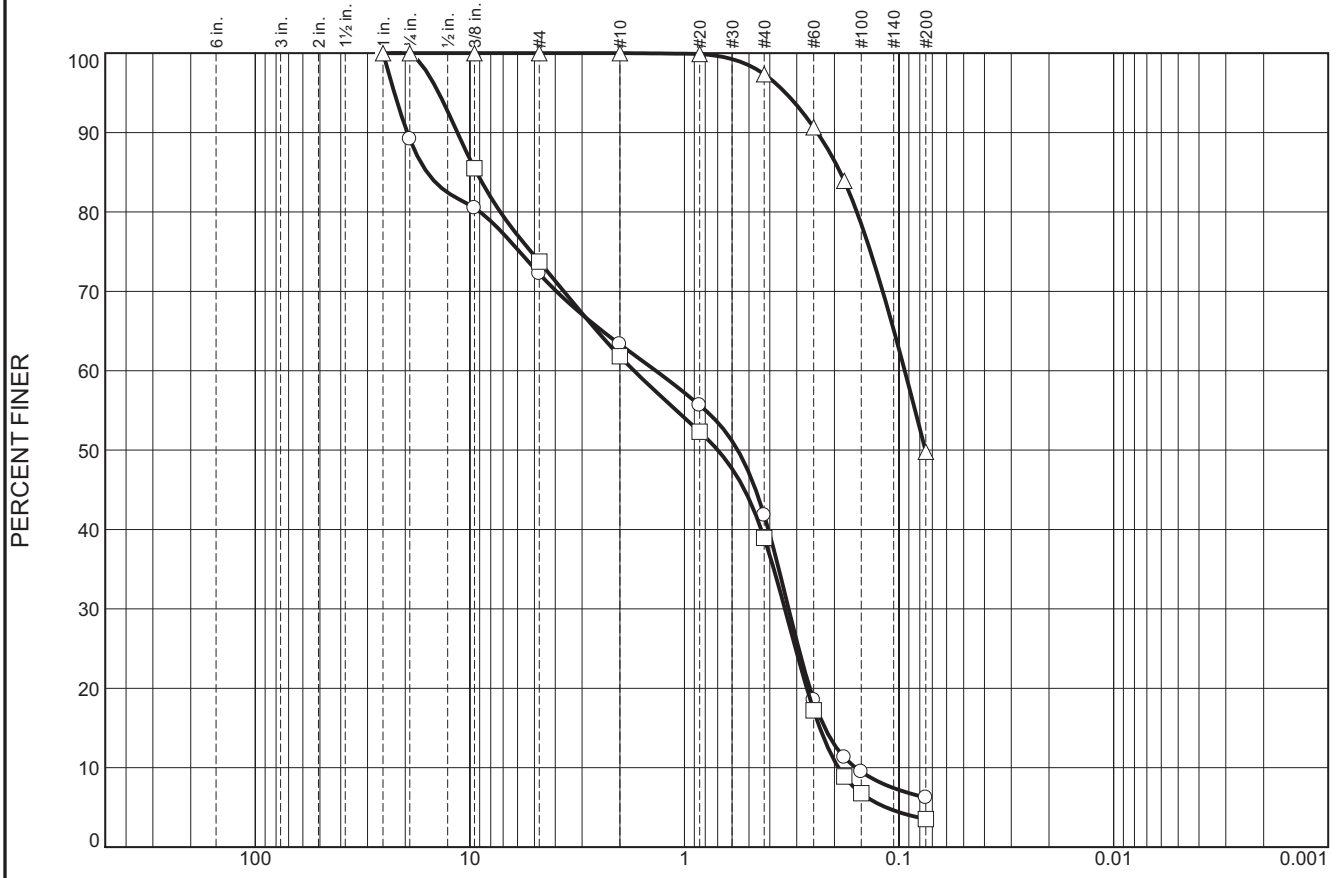
MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Remarks:

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	10.8	17.0	8.9	21.5	35.6	6.2	
□	0.0	0.0	26.3	11.9	22.8	35.5	3.5	
△	0.0	0.0	0.0	0.0	2.7	47.5	49.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			15.8397	1.3613	0.5649	0.3268	0.2215	0.1593	0.49	8.54
□			9.3182	1.7174	0.6993	0.3402	0.2339	0.1917	0.35	8.96
△			0.1879	0.0941	0.0753					

Material Description	USCS	AASHTO
○ Poorly Graded Sand with Clay and Gravel	SP-SC	
□ Poorly Graded Sand with Gravel	SP	
△ Clayey Sand	SC	

Project No. 111266.2 **Client:** Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

○ **Loc.:** Boring B6 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-4

□ **Loc.:** Boring B7 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-5

△ **Loc.:** Boring B7 Sample S6 **Depth:** 18.5-20 ft **Sample No.:** 36317-6

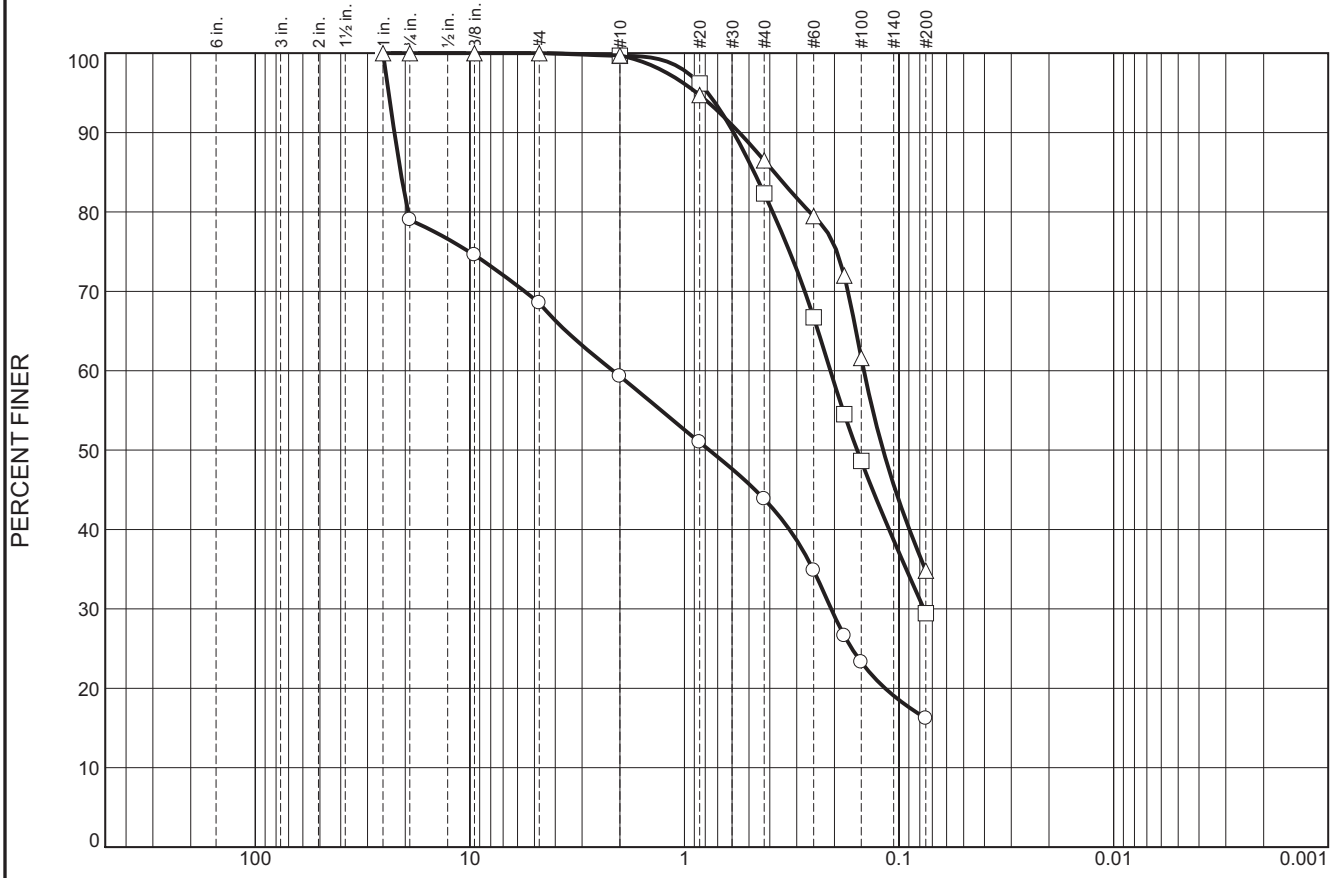
MATERIALS TESTING CONSULTANTS, INC.

Grand Rapids, MI

Remarks:

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	21.0	10.5	9.2	15.5	27.6	16.2	
□	0.0	0.0	0.0	0.3	17.4	52.8	29.5	
△	0.0	0.0	0.0	0.3	13.2	51.7	34.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			21.0156	2.1522	0.7661	0.2070				
□			0.4736	0.2088	0.1568	0.0765				
△			0.3812	0.1458	0.1186					

Material Description	USCS	AASHTO
○ Clayey Sand with Gravel	SC	
□ Clayey Sand	SC	
△ Silty Sand	SM	

Project No. 111266.2 **Client:** Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

○ **Location:** Boring B8 Sample S2 **Depth:** 3.5-5 ft **Sample Number:** 36317-7

□ **Loc.:** Boring B10 Sample S5 **Depth:** 13.5-15 ft **Sample No.:** 36317-8

△ **Loc.:** Boring B11 Sample S3 **Depth:** 6-7.5 ft **Sample No.:** 36317-9

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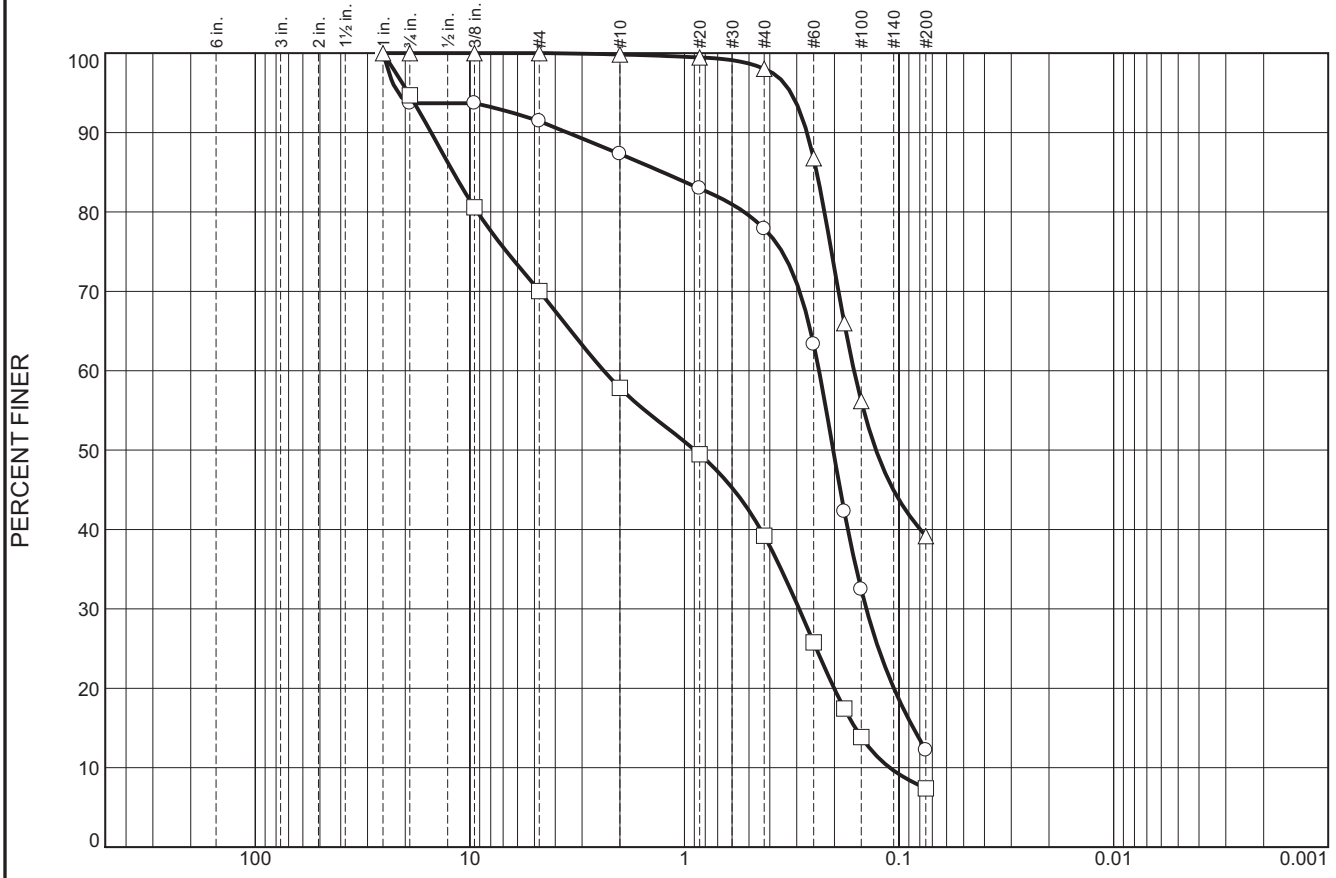
Remarks:

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	6.3	2.3	4.1	9.4	65.7	12.2	
□	0.0	5.3	24.7	12.2	18.6	31.8	7.4	
△	0.0	0.0	0.0	0.2	1.8	58.8	39.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			1.2631	0.2359	0.2026	0.1420	0.0857			
□			11.9455	2.3764	0.8941	0.2923	0.1598	0.1104	0.33	21.52
△			0.2419	0.1622	0.1280					

	Material Description	USCS	AASHTO
○	Silty Sand	SM	
□	Poorly Graded Sand with Silt and Gravel	SP-SM	
△	Silty Sand	SM	

Project No. 111266.2 **Client:** Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

Remarks:

○ **Loc.:** Boring B12 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-10

□ **Loc.:** Boring B12 Sample S6 **Depth:** 18.5-20 ft **Sample No.:** 36317-11

△ **Loc.:** Boring B14 Sample S5 **Depth:** 13.5-15 ft **Sample No.:** 36317-12

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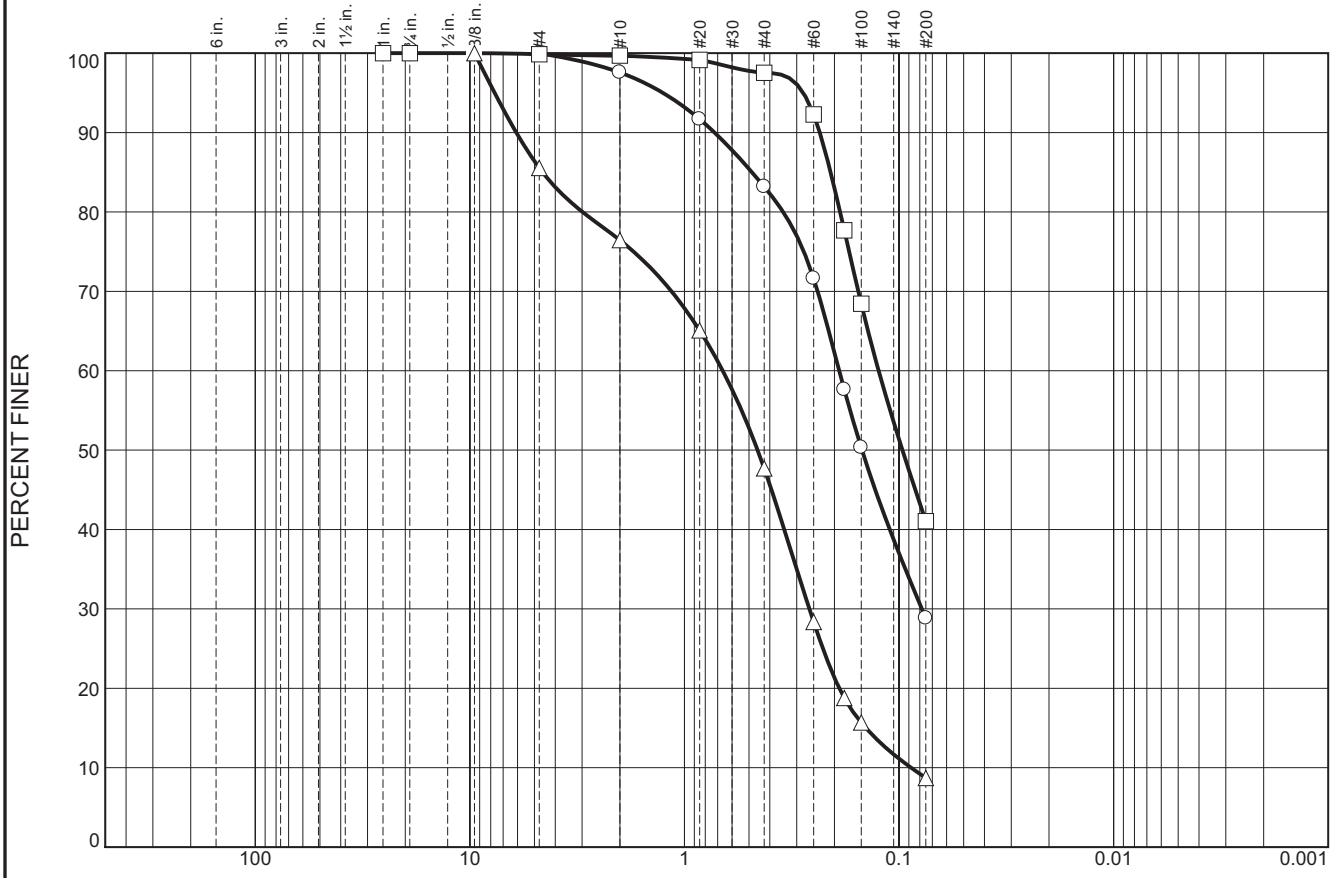
Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	2.4	14.4	54.4	28.8	
□	0.0	0.0	0.1	0.2	2.2	56.5	41.0	
△	0.0	0.0	14.5	9.1	28.7	39.0	8.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.4850	0.1901	0.1487	0.0782				
□			0.2083	0.1245	0.0964					
△	40	21	4.5856	0.6630	0.4564	0.2618	0.1426	0.0878	1.18	7.55

Material Description	USCS	AASHTO
○ Silty Sand	SM	
□ Silty Sand	SM	
△ Poorly Graded Sand with Clay	SP-SC	

Project No. 111266.2 **Client:** Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

○ **Loc.:** Boring B16 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-13

□ **Loc.:** Boring B18 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-14

△ **Loc.:** Boring B19 Samples S3 / S4 **Depth:** 6-10 ft **Sample No.:** 36317-15

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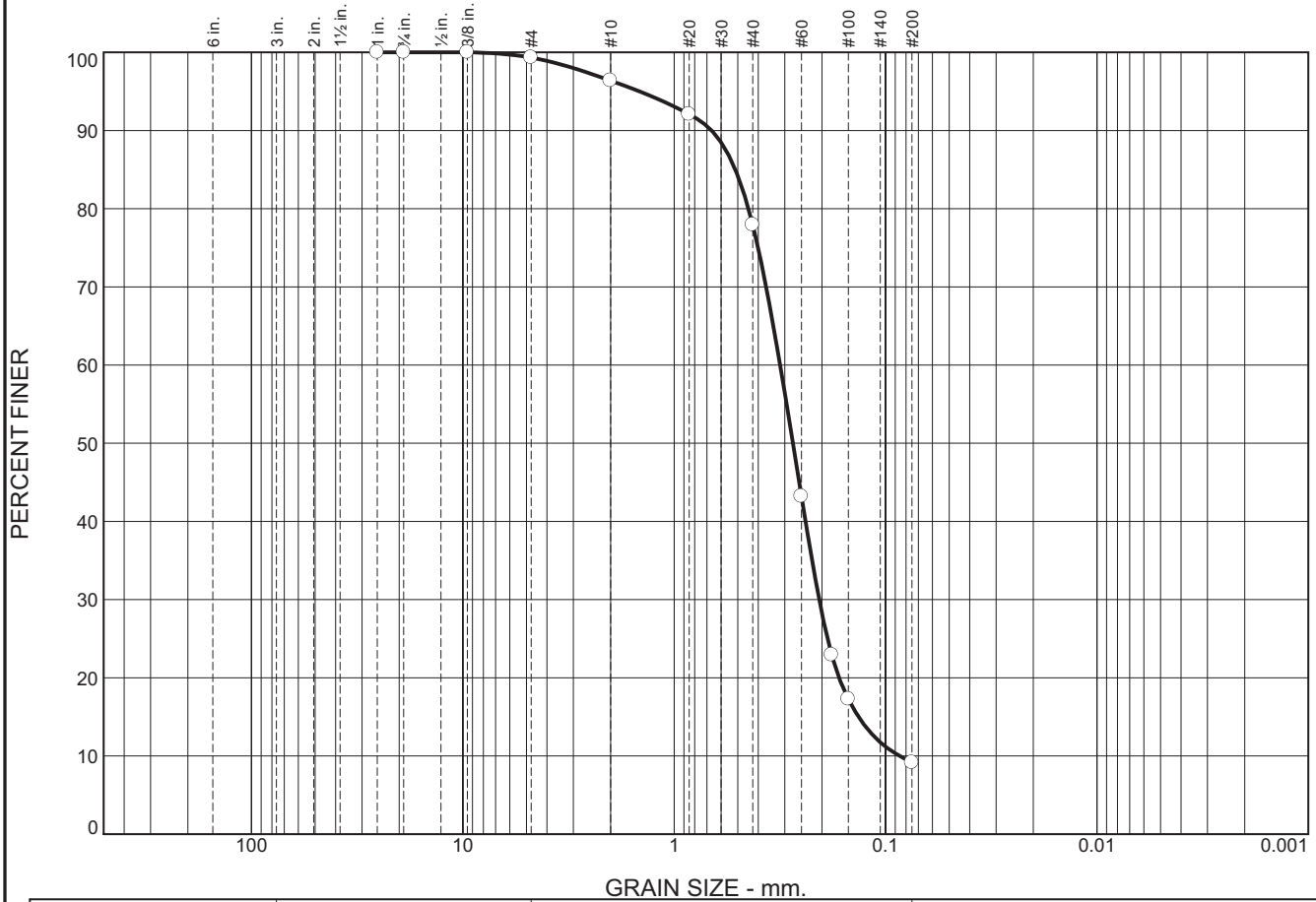
Remarks:

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.7	2.9	18.5	68.7	9.2	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.5141	0.3154	0.2744	0.2060	0.1342	0.0857	1.57	3.68

Material Description	USCS	AASHTO
○ Poorly Graded Sand with Silt	SP-SM	

Project No. 111266.2 **Client:** Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

○ **Loc.:** Boring B22 Sample S4 **Depth:** 8.5-10 ft **Sample No.:** 36317-16

Remarks:

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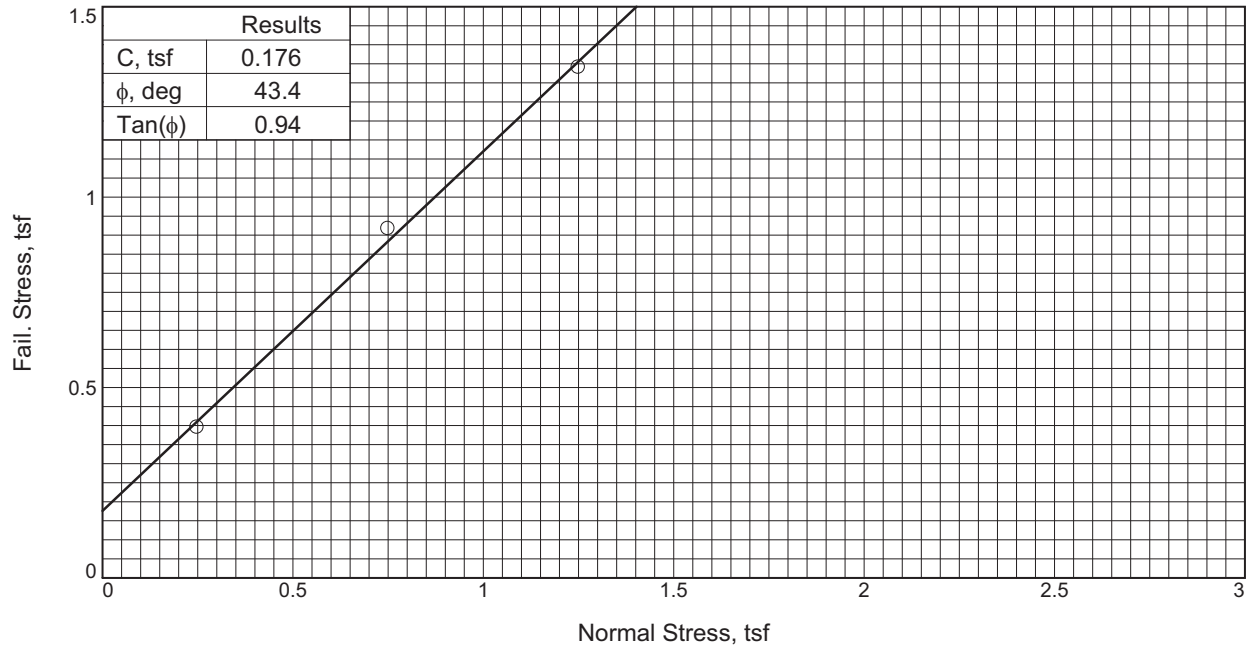
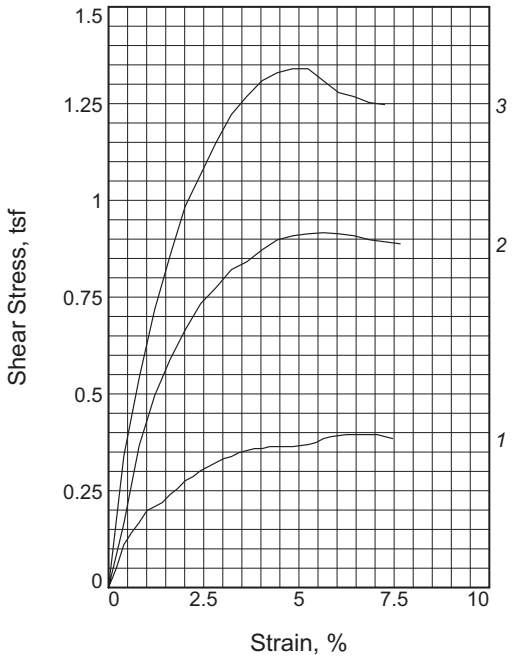
Figure





Sample No.		1	2	3
Initial	Water Content, %	4.2	4.0	3.8
	Dry Density, pcf	98.4	97.9	98.2
	Saturation, %	16.4	15.2	14.8
	Void Ratio	0.6818	0.6900	0.6840
	Diameter, in.	2.48	2.48	2.48
	Height, in.	1.30	1.34	1.34
At Test	Water Content, %	1.8	3.7	3.6
	Dry Density, pcf	98.8	99.1	100.4
	Saturation, %	6.9	14.6	14.9
	Void Ratio	0.6752	0.6701	0.6485
	Diameter, in.	2.48	2.48	2.48
	Height, in.	1.29	1.32	1.31
Normal Stress, tsf		0.249	0.750	1.250
Fail. Stress, tsf		0.395	0.916	1.340
Strain, %		6.3	5.6	4.8
Ult. Stress, tsf				
Strain, %				
Strain rate, in./min.		0.08	0.08	0.08

Sample Type: SPT Sample
Description: Brown Silty Sand

Assumed Specific Gravity= 2.65
Remarks:

Figure _____

Client: Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

Location: Boring B14 Samples S3 / S4

Sample Number: 36317-17 **Depth:** 6-10 ft

Proj. No.: 111266.2 **Date Sampled:** 10-02-2013

DIRECT SHEAR TEST REPORT
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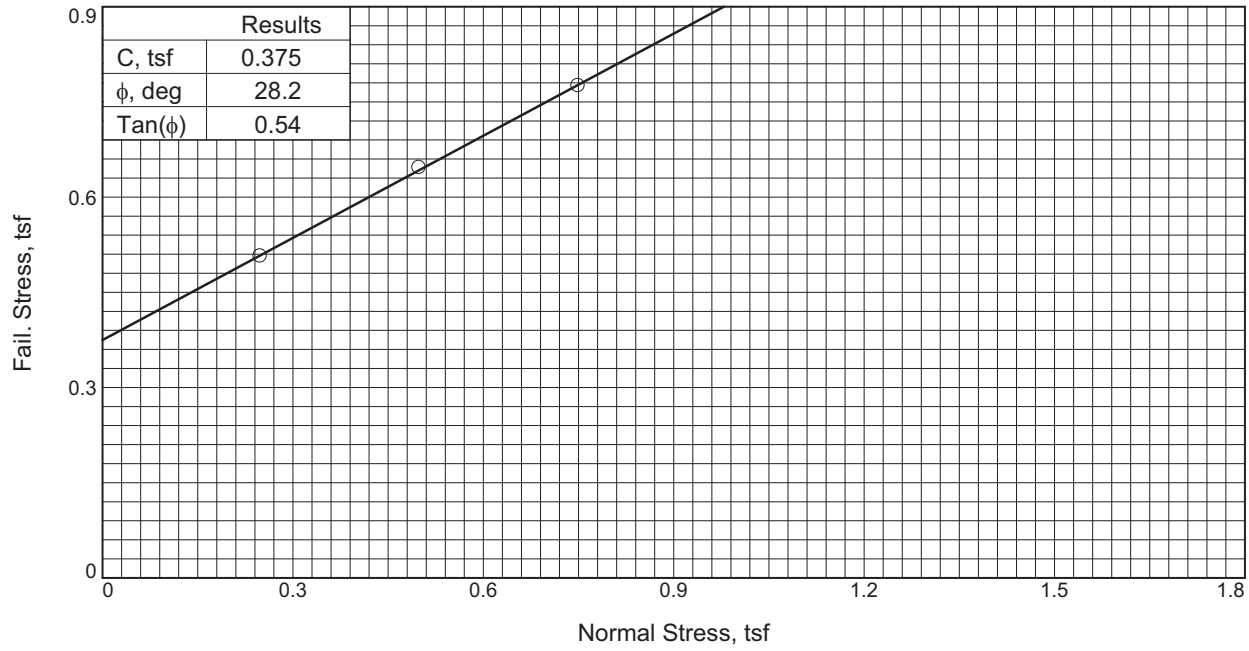

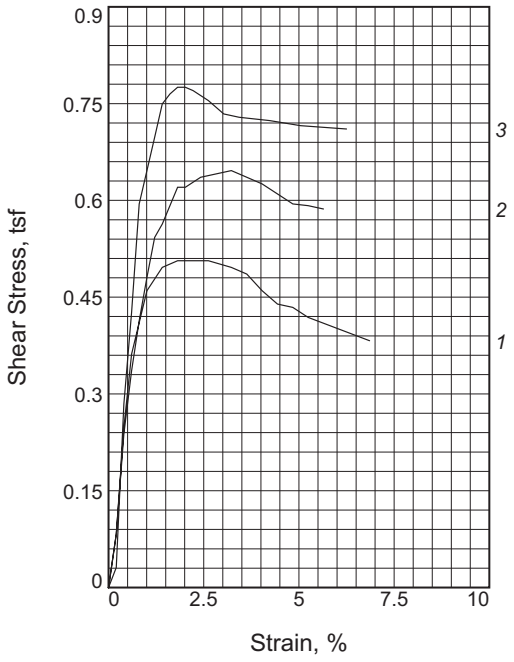

Sample No.		1	2	3
Initial	Water Content, %	6.1	6.1	6.1
	Dry Density, pcf	103.3	102.8	103.6
	Saturation, %	26.8	26.5	27.0
	Void Ratio	0.6013	0.6087	0.5974
	Diameter, in.	2.48	2.48	2.48
	Height, in.	1.22	1.15	1.18
At Test	Water Content, %	5.4	5.4	5.1
	Dry Density, pcf	103.6	102.8	105.2
	Saturation, %	24.1	23.7	23.7
	Void Ratio	0.5969	0.6087	0.5732
	Diameter, in.	2.48	2.48	2.48
	Height, in.	1.22	1.15	1.16
Normal Stress, tsf		0.249	0.499	0.750
Fail. Stress, tsf		0.507	0.646	0.775
Strain, %		1.8	3.2	1.8
Ult. Stress, tsf				
Strain, %				
Strain rate, in./min.		0.05	0.07	0.07

Sample Type: SPT Sample

Description: Brown Poorly Graded Sand with Silt

Assumed Specific Gravity= 2.65

Remarks: Trace fine gravel removed from sample prior to testing

Figure _____

Client: Fishbeck, Thompson, Carr & Huber

Project: GR WWTP Stability Eval

Location: Boring B12 S3 / B14 S3 Composite Sample

Sample Number: 36317-18 **Depth:** 6-7.5 ft

Proj. No.: 111266.2 **Date Sampled:** 10-2-2013

DIRECT SHEAR TEST REPORT

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APPENDIX B – Engineering Evaluations

- **Stability Evaluation Summary Tables p**
- **Evaluation Summary p**
  - **Photographs p**
  - **lope Stability p**
  - **Steady State Seepage p**
  - **Floodwall External Stability p**
  - **ettlement p**

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Grand Rapids Floodwalls and Embankment Study
MTC Project No.: 111266.
Date: January 16, 2018.

Slope Stability Analysis Summar

				Global Factor of Safety			
Reach.	**Section .**	**ood Protection Type.**	**Address.**	**Case I. Existing Condition.**	**Case 2. Sudden Drawdown.**	**Case 3 . Steady State Seepage.**	**Case 4. Earthquake.**
		Embankment / Floodwall					
		Counterfort Floodwall					
		Floodwall and Trunk Sewer			>10	>10	>10
		Cantilever Floodwall					
			1930 Alpine Ave NW				
		Gravity / Cantilever Floodwall	1300 Front Avenue NW				
	W2C	Gravity Floodwall					
		Counterfort Floodwall					
			850 Wealthy St SW				

Materials Testing Consultants, INC.

Grand Rapids Floodwalls and Embankment Study.
MTC Project No.: 111266
Date: January 22, 2018.

Floodwall Stability Analysis Summar

Reach.	Section .	ood Protection Type.	Address.	Load Case.	Hydrostatic Head Differential (ft).	ooting Width . B (ft).	Eccentricity e (ft).	Base Area in . Compression (%).	S. Bearing.	S. Overturning.	S. Sliding.
		Embankment and Cantilever Floodwall		Existing Condition			-0.38		>3		
				Sudden Drawdown				Resultant within Base	>3		
		Counterfort Floodwall		Existing Condition			-0.69		>3		
				Sudden Drawdown					>3		
		Integral Floodwall and Trunk Sewer		Existing Condition					>3		
				Sudden Drawdown					>3		
		Cantilever Floodwall		Existing Condition			-0.76		>3		
				Sudden Drawdown			-0.10		>3		
		Gravity / Cantilever Floodwall	1300 Front Avenue NW	Existing Condition			-1.50		>3		
				Sudden Drawdown				Resultant within Base	>3		
	W2C	Gravity Floodwall		Existing Condition					>3		
				Sudden Drawdown				Resultant within Base	>3		
		Counterfort Floodwall		Existing Condition					>3		
				Sudden Drawdown					>3		

Materials Testing Consultants, INC.

Grand Rapids Floodwalls and Embankment Study.
MTC Project No.: 111266.
Date: January 16, 2018.

Steady State Seepage Analysis Summar

Reach.	Section .	ood Protection Type.	Address.	Seepage Analysis . Performed.	Seepage Faces Present on . Landside of Protection.	/ $i_{cr.}$	Piping/Heave . Expected.
				Yes	Yes		
				Yes			
	Outfall 56			Yes	Yes		
				Yes			
		Embankment / Floodwall		Floodwall Bears on Bedrock			
	Outfall 48	Embankment / Floodwall	225 Michigan St NW	Yes	Yes		
		Counterfort Floodwall		Yes			
	Outfall 29		291 Fulton St W	Yes			
		Floodwall and Trunk Sewer		Floodwall Bears on Bedrock			
				Yes	Yes		
		Cantilever Floodwall		Yes			
			1930 Alpine Ave NW	Yes			
		Gravity / Cantilever Floodwall	1300 Front Avenue NW	Floodwall Bears on Bedrock			
	W2C	Gravity Floodwall		Floodwall Bears on Bedrock			
	Outfall 112	Gravity Floodwall		Yes	Yes		
				Yes	Yes		
		Counterfort Floodwall		Yes			
			850 Wealthy St SW	Yes			

Steady state seepage analyses performed using SLIDE 6.0 Groundwater Seepage Model software
i / $i_{cr.h}$ represents the ratio of the estimated hydraulic gradient to the critical hydraulic gradienth
At Section E3, the gradient ratio was estimated for seepage below the floodwall during sudden drawdowh

Materials Testing Consultants, INC.

Grand Rapids Floodwalls and Embankment Study
MTC Project No.: 111266.
Date: January 19, 2018.

Settlement Analysis Summar

Reach.	Section .	ood Protection Type.	Address.	Estimated Future . Settlement (in).	Existing Top of Flood . Protection (ft).	uture Top of Flood . Protection (ft).	Base Flood . Elevation (ft).
		Embankment / Floodwall					
		Counterfort Floodwall					
		Integral Floodwall and Trunk Sewer					
		Cantilever Floodwall					
			1930 Alpine Ave NW				
		Gravity / Cantilever Floodwall	1300 Front Avenue NW				
	W2C	Gravity Floodwall					
		Counterfort Floodwall					
			850 Wealthy St SW				

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REACH E1

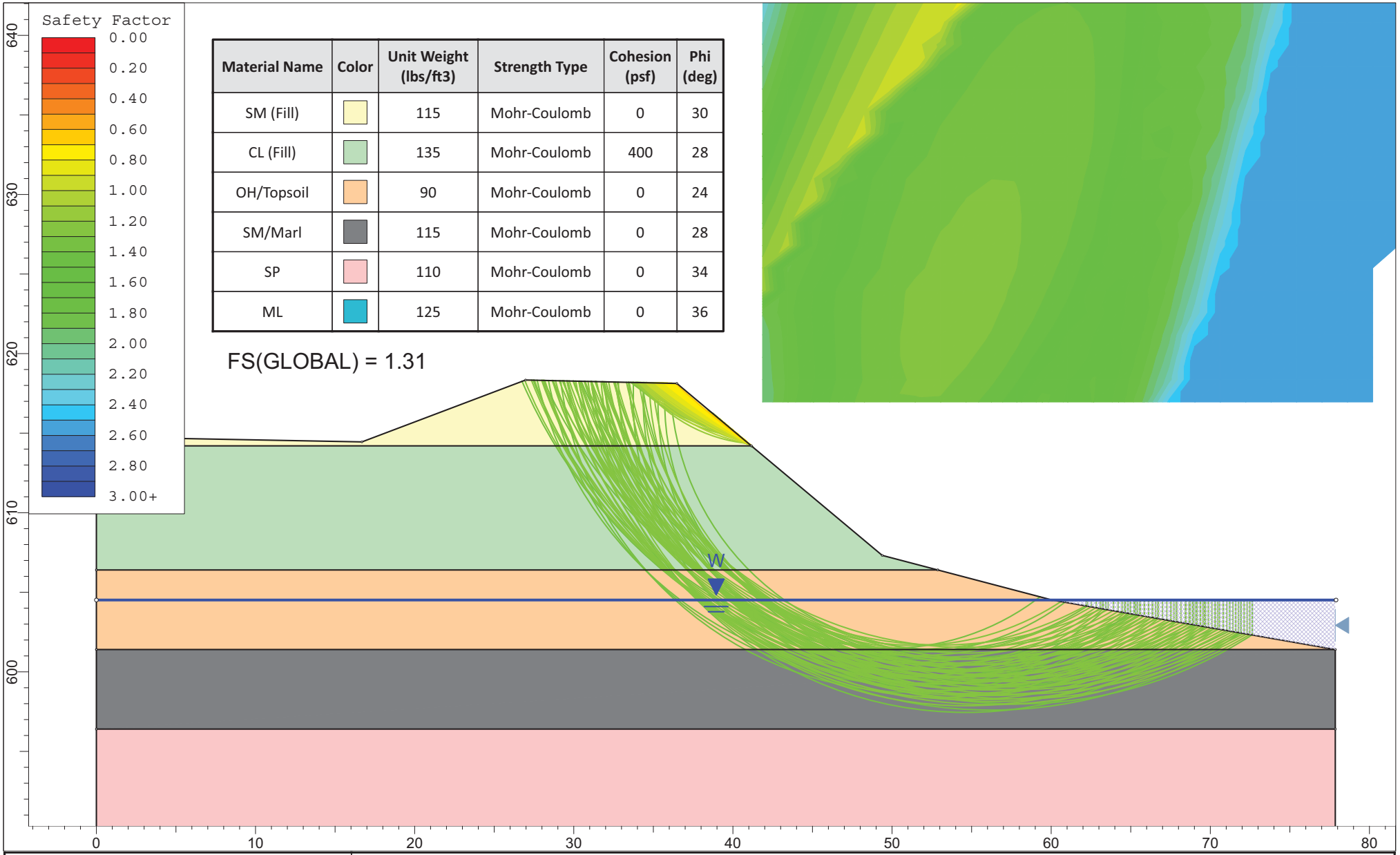
SECTION E1A PHOTOGRAPHS



Looking Southwest



Looking South



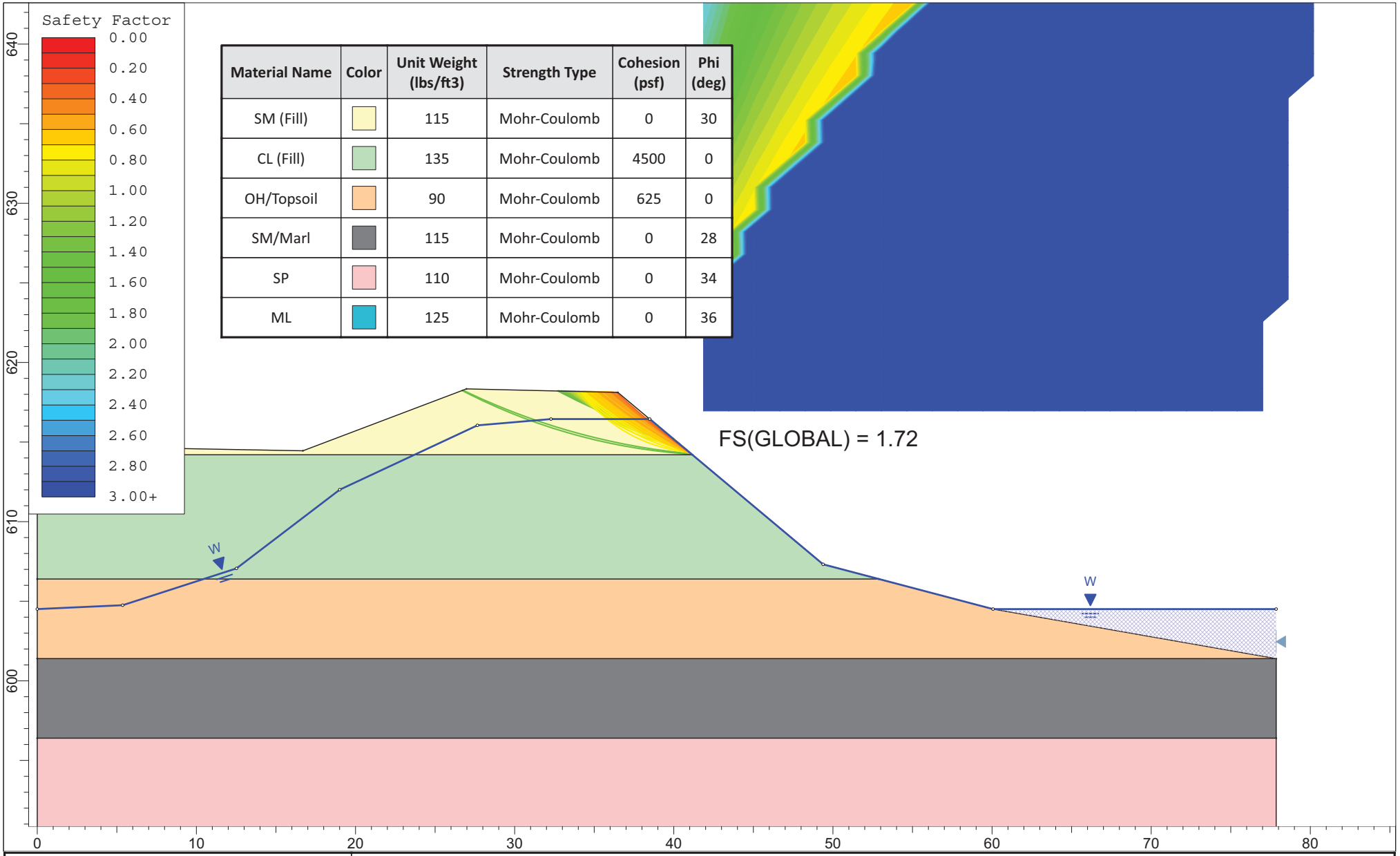
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		135	Mohr-Coulomb	400	28
OH/Topsoil		90	Mohr-Coulomb	0	24
SM/Marl		115	Mohr-Coulomb	0	28
SP		110	Mohr-Coulomb	0	34
ML		125	Mohr-Coulomb	0	36

FS(GLOBAL) = 1.31

rocscience

SLIDEINTERPRET 6.039B

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section 3 Existing Conditions		
Drawn By	TM	Scale	1:100
Company	MTC		
Date	8-18-2016	File Name	Section 3 Existing Conditions.sli

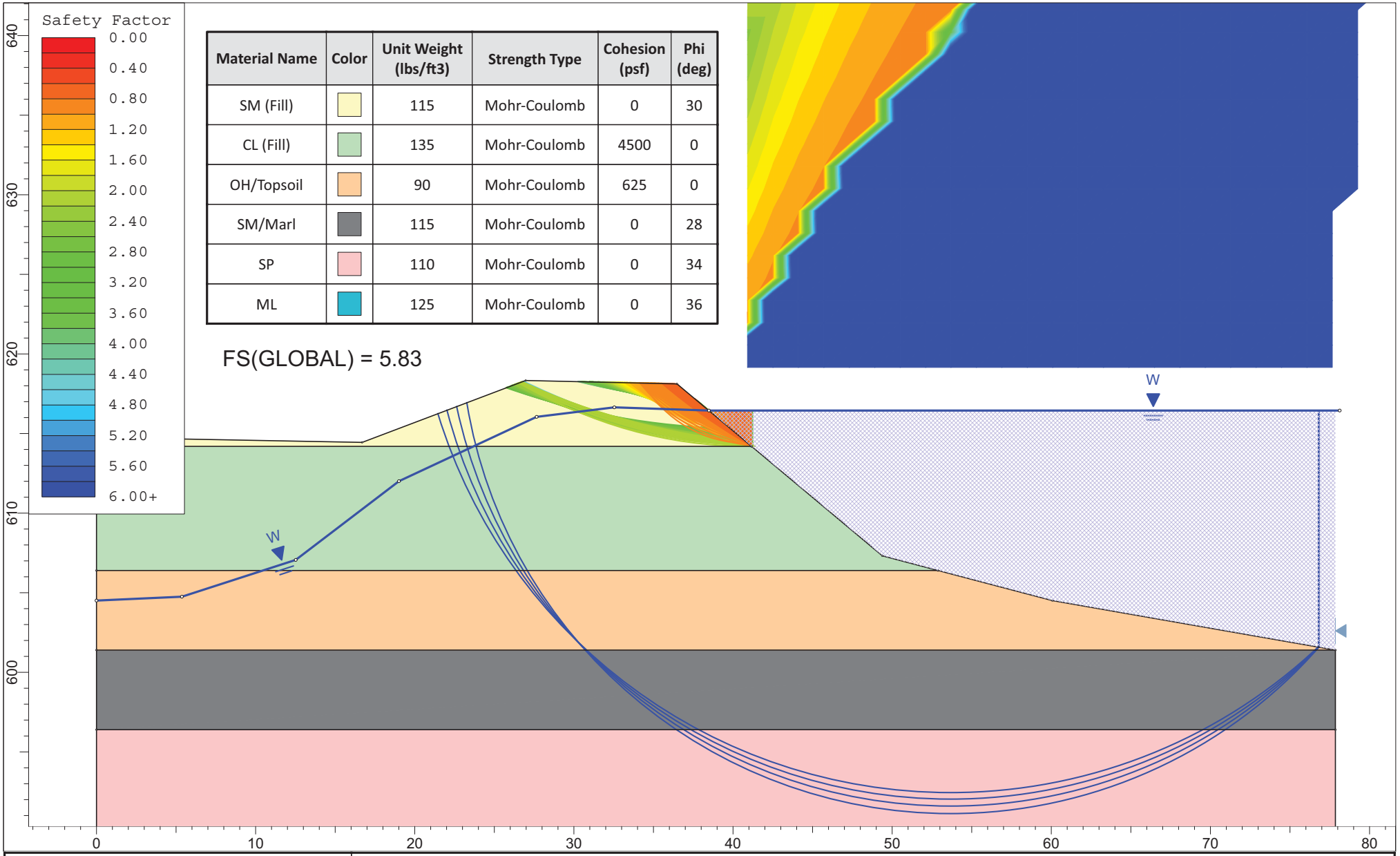


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		135	Mohr-Coulomb	4500	0
OH/Topsoil		90	Mohr-Coulomb	625	0
SM/Marl		115	Mohr-Coulomb	0	28
SP		110	Mohr-Coulomb	0	34
ML		125	Mohr-Coulomb	0	36

FS(GLOBAL) = 1.72

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1A - Sudden Drawdown		
Drawn By	TM	Scale 1:100	Company MTC
Date	8-23-2016		File Name Section E1A Sudden Drawdown

SLIDEINTERPRET 6.039B



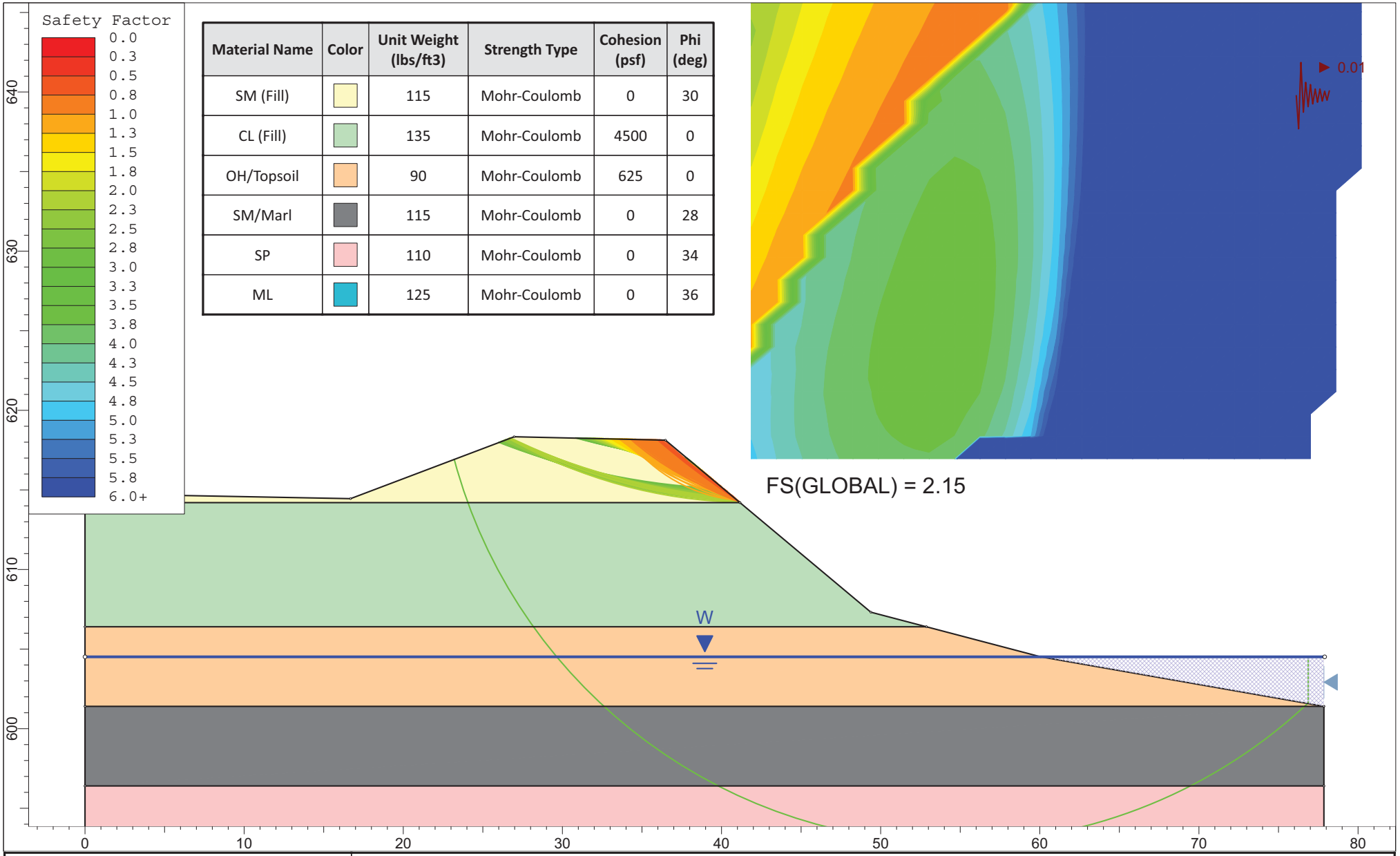
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		135	Mohr-Coulomb	4500	0
OH/Topsoil		90	Mohr-Coulomb	625	0
SM/Marl		115	Mohr-Coulomb	0	28
SP		110	Mohr-Coulomb	0	34
ML		125	Mohr-Coulomb	0	36

FS(GLOBAL) = 5.83

rocscience

SLIDEINTERPRET 6.039B

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1A - Steady State Seepage		
Drawn By	TM	Scale 1:100	Company MTC
Date	8-18-2016		File Name Section E1A - Steady State Seepage ection 3 - Base Flood.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		135	Mohr-Coulomb	4500	0
OH/Topsoil		90	Mohr-Coulomb	625	0
SM/Marl		115	Mohr-Coulomb	0	28
SP		110	Mohr-Coulomb	0	34
ML		125	Mohr-Coulomb	0	36

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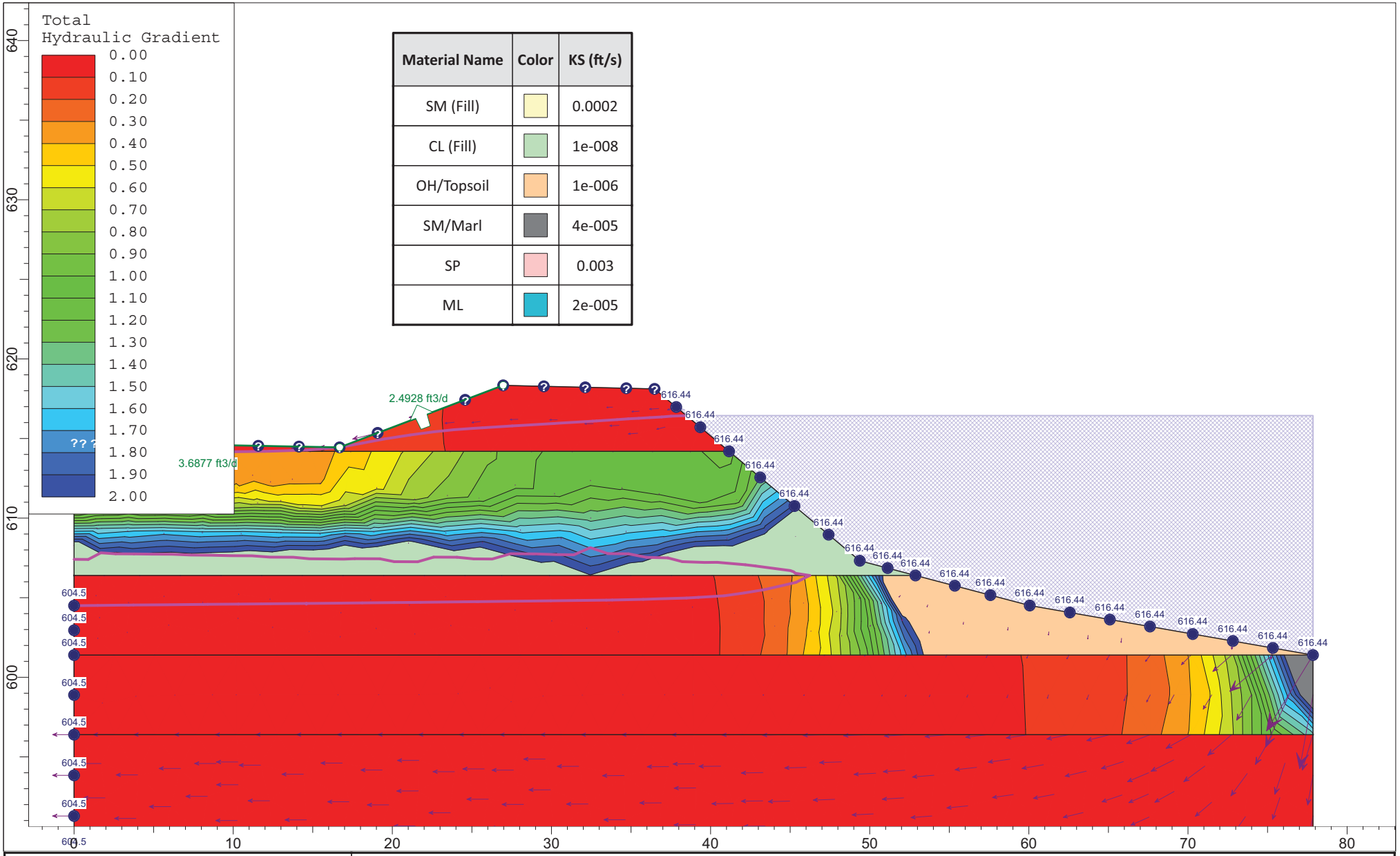
SLIDEINTERPRET 6.039B

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section 3 - Earthquake		
Drawn By	TM	Scale	1:100
Company	MTC		
Date	8-15-2016	File Name	Section 3 - Earthquake.slim



ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1A - Steady State Seepage		
Drawn By	TM	Scale 1:100	Company MTC
Date	8-18-2016		File Name Section E3A Steady State Seepage.slim

SLIDEINTERPRET 6.039B

REACH E1, SECTION E1A - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-4 (111266)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log \frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_c \log\left(\frac{t_2}{t_1}\right)$$

Organic Decompositionh
Consider settlement percentage due to decomposition of organic material equal to loss of 1/2 percent of organics by weigh

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill				
	Clay, Fill	CL			
	Organic Clay	OH			
	Sand, Marl	SM, OH			
	Sand				
	Silt	ML			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s

Settlement Analysis

					ΔH (in)			
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary	Organics
				TOTAL (in).	**2.87.**			

Freeboard Summar

Existing Flood Protection El = .	**618.3.**
uture Flood Protection El = .	**618.1.**
BFE = .	**616.4.**

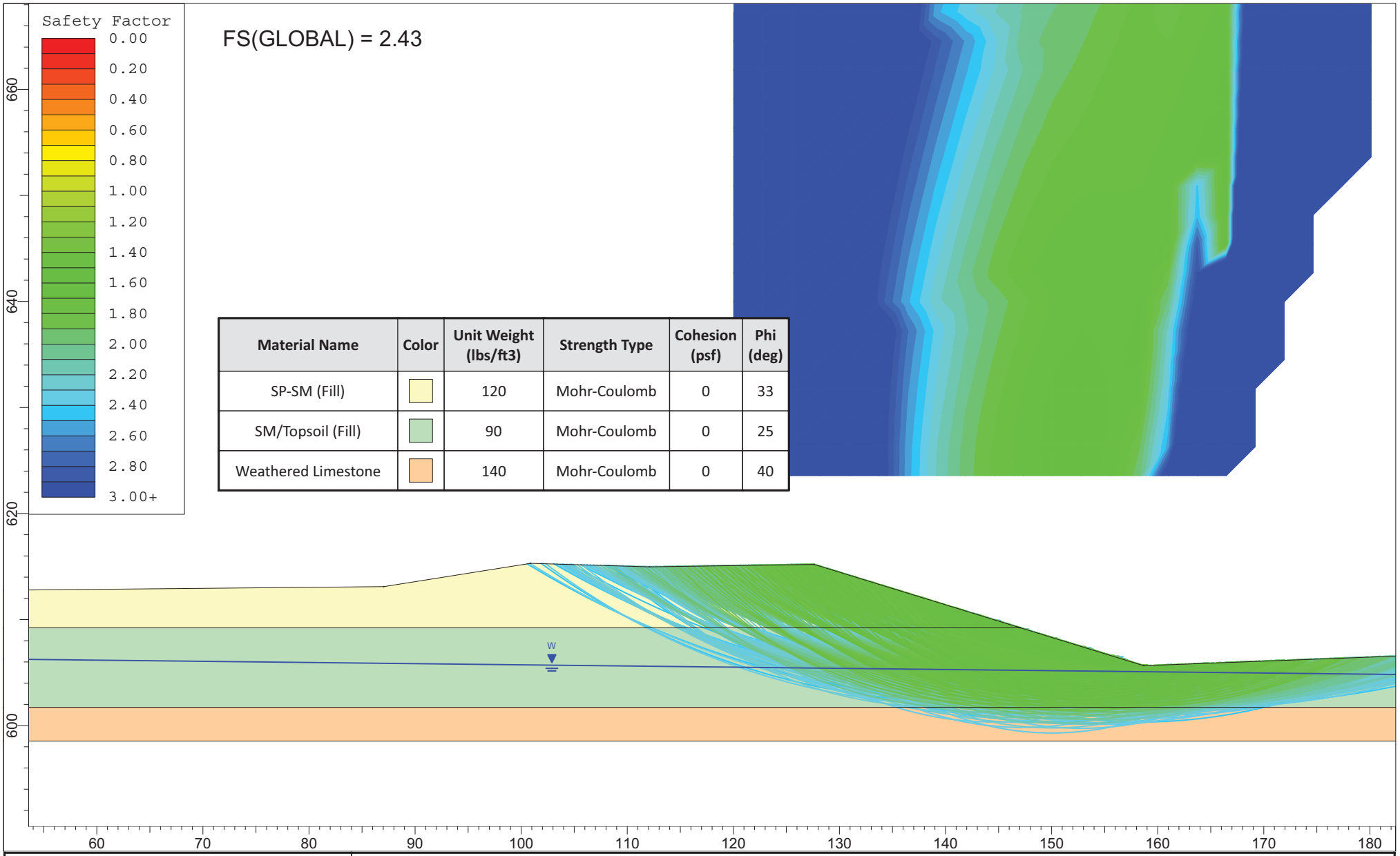
SECTION E1B PHOTOGRAPHS



Looking South



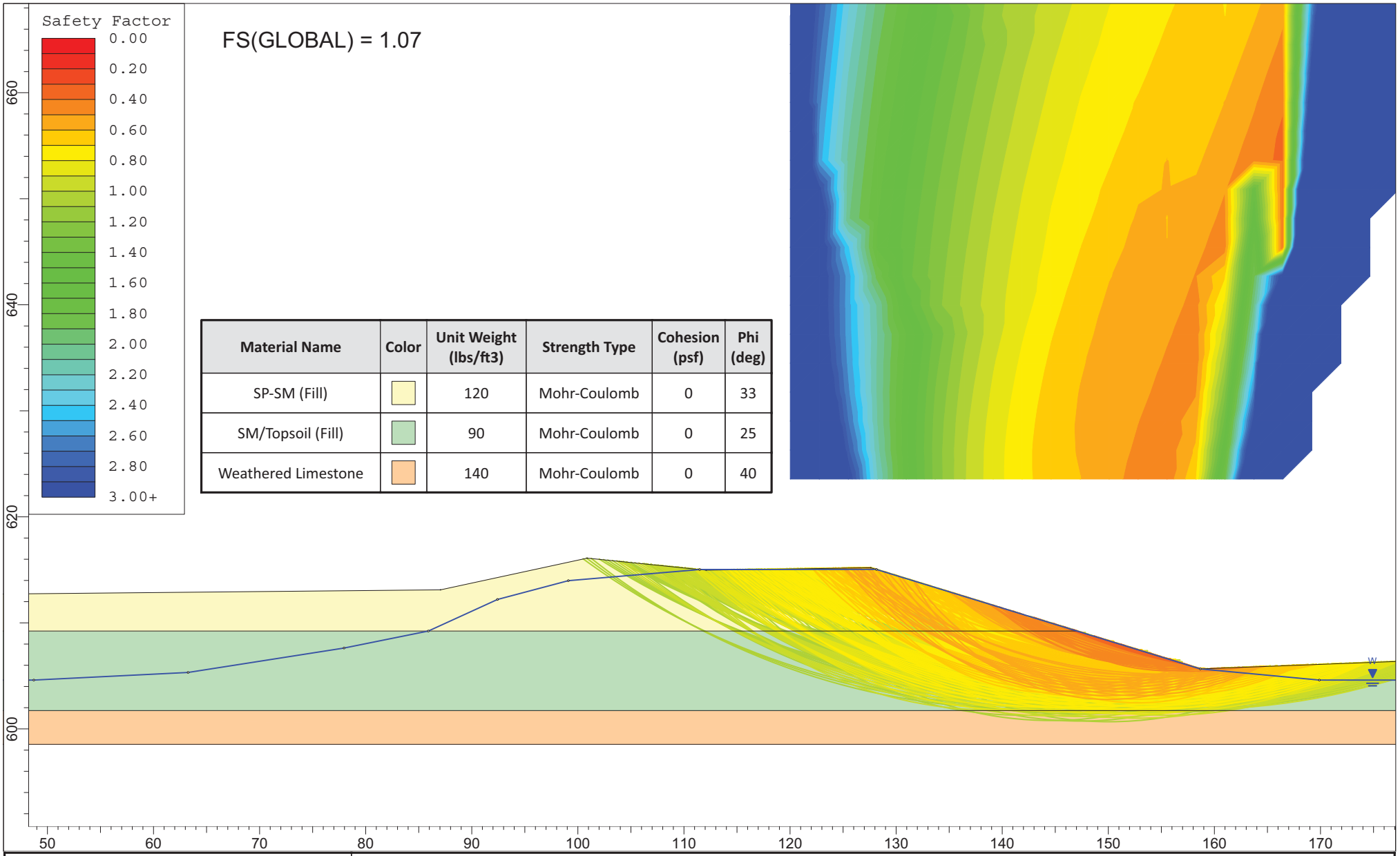
Looking North



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1B - Existing Conditions		
Drawn By	TM	Scale 1:150B	Company MTC
Date	8-22-2016		File Name Section E1B - Existing Conditions.slim

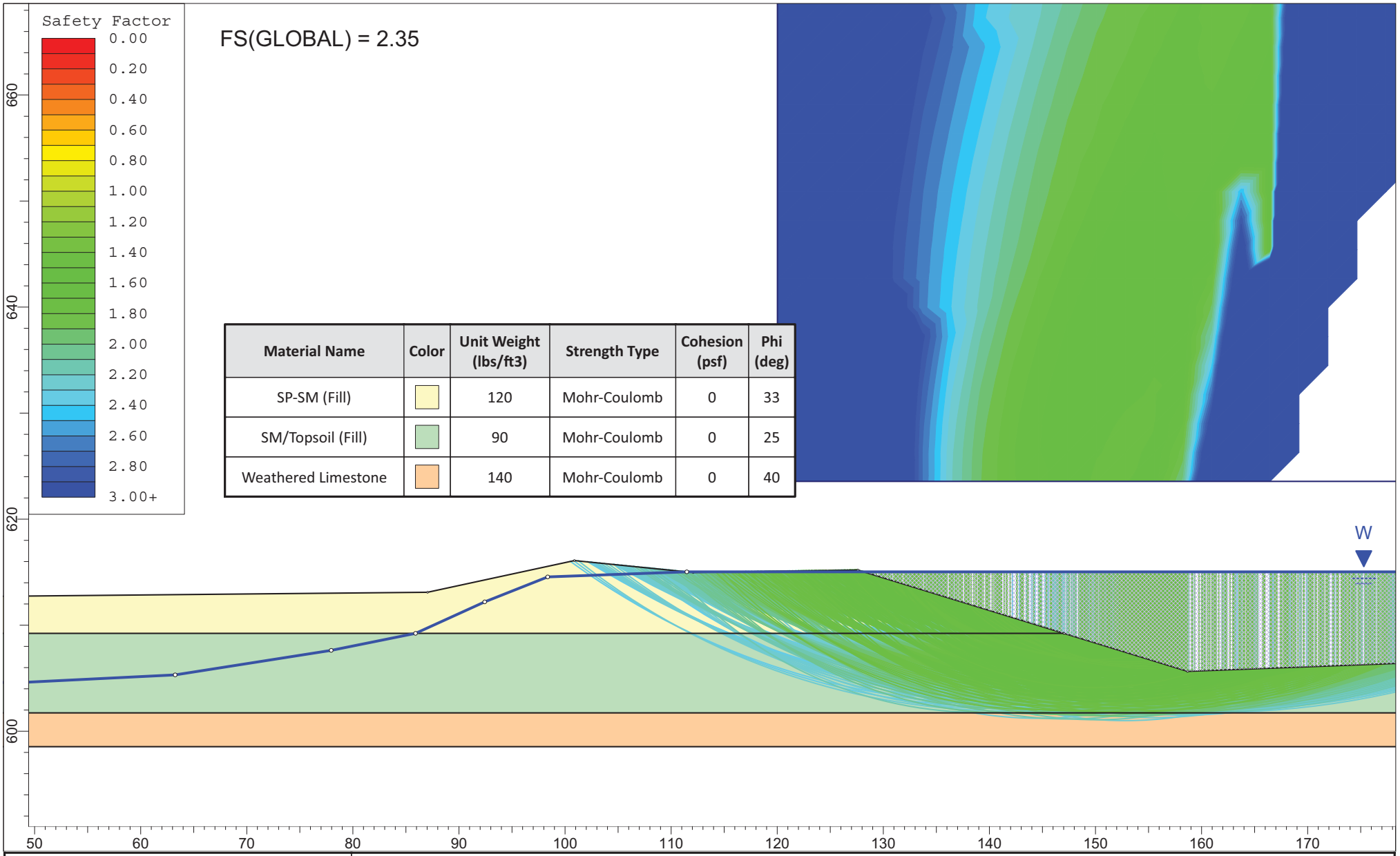
SLIDEINTERPRET 6.039B



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1B Sudden Drawdown		
Drawn B	TM	Scale 1:150B	Company MTC
Date	8/2/2016		File Name Section E1B Sudden Drawdown.slim

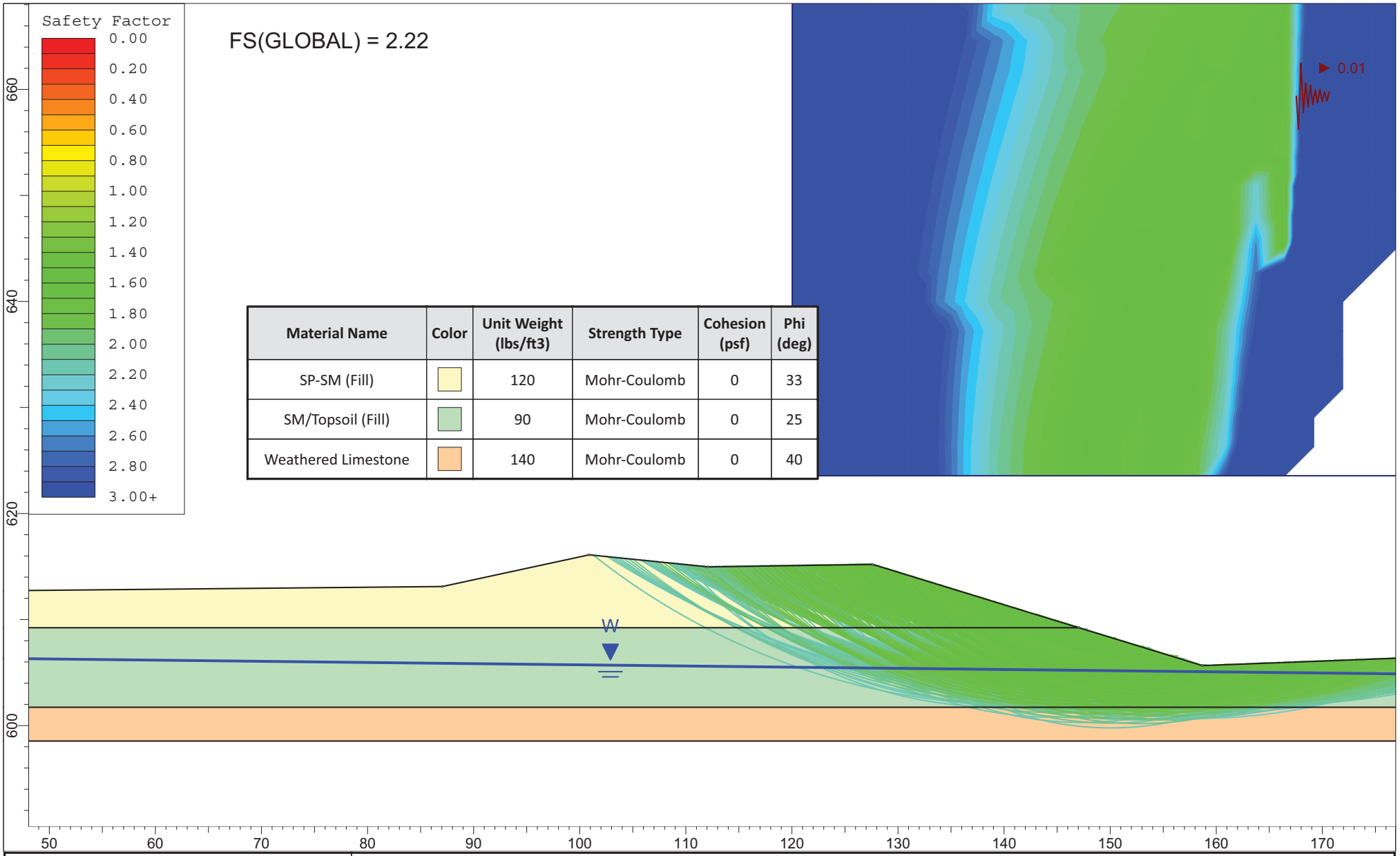
SLIDEINTERPRET 6.039B



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1B - Steady State Seepage		
Drawn By	TM	Scale	1:150B
Company	MTC		
Date	8-12-2016	File Name	Section E1B - Steady State Seepage ection 2 - Base Flood.slimB

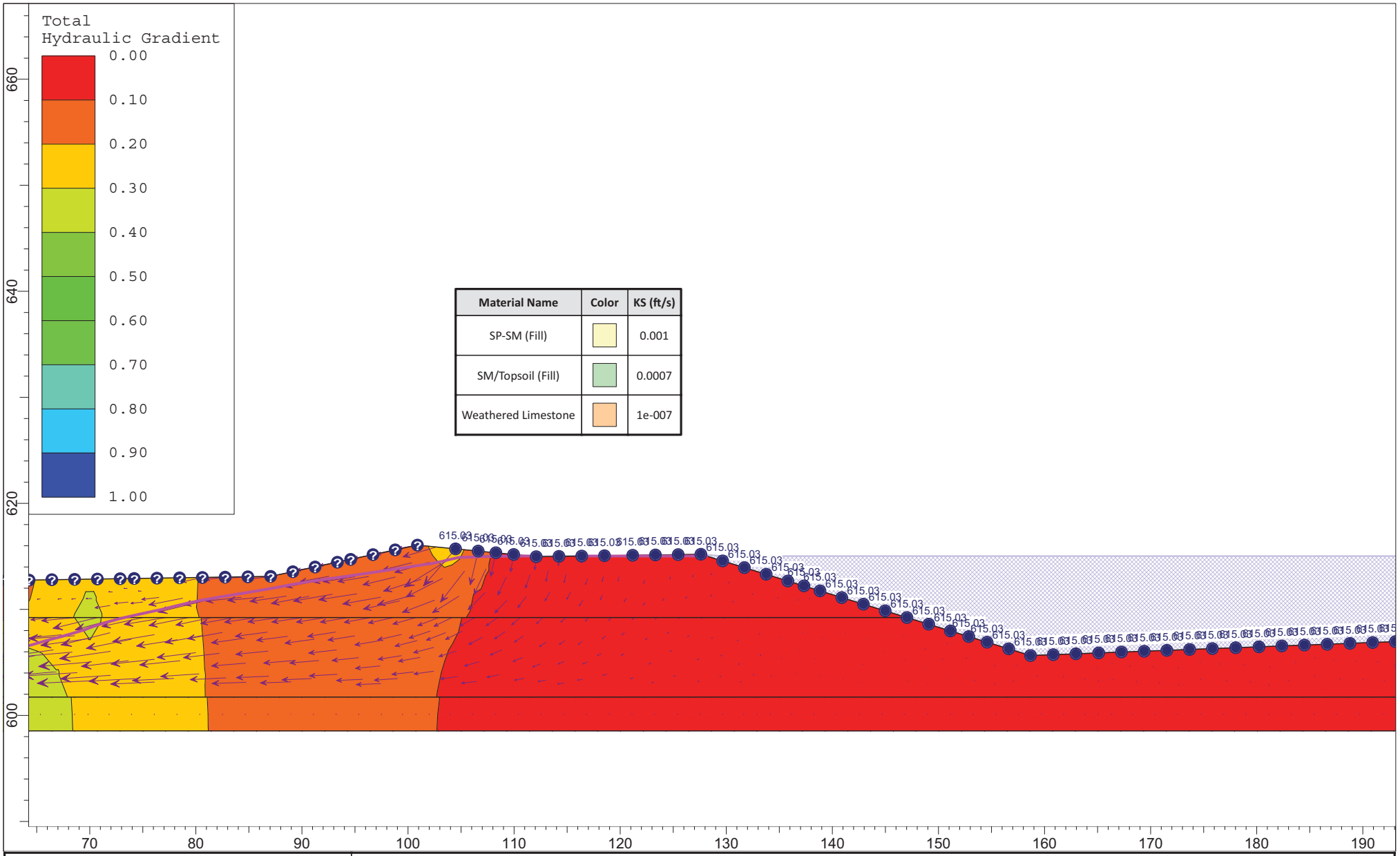
SLIDEINTERPRET 6.039B



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		120	Mohr-Coulomb	0	33
SM/Topsoil (Fill)		90	Mohr-Coulomb	0	25
Weathered Limestone		140	Mohr-Coulomb	0	40

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E1B - Earthquake		
Drawn By	TM	Scale	1:150B
Company	MTC		
Date	8-22-2017	File Name	Section E1B Earthquake.slim

SLIDEINTERPRET 6.039B



Material Name	Color	KS (ft/s)
SP-SM (Fill)		0.001
SM/Topsoil (Fill)		0.0007
Weathered Limestone		1e-007

rocscience

SLIDEINTERPRET 6.039B

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section F1B2 - Steady State Seepage		
Drawn By	TM	Scale	1:150
Company	MTC		
Date	8-18-2016	File Name	Section F1B Steady State Seepage.slim

REACH E1, SECTION E1B - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-3 (111266)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_z}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_p \log\left(\frac{t_2}{t_1}\right)$$

Organic Decompositionh
Consider settlement percentage due to decomposition of organic material equal to loss of 1/2 percent of organics by weigh

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP-SM			
	Sand, Topsoil, Fill				
	Sandstone	Bedrock			

Soil Properties

Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		NAVFAC 7.1-237 C_s
			50+										

Settlement Analysis

Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	ΔH (in) Immediate	Primary	Secondary	Organics
				TOTAL (in).	**4.05.**			

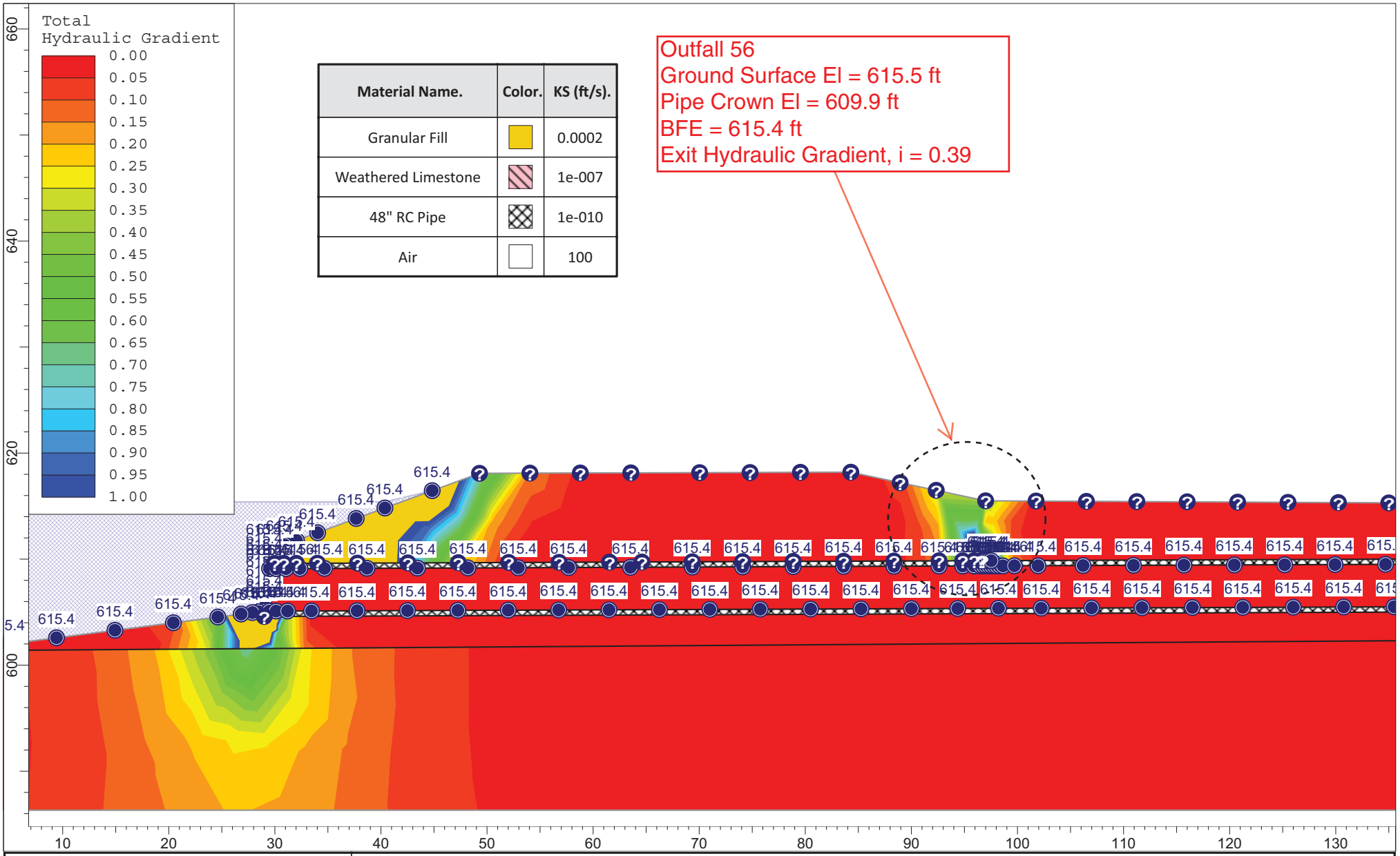
Freeboard Summar

Existing Flood Protection El = .	**616.1.**
uture Flood Protection El = .	**615.8.**
BFE = .	**615.0.**

Materials Testing Consultants, INC.

OUTFALL 56 PHOTOGRAPH





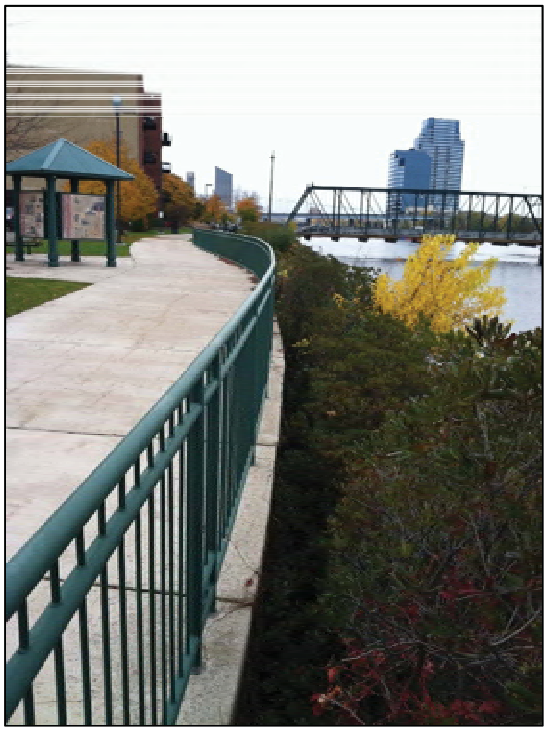
ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Reach E1 - 48-inch RCP Outfall		
Drawn B	TM	Scale 1:150B	Company MTC
Date	2/7/2018B		File Name Reach E1 - 48-inch RCP Outfall.slimB

SLIDEINTERPRET 7.024B

Materials Testing Consultants, INC.

REACH E2

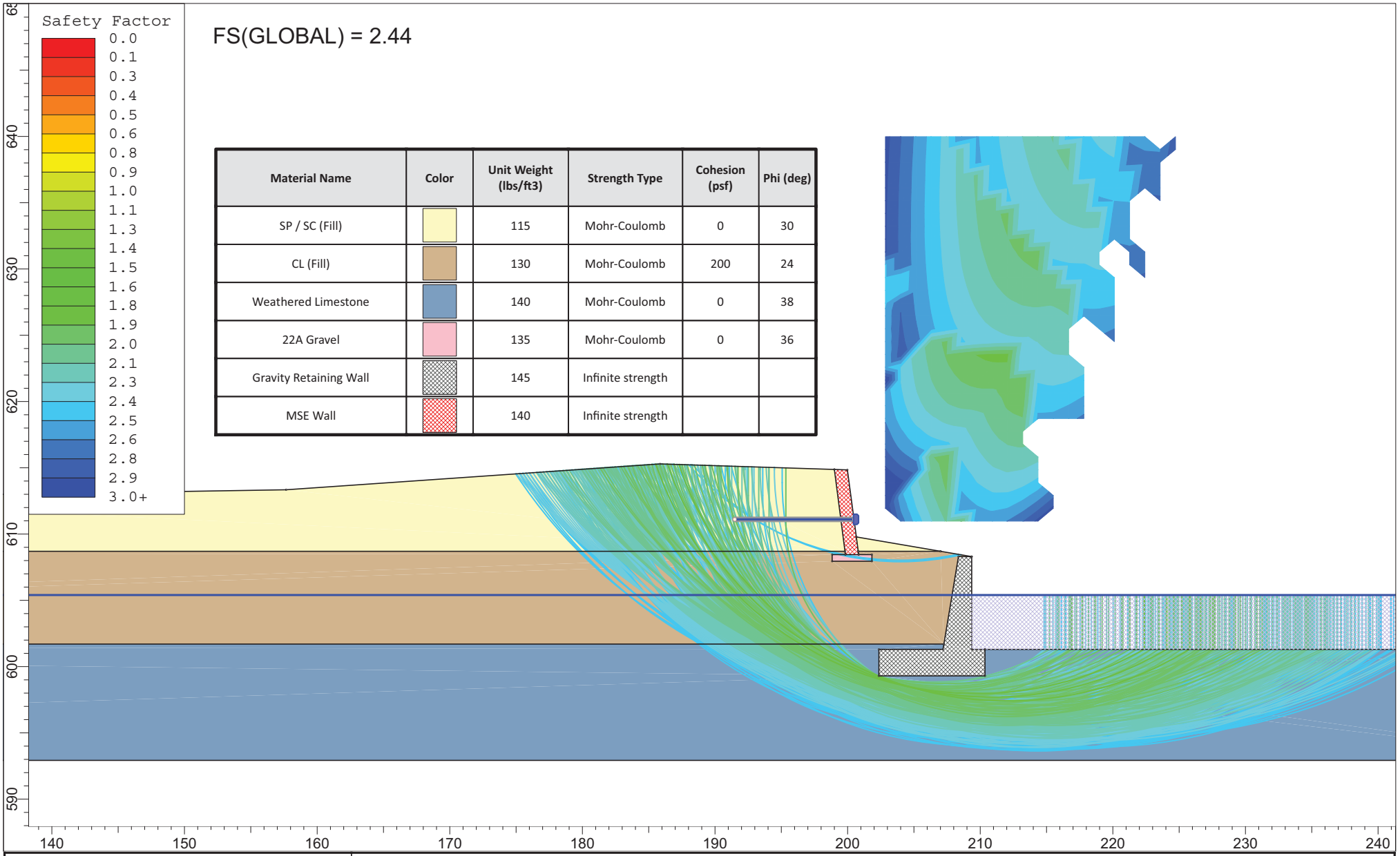
SECTION E2A PHOTOGRAPHS



Looking South



Looking North



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	200	24
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	Infinite strength		
MSE Wall		140	Infinite strength		

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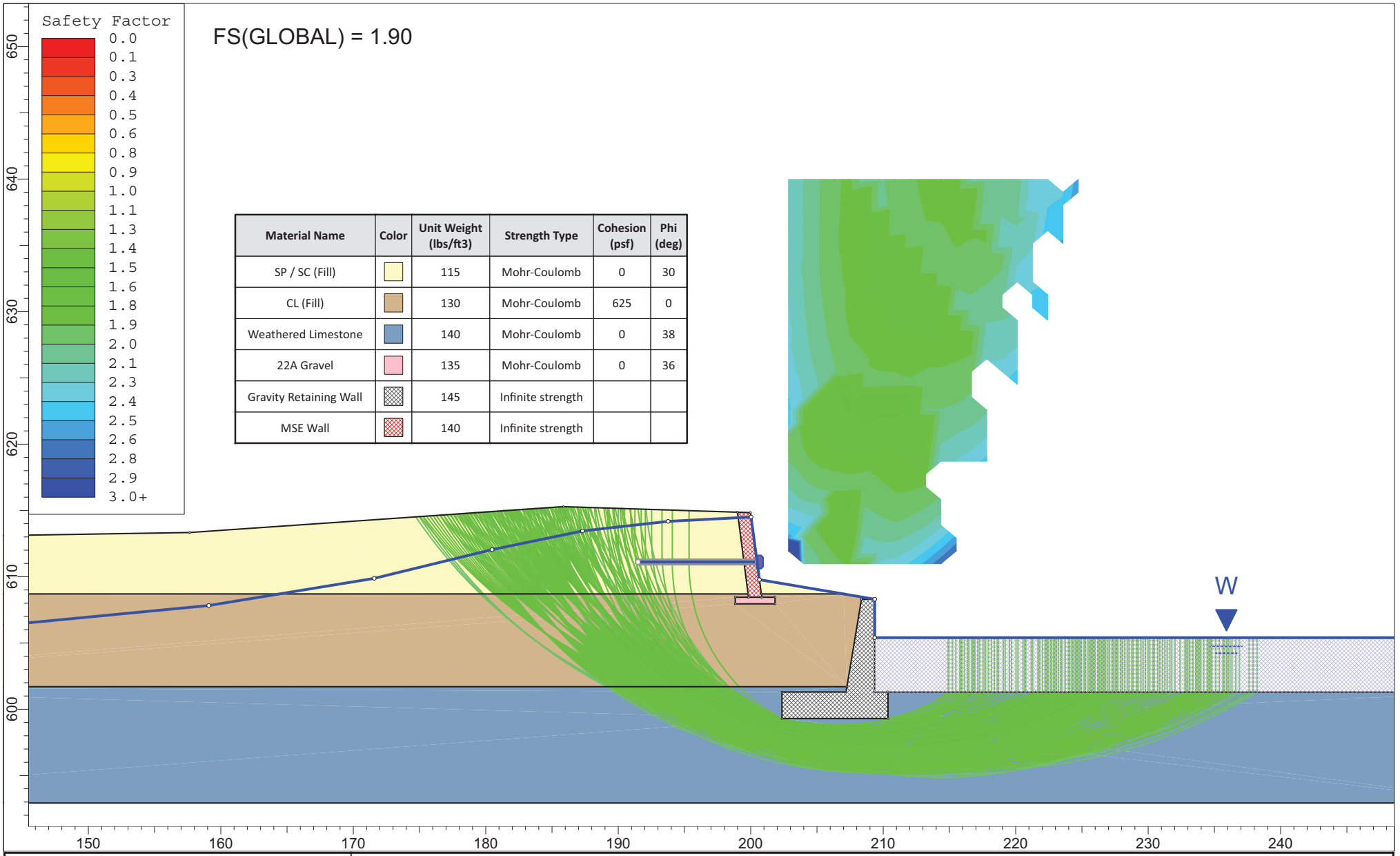
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section E2A Existing Condition (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012
File NameB	Section E2A Existing Conditions (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	625	0
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	Infinite strength		
MSE Wall		140	Infinite strength		

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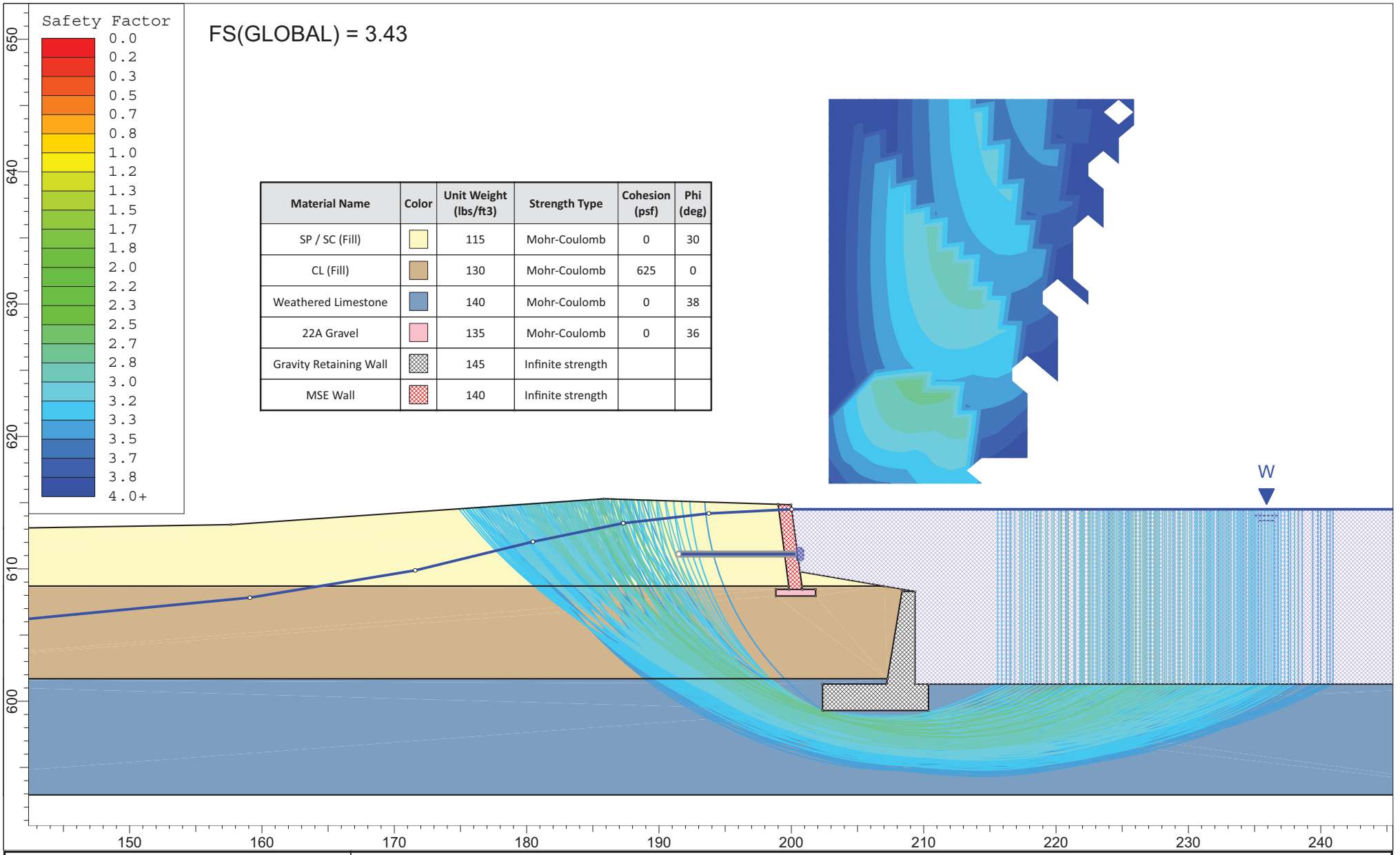
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 4E - Drawdown (waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8/16/2012
File NameB	Case 2, Section 4E Drawdown (waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	625	0
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	Infinite strength		
MSE Wall		140	Infinite strength		

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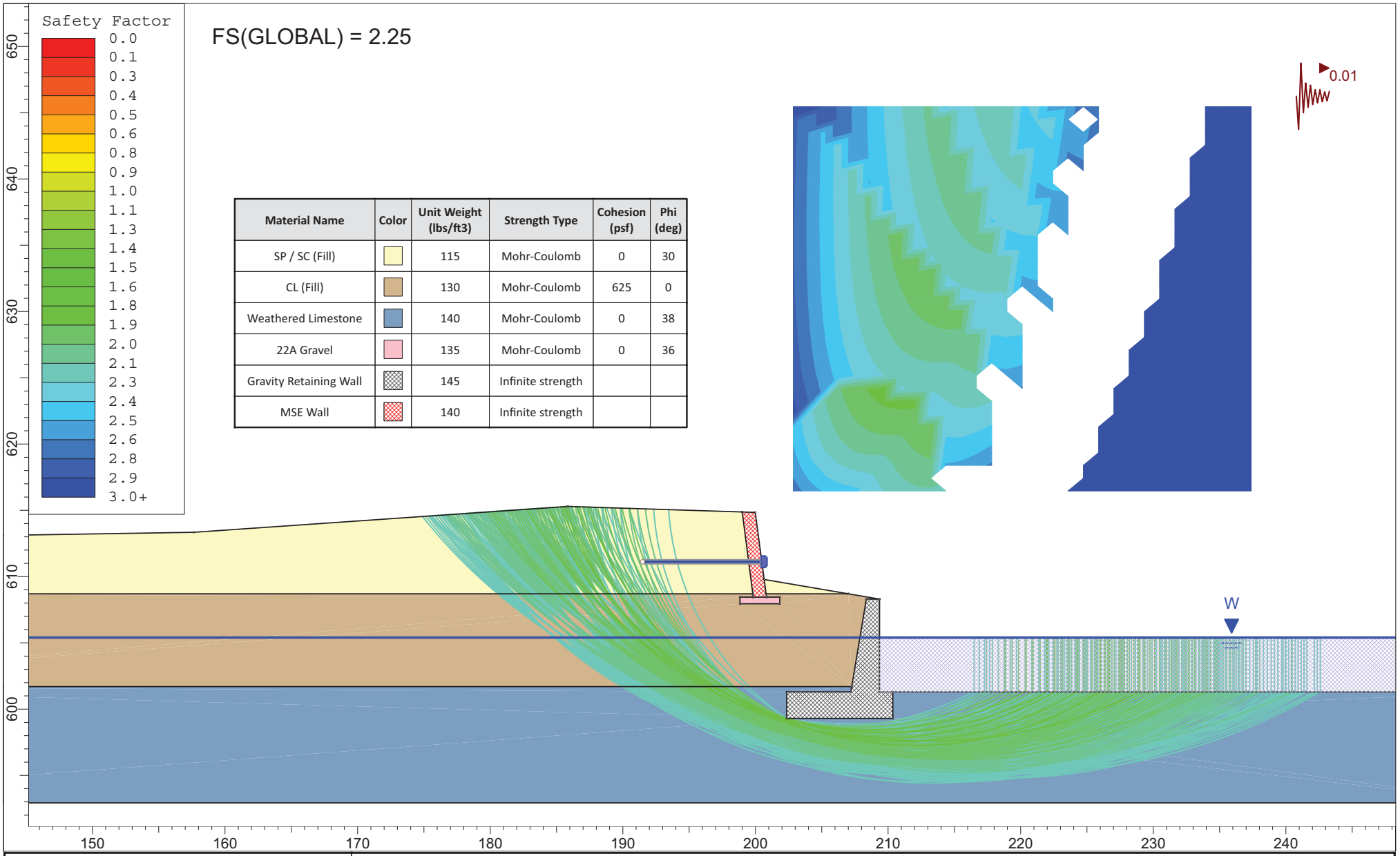
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section E2AE - Steady State SeepageSection E2A - Steady State Seepage
Drawn ByB	TMB
DateB	8/16/2017 11/14/2012B
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
File Name	Case 3, Section 4E Base Flood (Wattage).slimBSection E2A - Steady State Seepage



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP / SC (Fill)		115	Mohr-Coulomb	0	30
CL (Fill)		130	Mohr-Coulomb	625	0
Weathered Limestone		140	Mohr-Coulomb	0	38
22A Gravel		135	Mohr-Coulomb	0	36
Gravity Retaining Wall		145	Infinite strength		
MSE Wall		140	Infinite strength		

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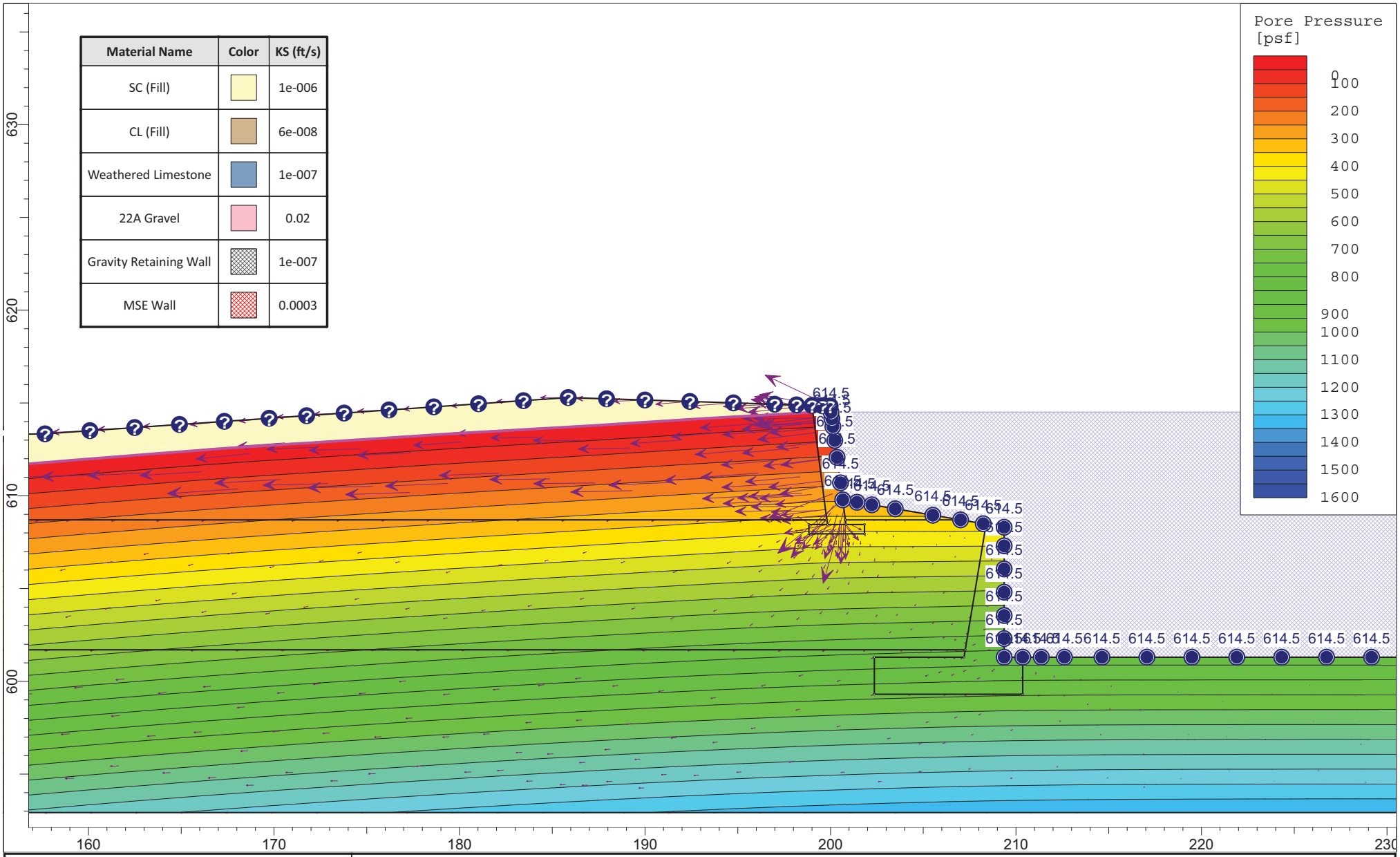
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section E-2A - Earthquake (Waterside)
Drawn ByB	TMB
DateB	11/14/2012
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Case 4, Section 4E Earthquake (Waterside).slim



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 4E Steady State Seepage
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8/16/2012
File NameB	Section 4E Steady State Seepage.slim

REACH E2, SECTION E2A - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-3 (031455)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_s}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP and SC			
	Clay, Fill	CL			
	Limestone	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s
			50+										

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**0.00.**		

Freeboard Summar

Existing Flood Protection El = .	**615.3.**
uture Flood Protection El = .	**615.3.**
BFE = .	**614.2.**

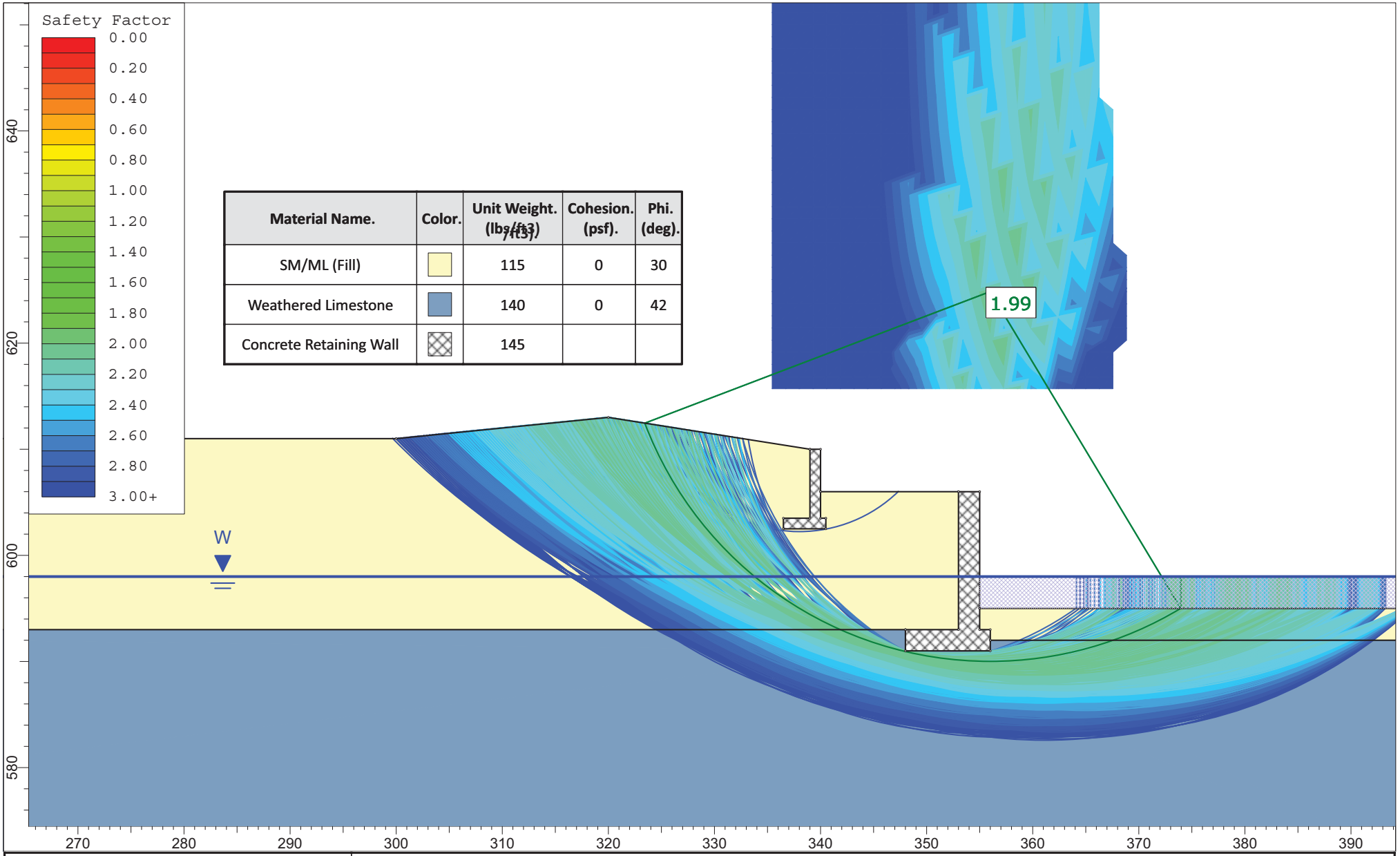
SECTION E2B PHOTOGRAPHS



Looking South

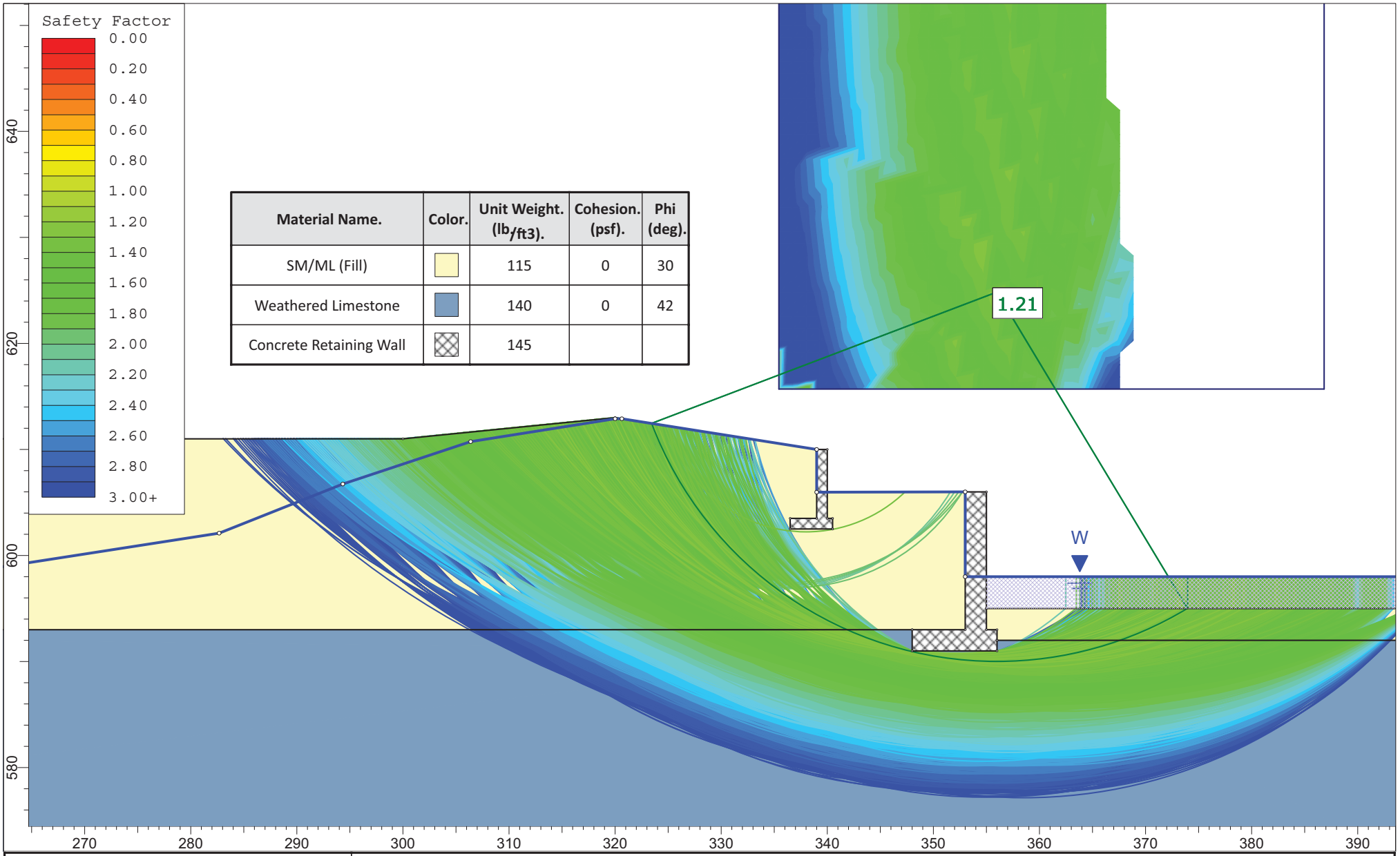


Looking North



ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E2B - Existing Condition		
Drawn By	TM	Scale 1:150B	Company Fishbeck, Thompson, Carr & Huber, Inc.B
Date	1-15-2018		File Name Section E2B - Existing Condition.slim

SLIDEINTERPRET 7.024B

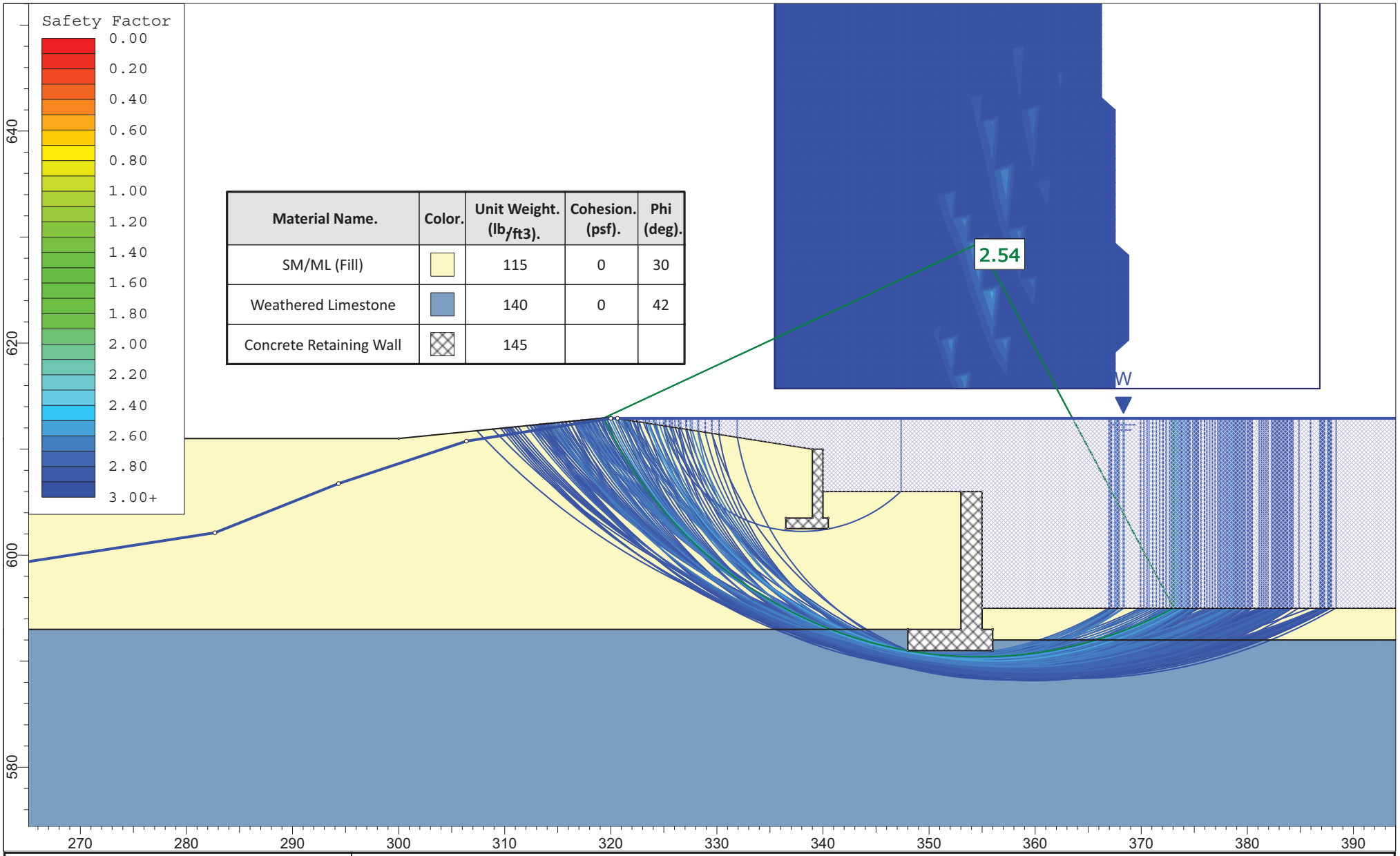


Material Name.	Color.	Unit Weight. ($lb_{/ft3}$).	Cohesion. (psf).	Phi (deg).
SM/ML (Fill)		115	0	30
Weathered Limestone		140	0	42
Concrete Retaining Wall		145		

rocscience

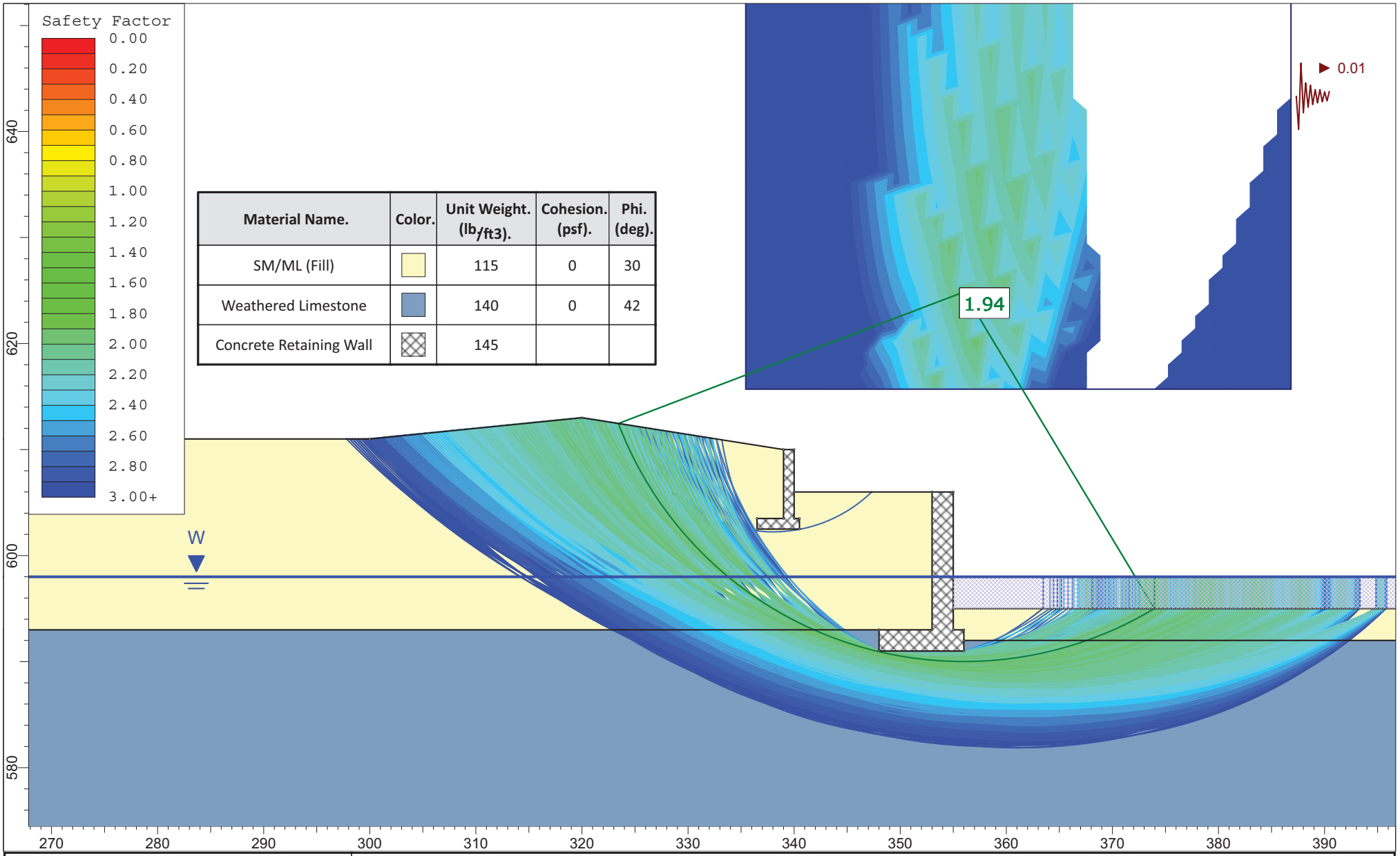
SLIDEINTERPRET 7.024B

ProjectB	Grand Rapids Floodwalls and Embankments Study			
Analysis Description	ection E2B - Sudden Drawdown			
Drawn By	TM	Scale	1:150B	Company: Fishbeck, Thompson, Carr & Huber, Inc.B
Date	1-16-2018			File Name: Section E2B - Sudden Drawdown.slim



ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Section E2B - Steady State Seepage		
Drawn By: TM	Scale: 1:150B	Company: Fishbeck, Thompson, Carr & Huber, Inc.B	
Date: 1-16-2018		File Name: Section E2B - Steady State Seepage.slim	

SLIDEINTERPRET 7.024B



Material Name.	Color.	Unit Weight. ($lb_{/ft3}$).	Cohesion. (psf).	Phi. (deg).
SM/ML (Fill)		115	0	30
Weathered Limestone		140	0	42
Concrete Retaining Wall		145		

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	ection E2B - EarthquakeB		
Drawn By	TM	Scale 1:150B	Company Fishbeck, Thompson, Carr & Huber, Inc.B
Date	1-16-2018		File Name Section E2B - Earthquake.slim

SLIDEINTERPRET 7.024B

REACH E2, SECTION E2B FLOODWALL STABILITY SUMMARY.

Existing Condition

GW El = 598.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Friction δ (deg)*	*Wall Slope α (deg)*	*Pult (lbs)*	*Px (lbs)*	*Py (lbs)*	*MAx (ft)*	*MAy (ft)*	*Mx (ft-lbs)*	*My (ft-lbs)*

Resisting Loads (Passive)	*Wall Friction δ (deg)*	*Wall Slope α (deg)*	*Pult (lbs)*	*Px (lbs)*	*Py (lbs)*	*MAx (ft)*	*MAy (ft)*	*Mx (ft-lbs)*	*My (ft-lbs)*

Resisting Loads (Weight)	*Wult (lbs)*	*MAy (ft)*	*My (ft-lbs)*

Stability Summar

Footing Width, B (ft)	**8.0.**
Summation M (ft-lbs)	**41,257.**
Summation P (lbs)	**9,413.**
Eccentricity, e (ft)	**-0.38.**
q(max) (psf)	**1,515.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**5.10.**
FS (Sliding)	**2.68.**

Foundation bears upon weathered limestone bedrock

Ah loads and moments estimated are per foot of walh

REACH E2, SECTION E2B FLOODWALL STABILITY SUMMARY.

Sudden Drawdown

GW El = 606.0

Grand River El = 598.

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summar

Footing Width, B (ft)	**8.0.**
Summation M (ft-lbs)	**115.**
Summation P (lbs)	**6,301.**
Eccentricity, e (ft)	**3.98.**
q(max) (psf)	**28,693.**
Base Area in Compression (%)	**NA.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.00.**
FS (Sliding)	**1.14.**

Resultant within base area of footinh

Foundation bears upon weathered limestone bedrock

Ah loads and moments estimated are per foot of walh

REACH E2, SECTION E2B - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-7 (990282)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C''} \log\left(\frac{\sigma'_o + \Delta\sigma_z}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_p \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increase, berm height increased to el 613.5, 2 ft of new fill placedh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill				
	Silt, Fill	ML			
	Limestone	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s
			50+										

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**0.73.**		

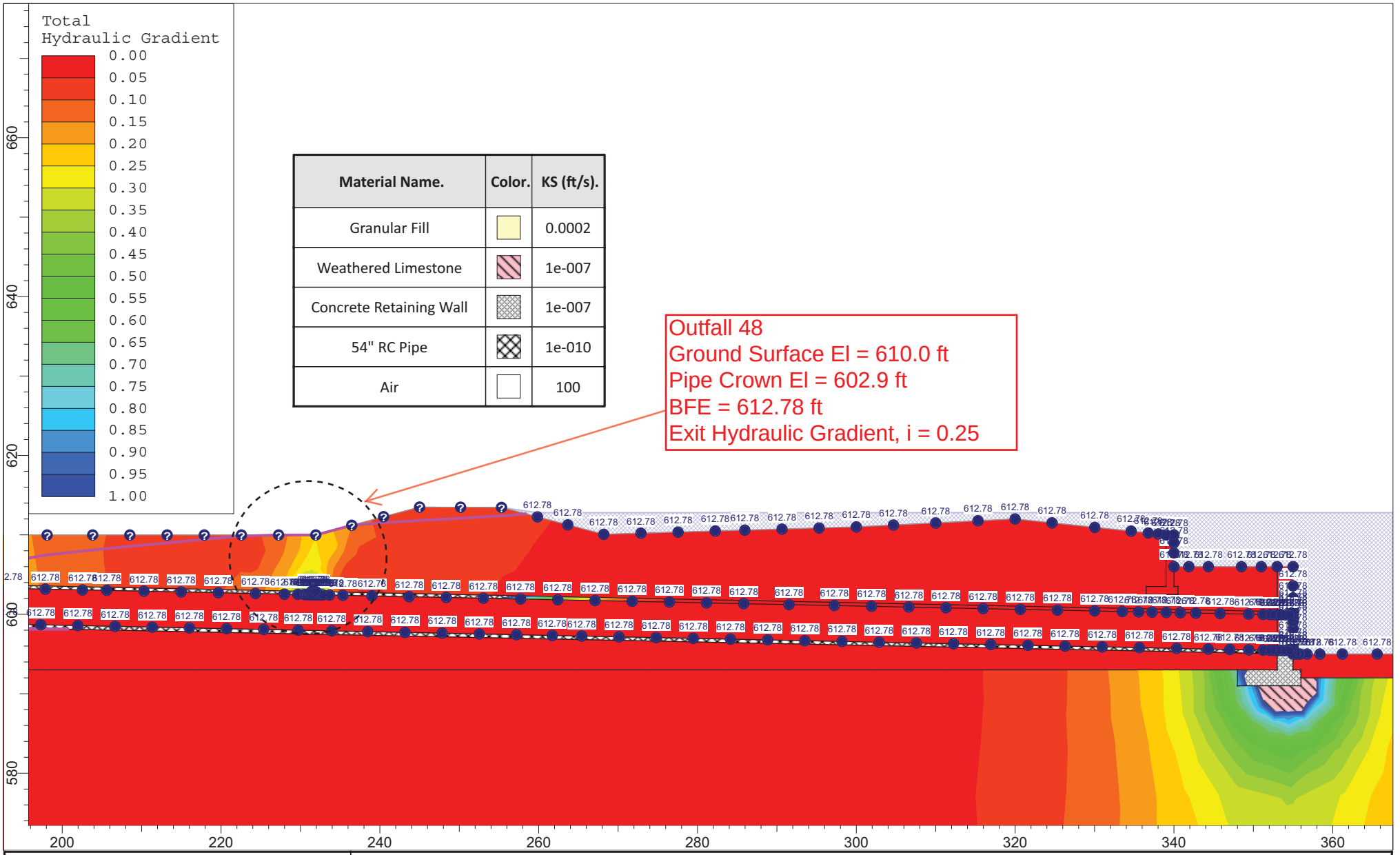
Freeboard Summar

Proposed Flood Protection El = .	**613.5.**
uture Flood Protection El = .	**613.4.**
BFE = .	**612.9.**

Materials Testing Consultants, INC.

OUTFALL 48 PHOTOGRAPH





ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Reach E2 - 54-inch RCP Outfall		
Drawn By	TM	Scale 1:200	Company MTC
Date	2-7-18B		File Name Reach E2 - 54-inch RCP Outfall.slimB

SLIDEINTERPRET 7.024B

Materials Testing Consultants, INC.

REACH E3

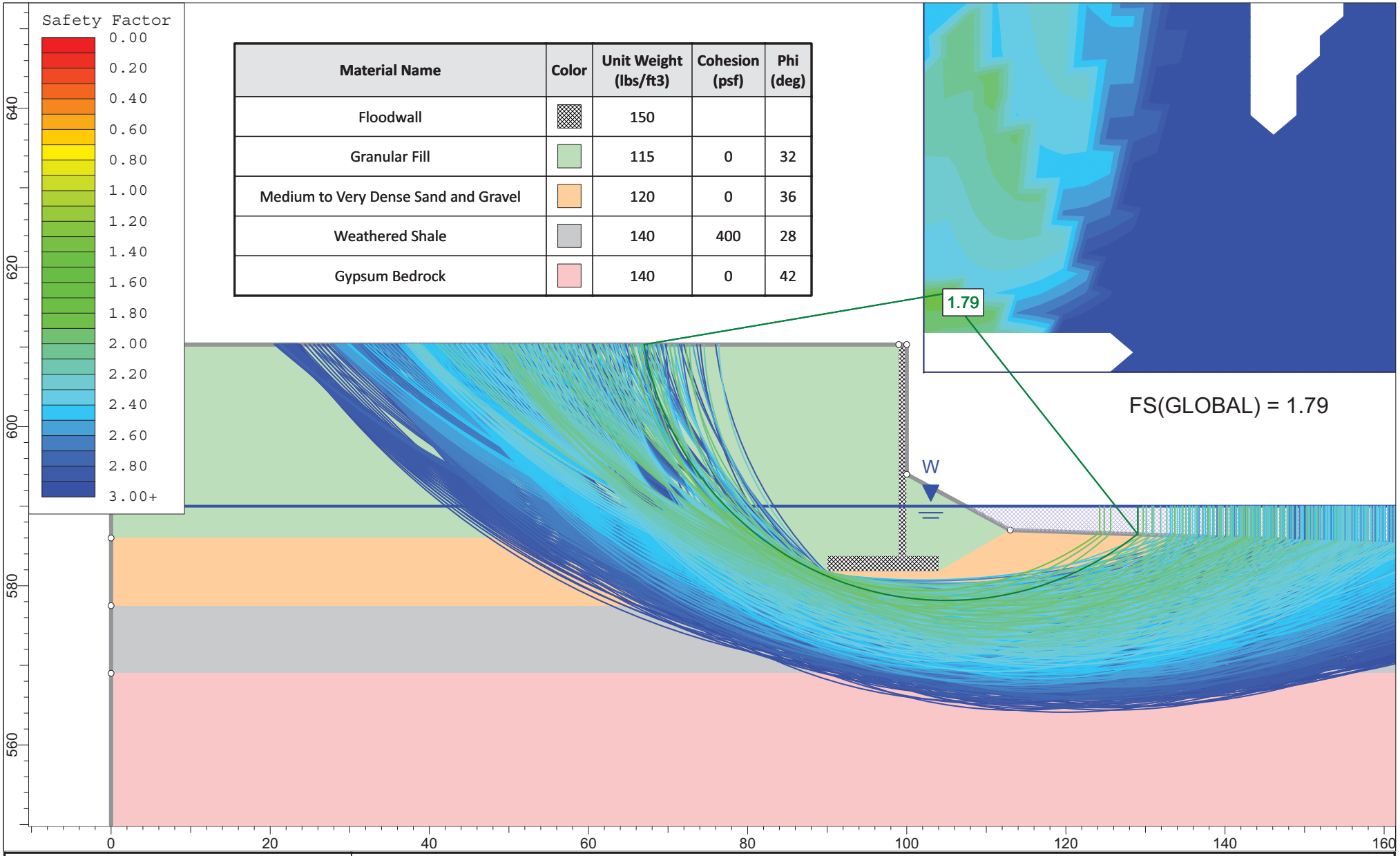
SECTION E3 PHOTOGRAPHS



Looking East



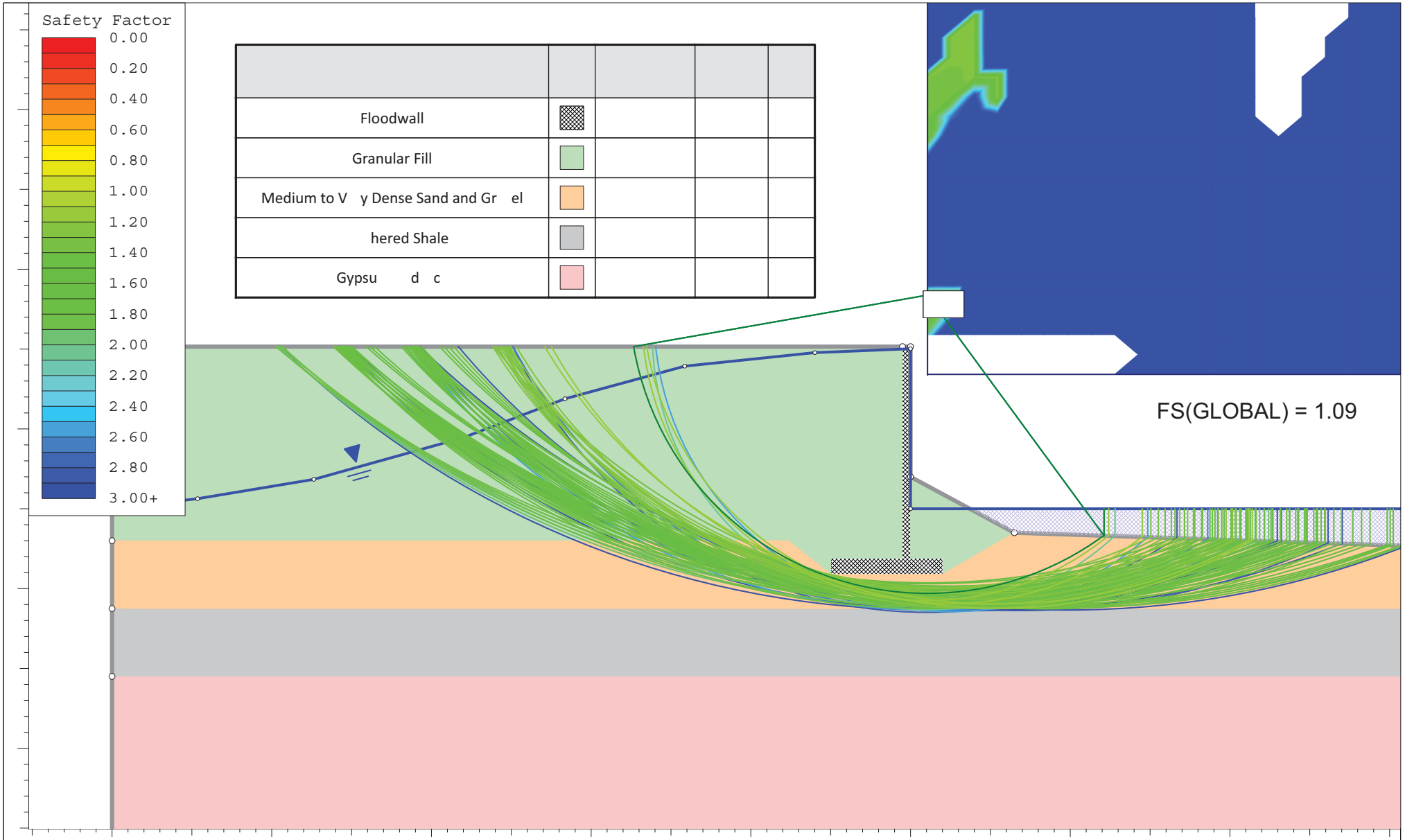
Looking Southeast



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Floodwall		150		
Granular Fill		115	0	32
Medium to Very Dense Sand and Gravel		120	0	36
Weathered Shale		140	400	28
Gypsum Bedrock		140	0	42

SLIDEINTERPRET 6.039B

ProjectB	Grand Rapids Floodwalls an Embankment Study		
Analysis Description	Section E1--Existing Condition		
Drawn By	TM	Scale	1:200
Company	MTC		
Date	8-22-2017	File Name	Section E1 (Existing Condition).slim



ProjectB

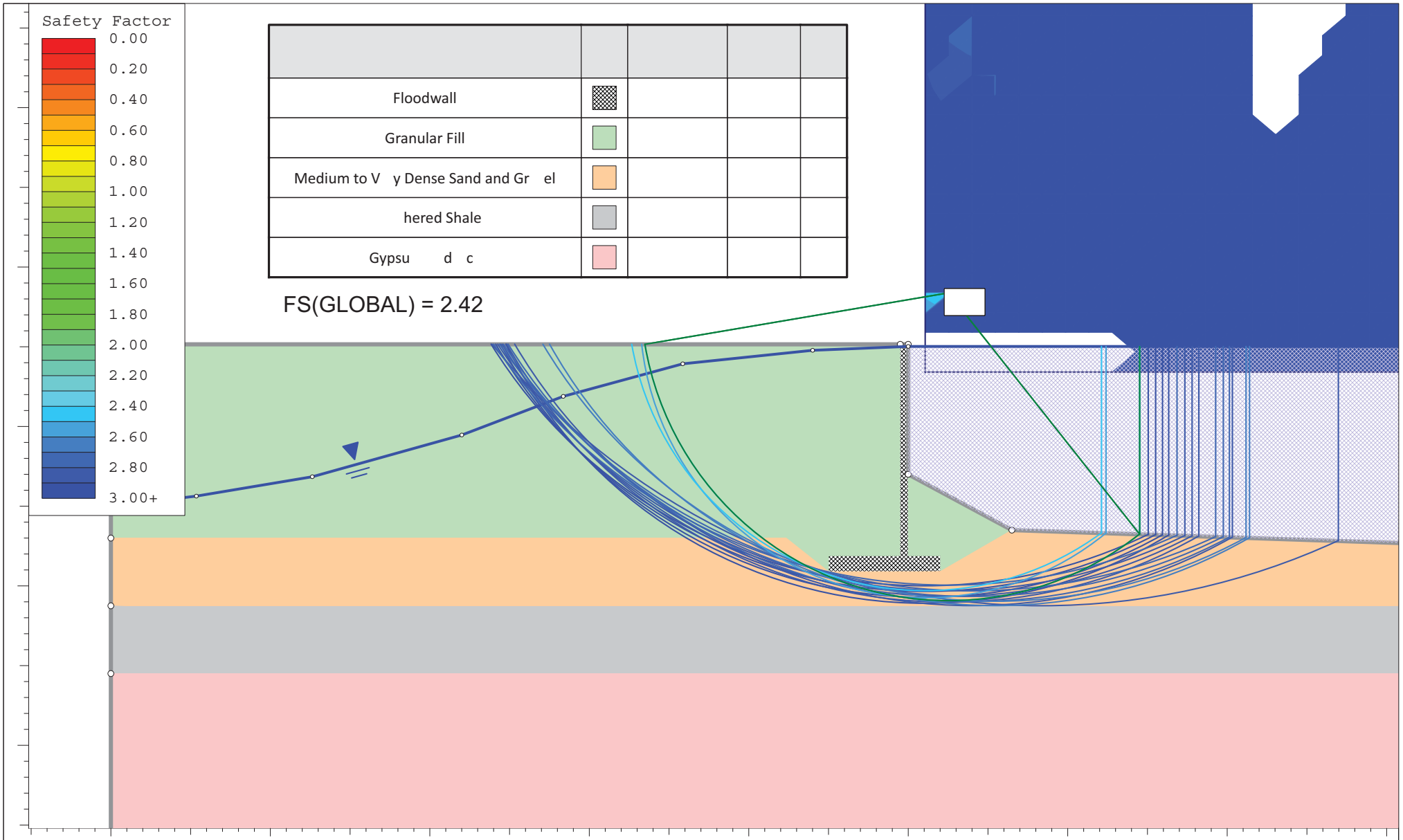
Grand Rapids Floodwalls and Embankment Study

Section E3 - Sudden Drawdown

8-16-2017

File Na

Section E3 (Sudden Drawdown).slim



ProjectB

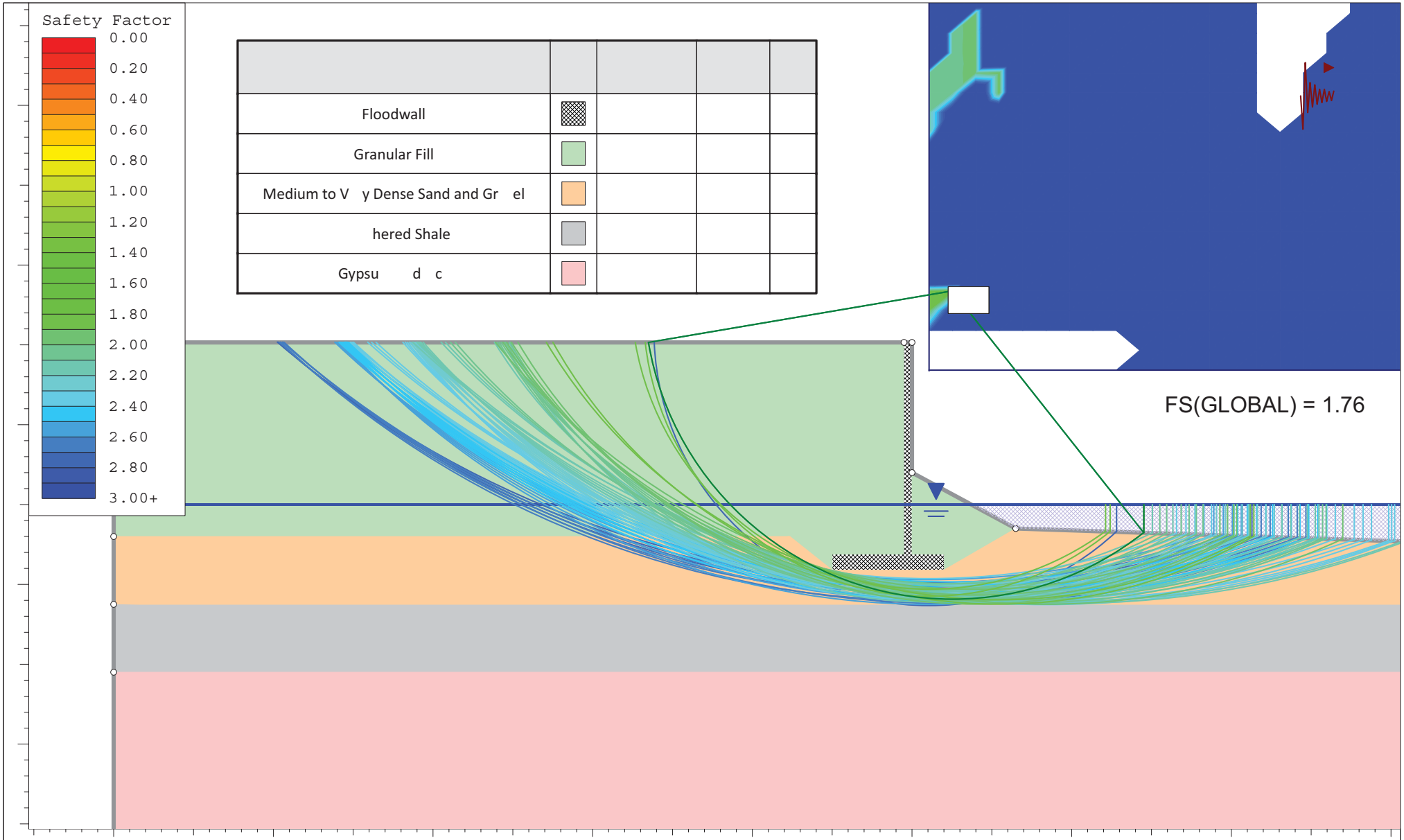
Grand Rapids Floodwalls and Embankment Study

Section E3 - Steady State Seepage

8-16-2017

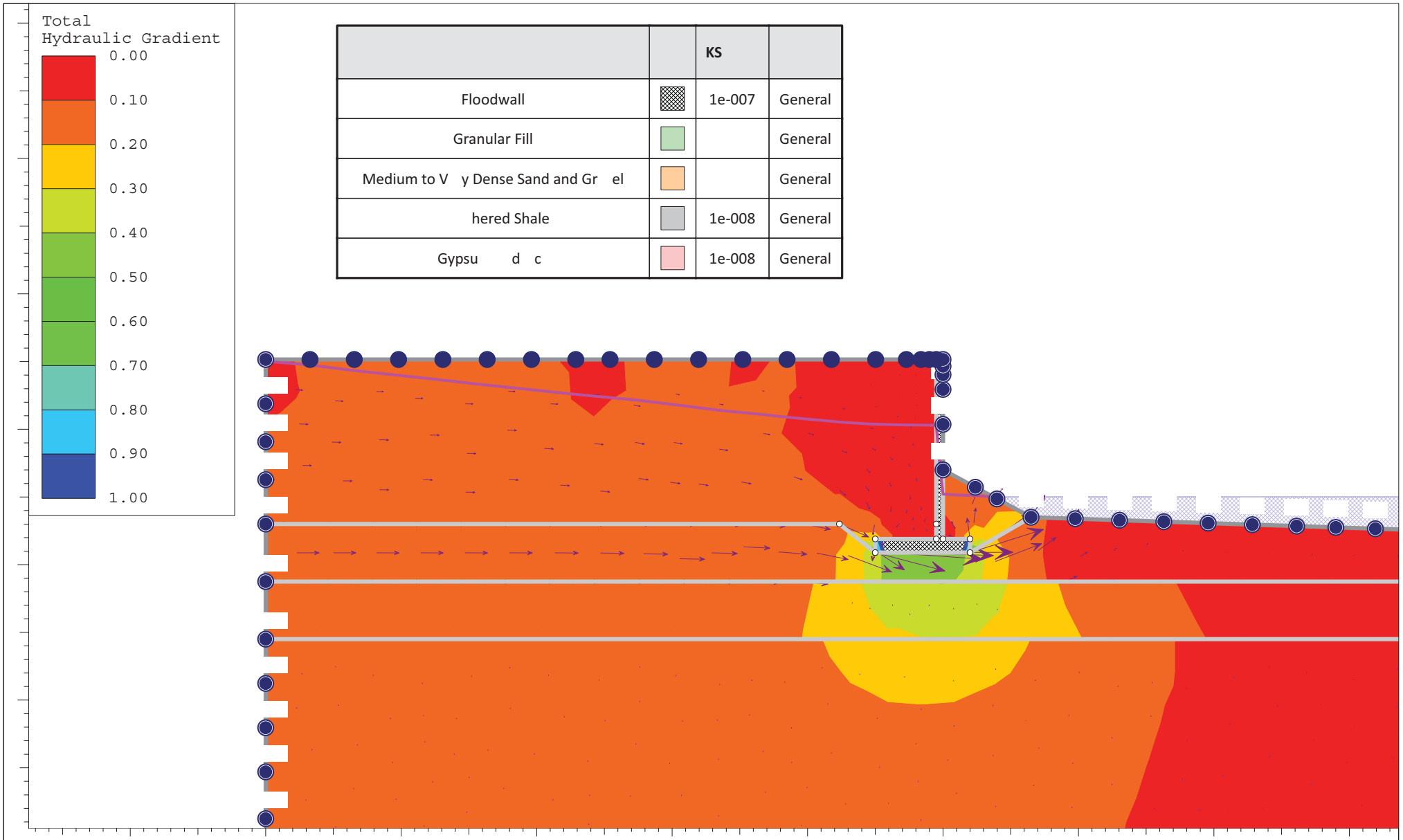
File Na Section E3 - Steady State Seepage ection 1 (Base Flood).slimB

L 9B



ProjectB	Grand Rapids Floodwalls and Embankments Study
	Section E3 - Earthquake
8-16-2017	File NaB Section E3 (Earthquake).slim

L 9B



		KS	
Floodwall		1e-007	General
Granular Fill			General
Medium to V y Dense Sand and Gr el			General
hered Shale		1e-008	General
Gypsu d c		1e-008	General

ProjectB

Grand Rapids Floodwalls and Embankment Study

Section E3 - Steady State Seepage

1:235B

8-16-2017

File Na Section E3 - Steady State Seepage

L 9B

REACH E3, SECTION E3 FLOODWALL STABILITY SUMMARY.

Existing Condition

GW El = 590.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Friction δ (deg)*	*Wall Slope α (deg)*	*Pult (lbs)*	*Px (lbs)*	*Py (lbs)*	*MAx (ft)*	*MAy (ft)*	*Mx (ft-lbs)*	*My (ft-lbs)*

Resisting Loads (Passive)	*Wall Friction δ (deg)*	*Wall Slope α (deg)*	*Pult (lbs)*	*Px (lbs)*	*Py (lbs)*	*MAx (ft)*	*MAy (ft)*	*Mx (ft-lbs)*	*My (ft-lbs)*

Resisting Loads (Weight)	*Wult (lbs)*	*MAy (ft)*	*My (ft-lbs)*

Stability Summar

Footing Width, B (ft)	**14.0.**
Summation M (ft-lbs)	**250,313.**
Summation P (lbs)	**32,568.**
Eccentricity, e (ft)	**-0.69.**
q(max) (psf)	**3,010.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**5.91.**
FS (Sliding)	**2.16.**

Foundation bears upon granular outwash above weathered shale bedrock

Ah loads and moments estimated are per foot of walh

REACH E3, SECTION E3 FLOODWALL STABILITY SUMMARY.

Sudden Drawdown

GW El = 604.0

Grand River El = 590.

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Friction δ (deg)*	*Wall Slope α (deg)*	*Pult (lbs)*	*Px (lbs)*	*Py (lbs)*	*MAx (ft)*	*MAy (ft)*	*Mx (ft-lbs)*	*My (ft-lbs)*

Resisting Loads (Passive)	*Wall Friction δ (deg)*	*Wall Slope α (deg)*	*Pult (lbs)*	*Px (lbs)*	*Py (lbs)*	*MAx (ft)*	*MAy (ft)*	*Mx (ft-lbs)*	*My (ft-lbs)*

Resisting Loads (Weight)	*Wult (lbs)*	*MAy (ft)*	*My (ft-lbs)*

Stability Summar

Footing Width, B (ft)	**14.0.**
Summation M (ft-lbs)	**64,921.**
Summation P (lbs)	**21,769.**
Eccentricity, e (ft)	**4.02.**
q(max) (psf)	**4,866.**
Base Area in Compression (%)	**64%.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.42.**
FS (Sliding)	**1.05.**

Foundation bears upon granular outwash above weathered shale bedrock

Ah loads and moments estimated are per foot of walh

REACH E3, SECTION E3 - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-3 and B-3A (269K)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log \frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*
BOF El =		*Bottom of floodwall elevationh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP, SM, SC			
	Gravel and Sand	GW			
	Shale	Bedrock			
	Gypsum	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s
			50+										
			50+										

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**0.00.**		

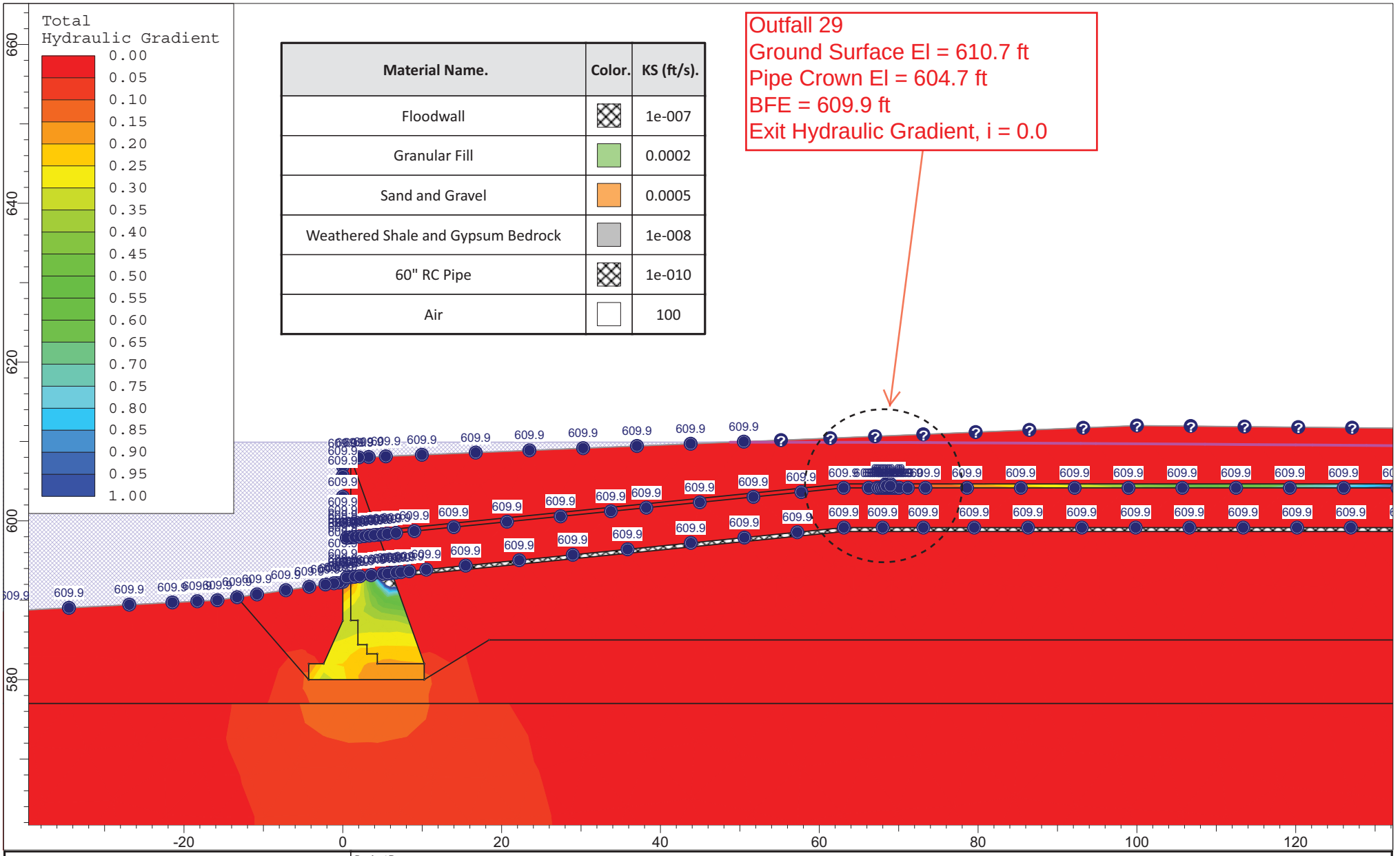
Freeboard Summar

Existing Flood Protection El = .	**610.3.**
uture Flood Protection El = .	**610.3.**
BFE = .	**610.0.**

Materials Testing Consultants, INC.

OUTFALL 29 PHOTOGRAPH





Material Name.	Color.	KS (ft/s).
Floodwall		1e-007
Granular Fill		0.0002
Sand and Gravel		0.0005
Weathered Shale and Gypsum Bedrock		1e-008
60" RC Pipe		1e-010
Air		100

ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Reach E3 - 60-inch RCP OutfallB		
Drawn By	TM	Scale 1:200	Company MTC
Date	2-9-18B		File Name Reach E3 - 60-inch RCP Outfall.slim

SLIDEINTERPRET 7.024B

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REACH E4

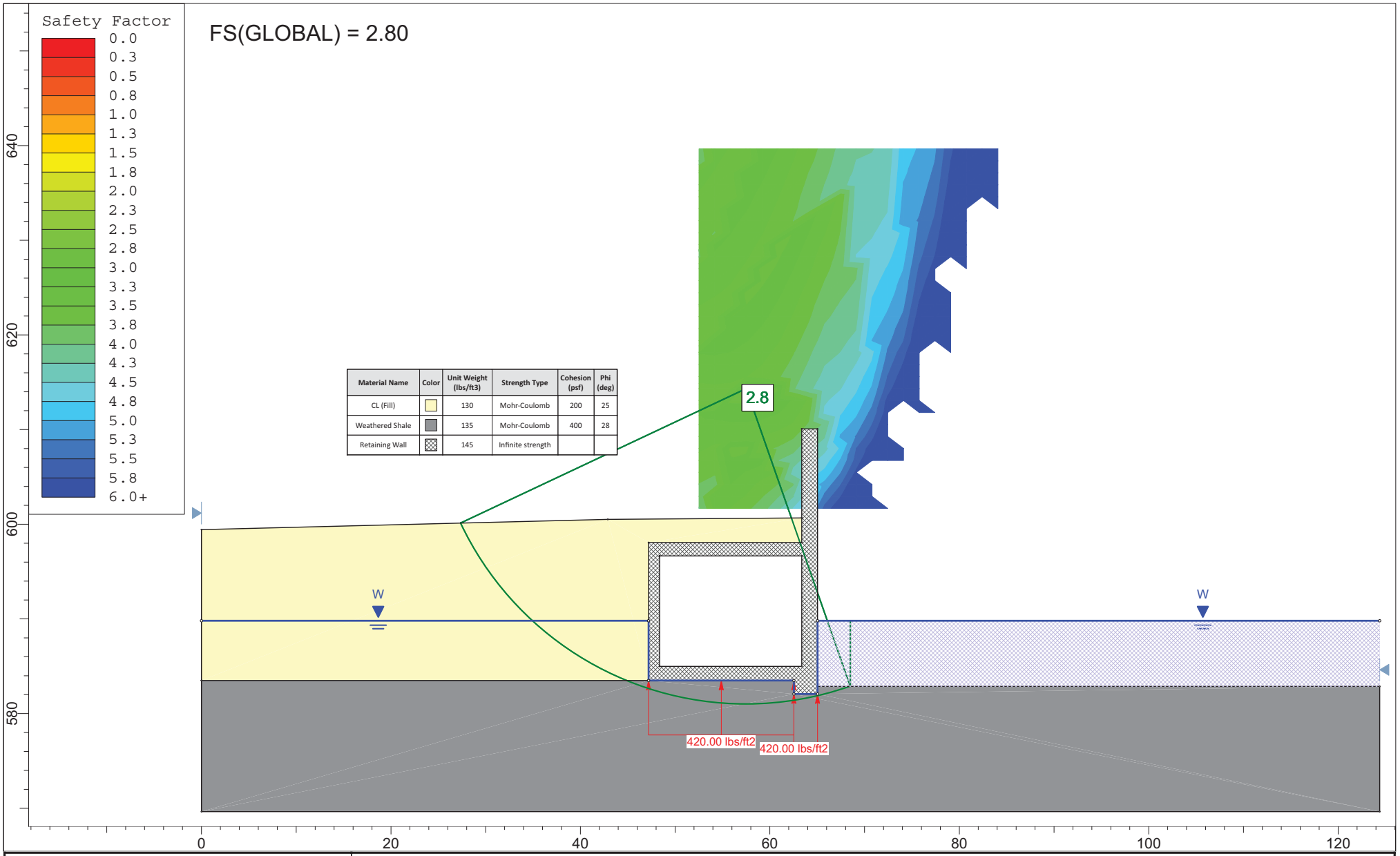
SECTION E4 PHOTOGRAPHS



Looking Northwest



Looking North



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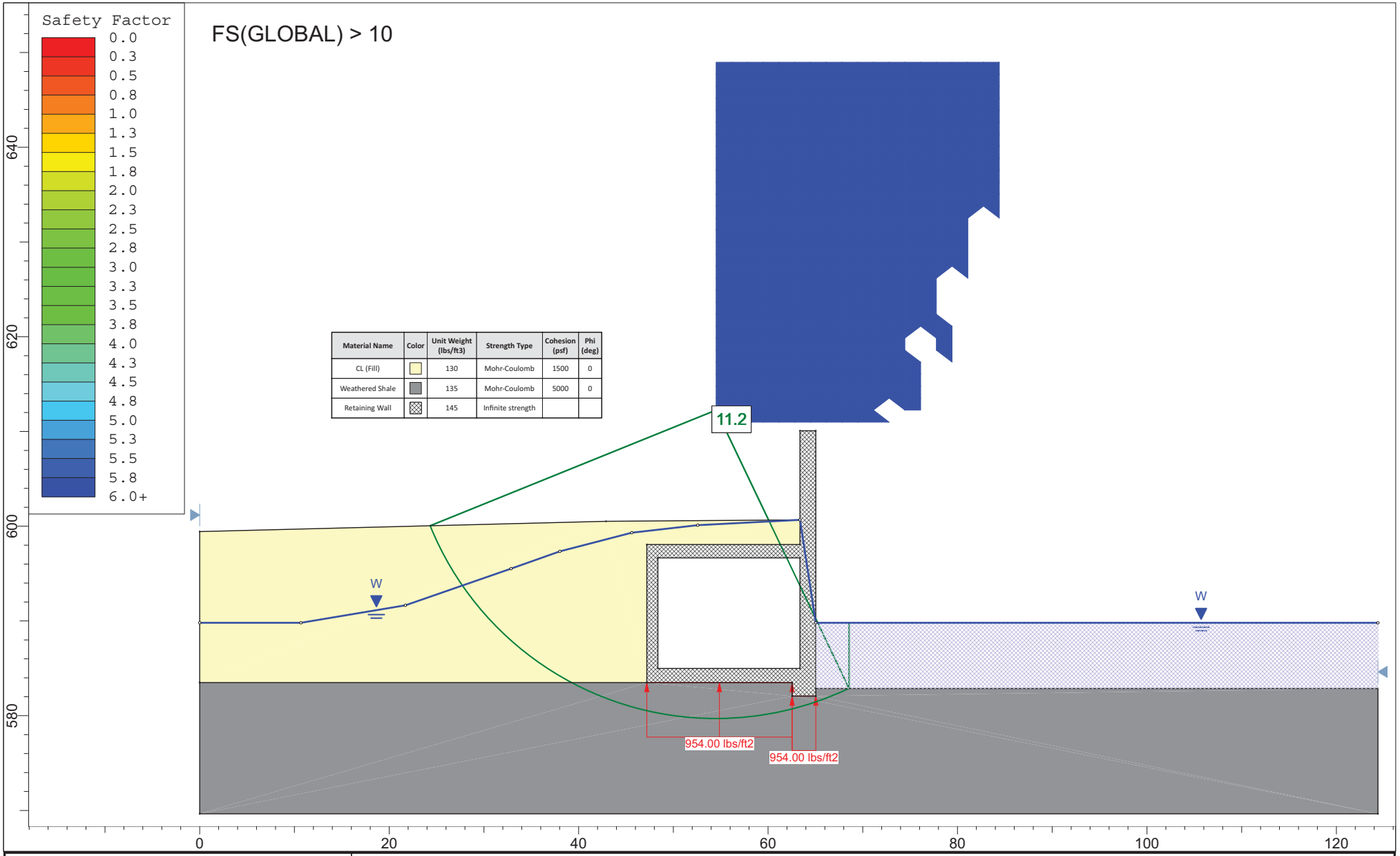
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section E4 - Existing Conditions (Waterside)
Drawn ByB	TMB
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012B
File NameB	Case 1, Section E4 - Existing Conditions (Waterside).slim



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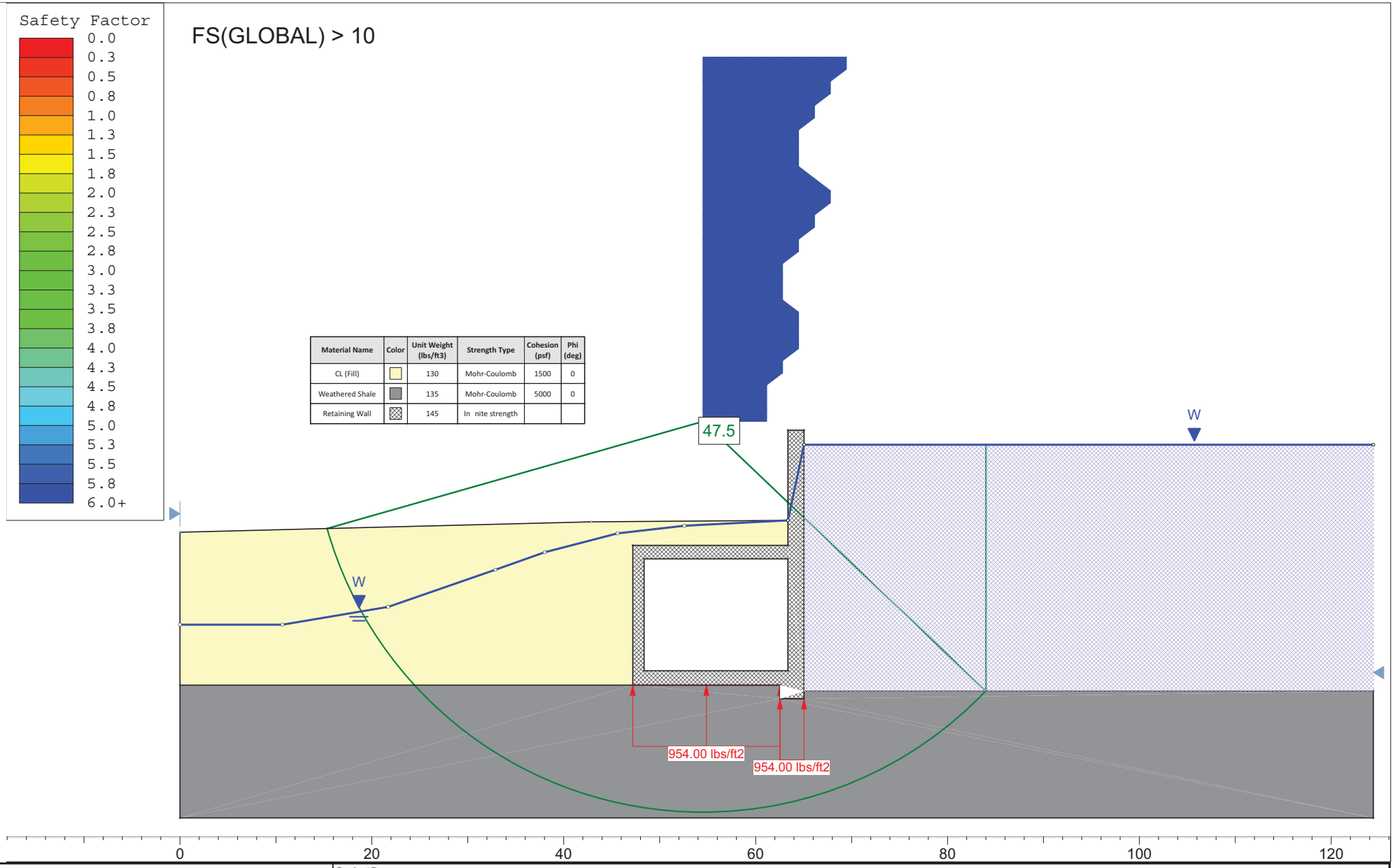
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 1E - Drawdown (Waterside)
Drawn ByB	TMB
DateB	8/16/2017
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
File Name	Case 2, Section 1E Drawdown (Waterside).slim



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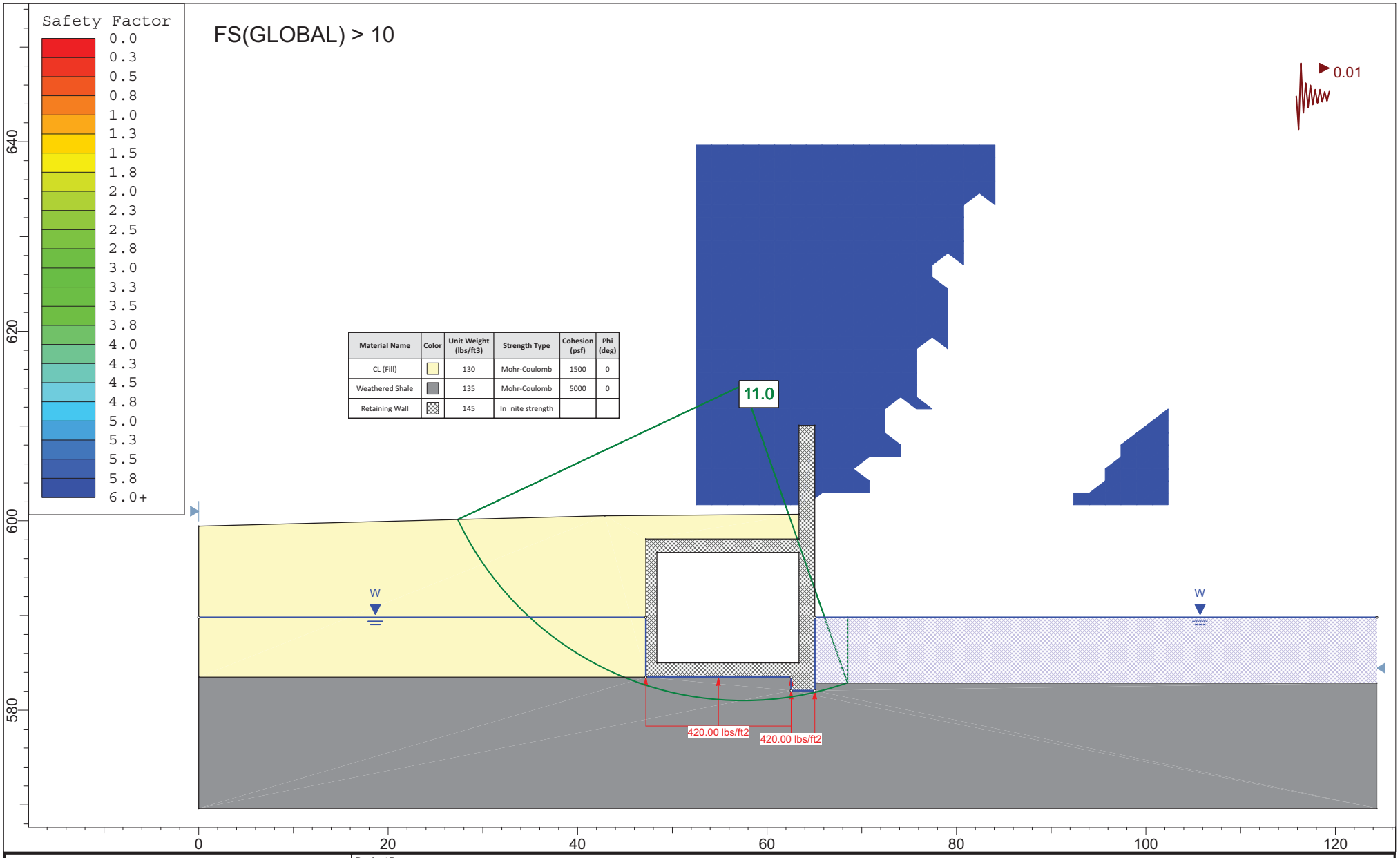
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section E4 - Steady State Seepage		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.
DateB	8-16-2017	File Name	Section E4 - Steady State Seepage



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section E4 - Existing Conditions (Waterside)
Drawn ByB	TMB
DateB	11/14/2012B
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
File Name	Case 4, Section E4 Earthquake (Waterside).slim

REACH E4, SECTION E4 FLOODWALL STABILITY SUMMARY.

Existing Condition

GW El = 590.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Uplift									

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**17.3.**
Summation M (ft-lbs)	**135,699.**
Summation P (lbs)	**19,604.**
Eccentricity, e (ft)	**1.70.**
q(max) (psf)	**1,810.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**3.02.**
FS (Sliding)	**2.00.**
FS (Uplift)	**3.71.**

Foundation bears upon weathered shale bedrockh

Ah loads and moments estimated are per foot of wallh

REACH E4, SECTION E4 FLOODWALL STABILITY SUMMARY.

Sudden Drawdown

GW El = 596.7

Grand River El = 590.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Uplift									

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**17.3.**
Summation M (ft-lbs)	**66,051.**
Summation P (lbs)	**15,422.**
Eccentricity, e (ft)	**4.34.**
q(max) (psf)	**2,401.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.48.**
FS (Sliding)	**1.00.**
FS (Uplift)	**2.41.**

Foundation bears upon weathered shale bedrockh

Ah loads and moments estimated are per foot of wallh

REACH E4, SECTION E4 - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-1 (071062)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log \frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_s}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

Organic Decompositionh
Consider settlement percentage due to decomposition of organic material equal to loss of 1/2 percent of organics by weigh

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*
BOF El =		*Bottom of floodwall elevationh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Clay, Fill	CL			
	Organic Silt	OL			
	Clay, Shale	CL			
	Shale	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s

Settlement Analysis

					ΔH (in)			
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary	Organics
				TOTAL (in).	**1.45.**			

Freeboard Summar

Existing Flood Protection El = .	**610.1.**
uture Flood Protection El = .	**610.0.**
BFE = .	**608.5.**

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REACH E5

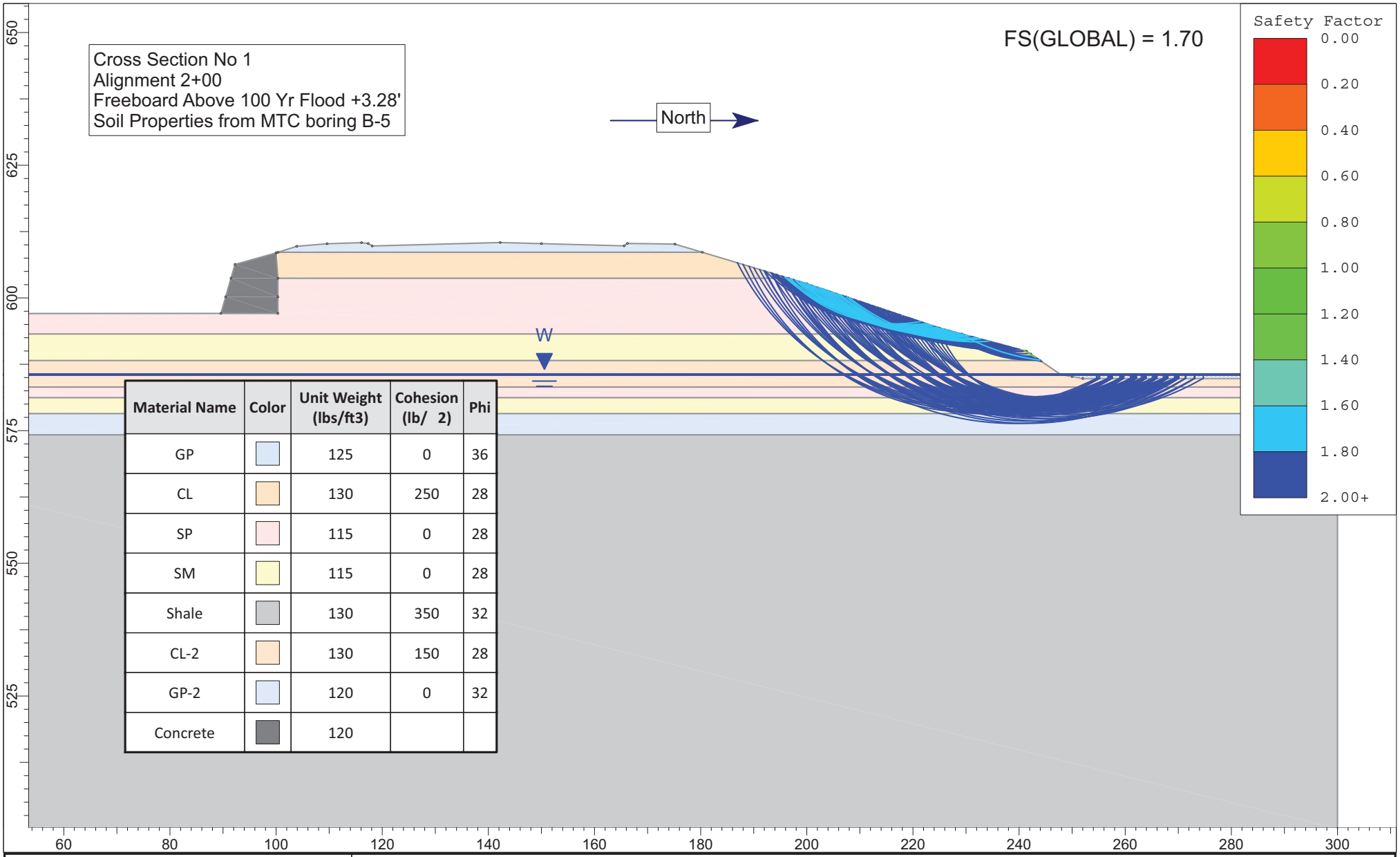
SECTION E5 PHOTOGRAPHS



Looking Northeast



Looking Southwest



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (lb/ 2)	Phi
GP		125	0	36
CL		130	250	28
SP		115	0	28
SM		115	0	28
Shale		130	350	32
CL-2		130	150	28
GP-2		120	0	32
Concrete		120		

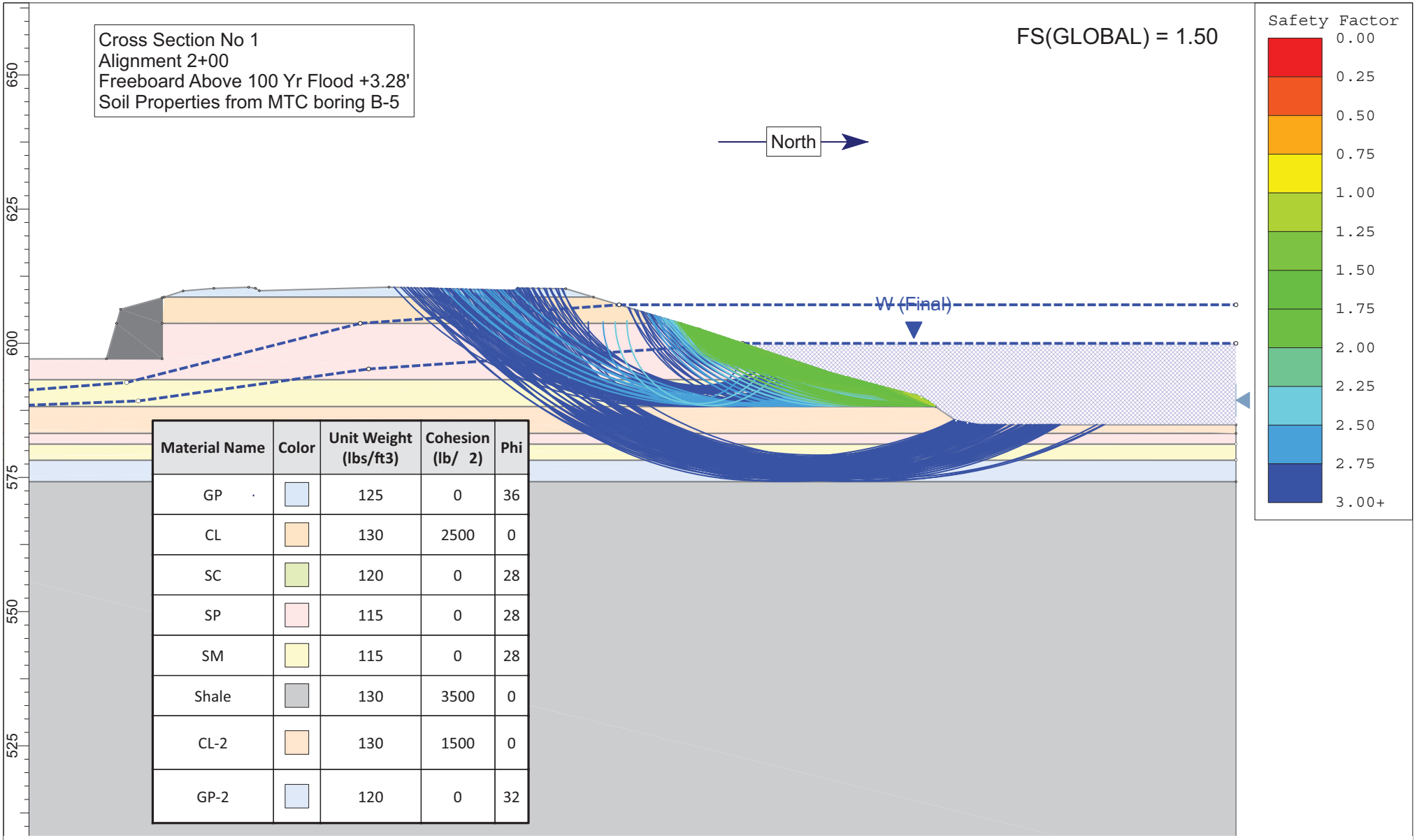
rocscience

SLIDEINTERPRET 6.012B

ProjectB	SLIDE - An Interactive Slope Stability ProgramB		
Analysis DescriptionB	Section E5 - Existing Condition		
Drawn ByB	Lexi FeutzB	ScaleB 1:300	CompanyB Materials Testing Consultants, Inc.
DateB	8-16-2017	File Name	Section E5 - Existing Condition

Cross Section No 1
Alignment 2+00
Freeboard Above 100 Yr Flood +3.28'
Soil Properties from MTC boring B-5

FS(GLOBAL) = 1.50

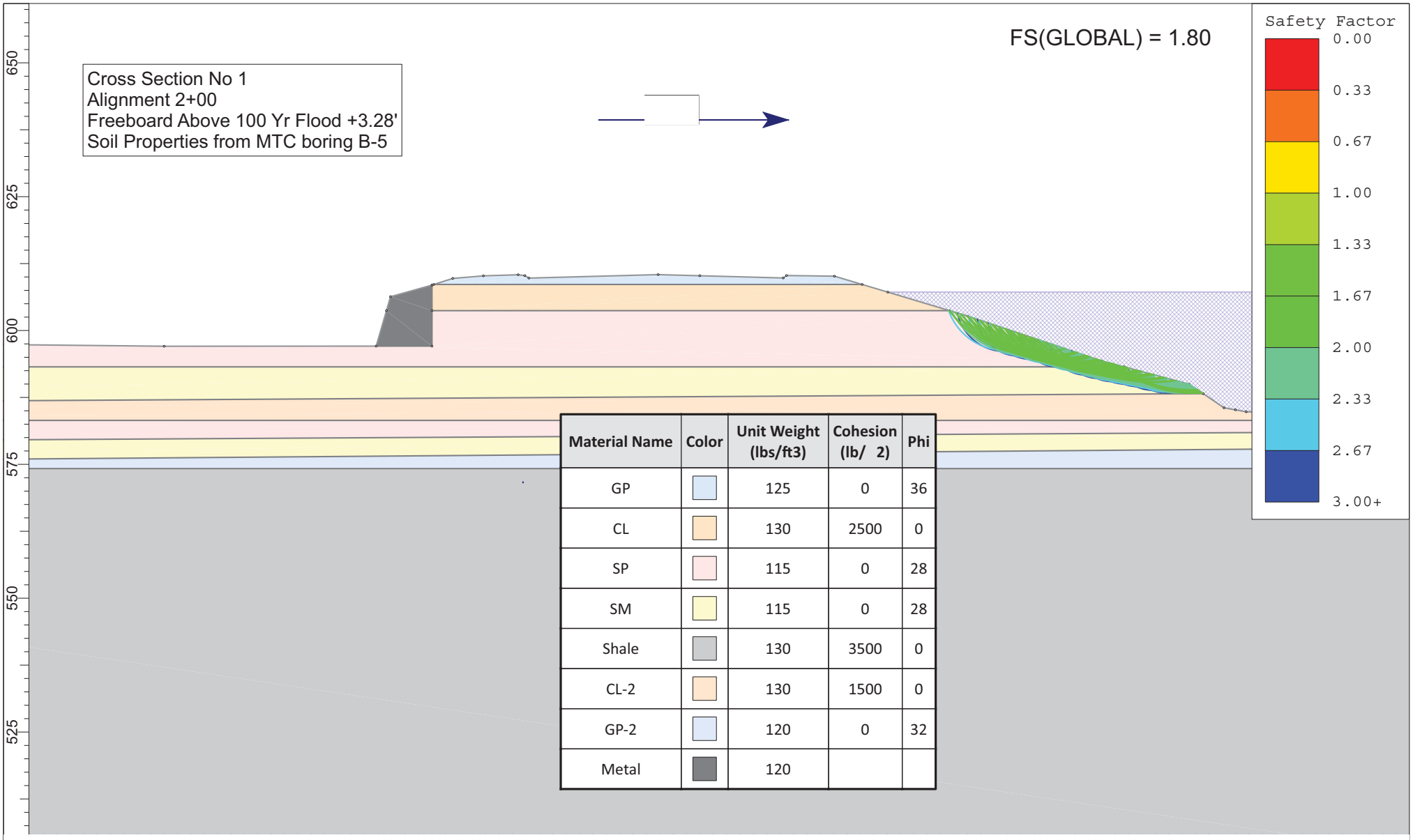


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (lb/ 2)	Phi
GP		125	0	36
CL		130	2500	0
SC		120	0	28
SP		115	0	28
SM		115	0	28
Shale		130	3500	0
CL-2		130	1500	0
GP-2		120	0	32

rocscience

SLIDEINTERPRET 6.012B

ProjectB	SLIDE - An Interactive Slope Stability ProgramB		
Analysis DescriptionB	Section E5 - Sudden Drawdown		
Drawn ByB	Lexi FeutzB	ScaleB 1:300	CompanyB Materials Testing Consultants, Inc.
DateB	8-16-2017		File Name

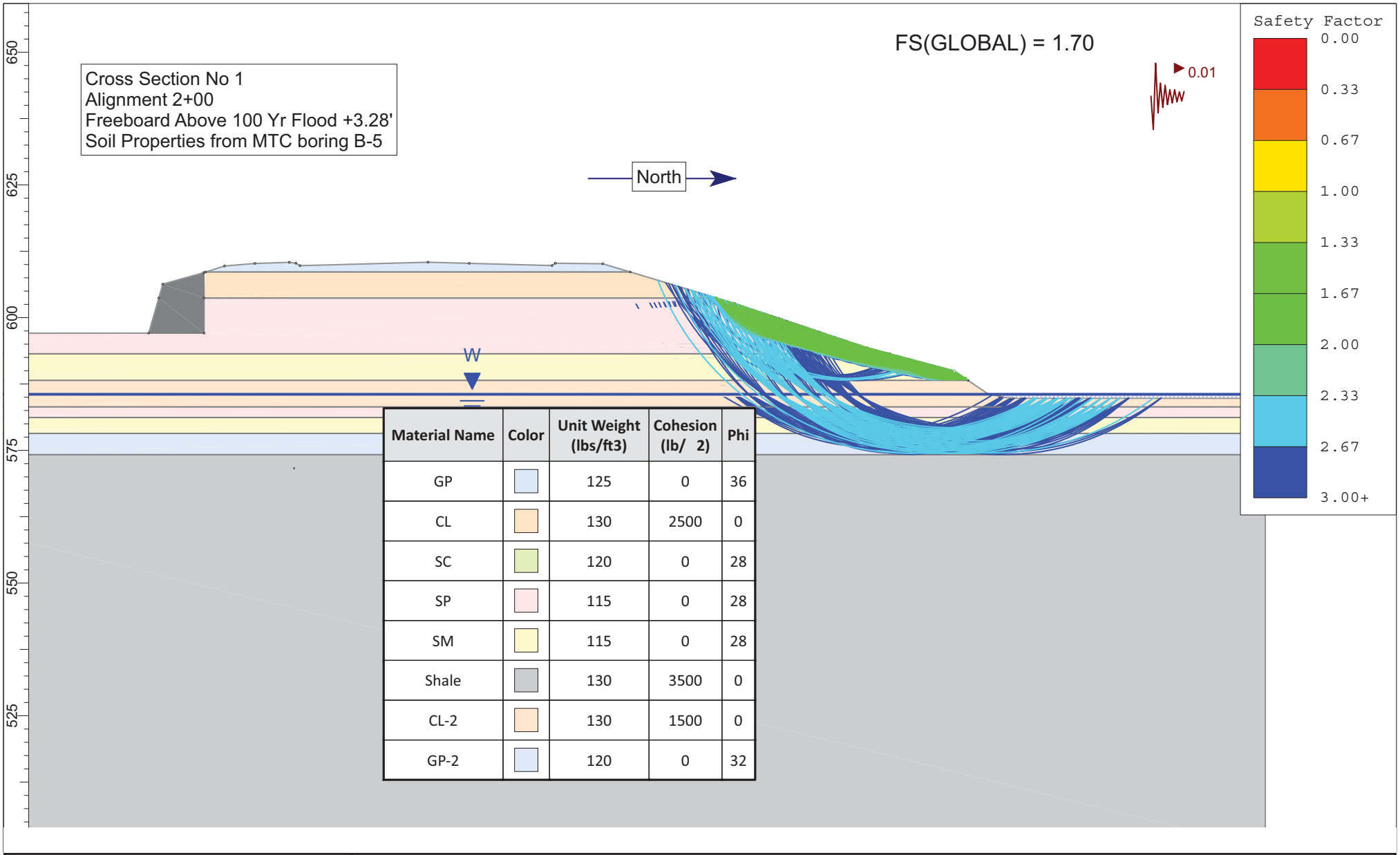


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (lb/ 2)	Phi
GP		125	0	36
CL		130	2500	0
SP		115	0	28
SM		115	0	28
Shale		130	3500	0
CL-2		130	1500	0
GP-2		120	0	32
Metal		120		

rocscience

SLIDEINTERPRET 6.012B

ProjectB	SLIDE - An Interactive Slope Stability ProgramB			
Analysis DescriptionB	111266.6 GRWWTP Slope StabilityB			
Drawn ByB	Lexi FeutzB	ScaleB	1:300	CompanyB Materials Testing Consultants, Inc.
DateB	8-16-2017			File Name Section E5 - Steady State Seepage



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (lb/ 2)	Phi
GP		125	0	36
CL		130	2500	0
SC		120	0	28
SP		115	0	28
SM		115	0	28
Shale		130	3500	0
CL-2		130	1500	0
GP-2		120	0	32

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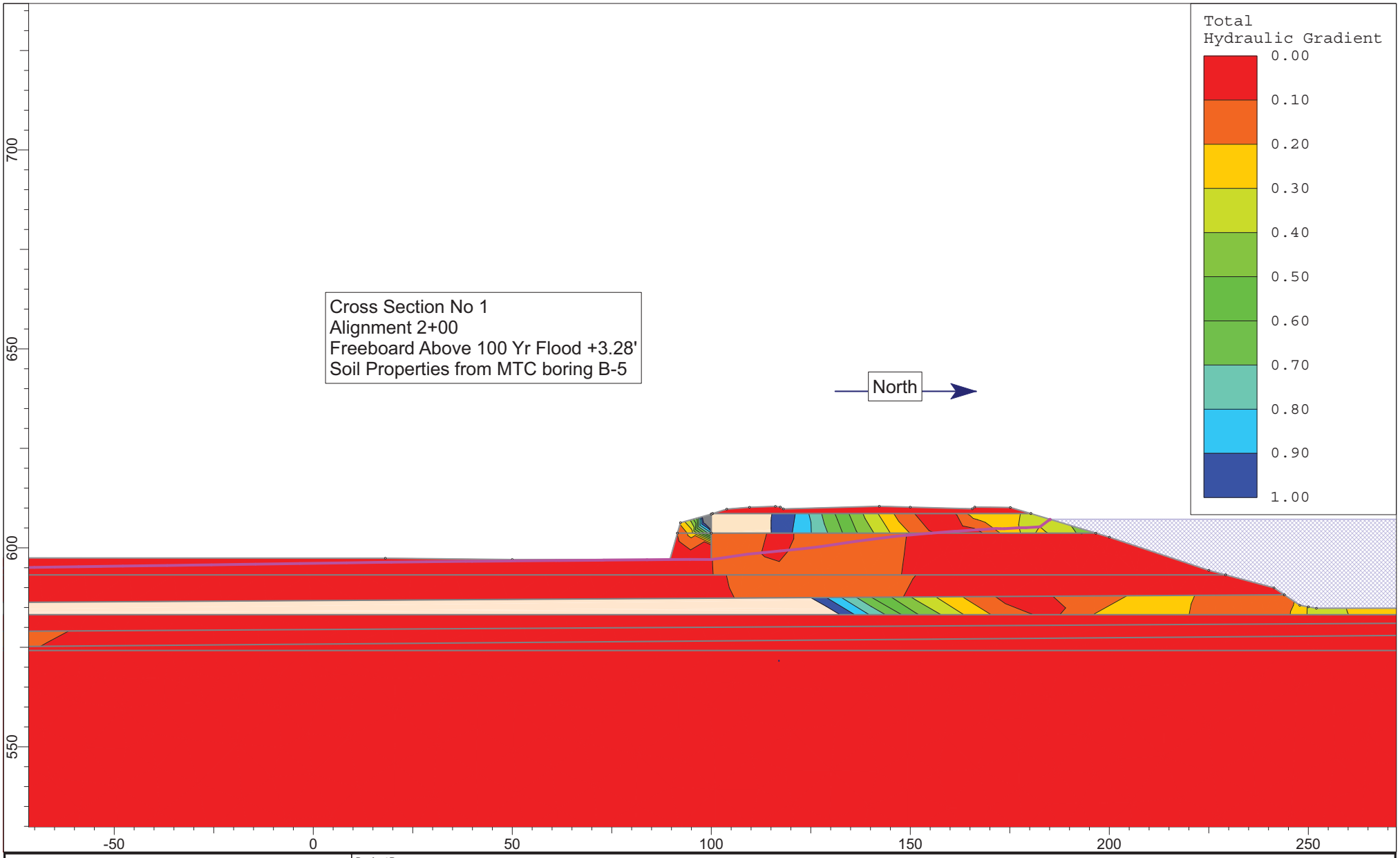
SLIDEINTERPRET 6.012B

ProjectB	SLIDE - An Interactive Slope Stability ProgramB			
Analysis DescriptionB	Section E5 - Earthquake			
Drawn ByB	Lexi FeutzB	ScaleB	1:300	CompanyB Materials Testing Consultants, Inc.
DateB	8-16-2017			File Name Section E5 - Earthquake



ProjectB	SLIDE - An Interactive Slope Stability ProgramB		
Analysis DescriptionB	Section E5 - Steady State Seepage		
Drawn ByB	Lexi FeutzB	ScaleB	1:400B
Company	Materials Testing Consultants, Inc.B		
DateB	11/21/2013, 10:35:10 AM	File Name	Cross Section 1 - SS GW Extended.slim

SLIDEINTERPRET 6.012B

REACH E5, SECTION E5 - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-5 (111266.2)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_s}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increase, 1.5 ft average fill height placed above existing berm to accommodate 3 ft of freeboard at flood protection bermsh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Clay, Fill	CL			
	Sand, Fill				
	Clay	CL			
	Sand and Gravel	SP, SM, GP			
	Shale	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s
			50+										

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**1.93.**		

Freeboard Summar

Existing Flood Protection El = .	**610.7.**
uture Flood Protection El = .	**610.5.**
BFE = .	**607.3.**

REACH W1

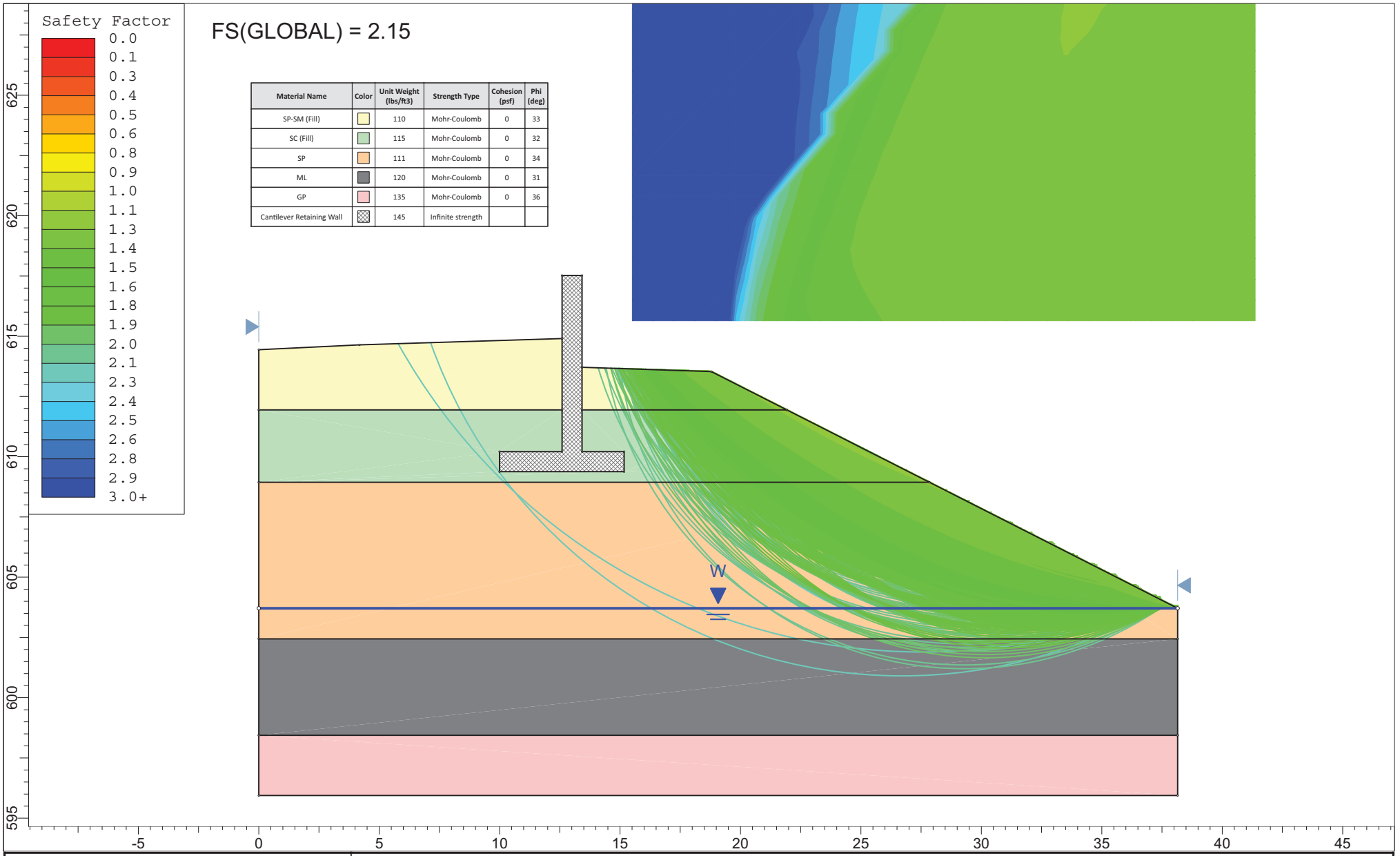
SECTION W1 PHOTOGRAPHS



Looking West



Looking Southwest



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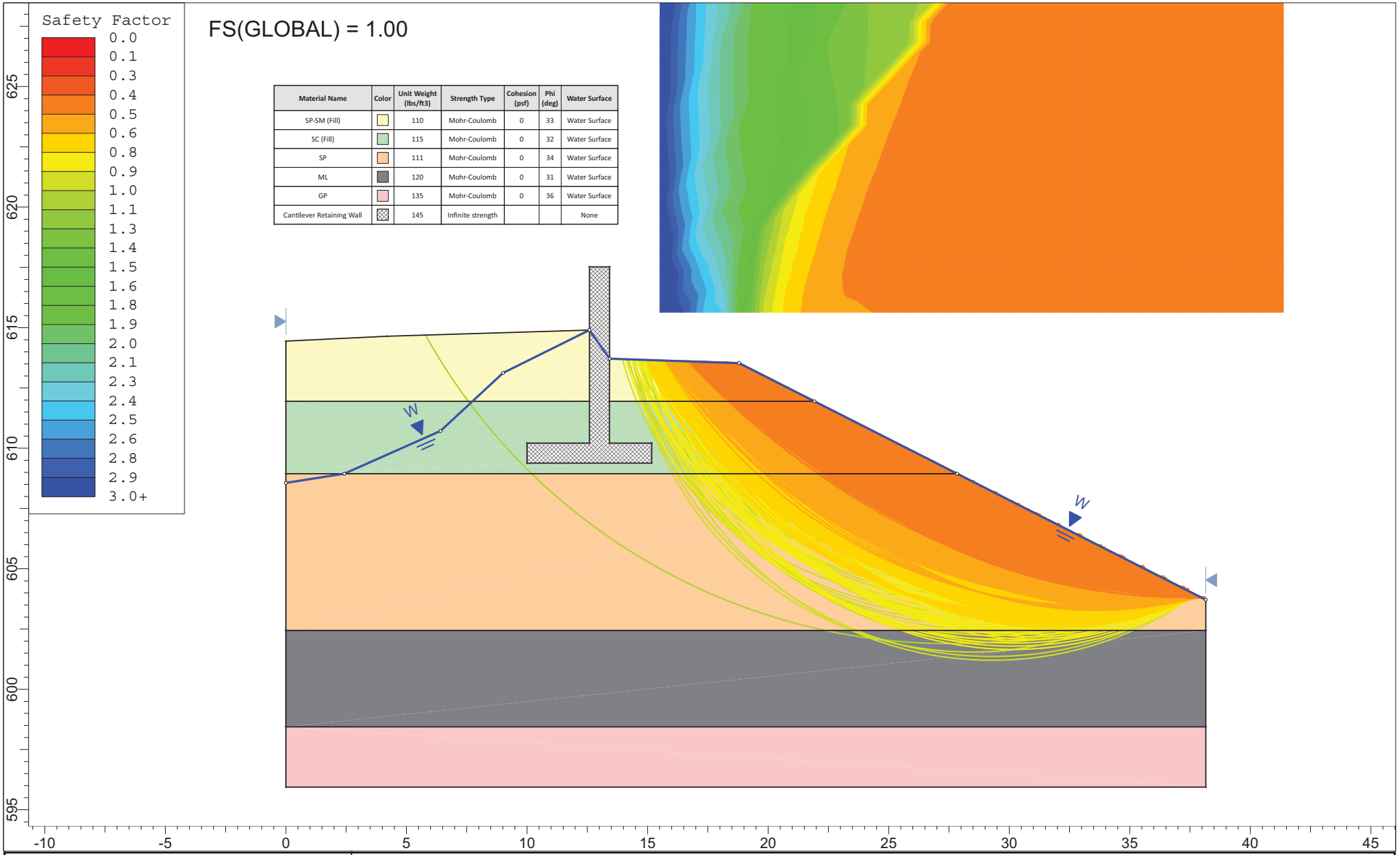
ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W17 - Existing Conditions (Waterside)
Drawn ByB	TMB
DateB	11/14/2012B
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Case 1, Section W17 - Existing Conditions (Waterside).slim

SLIDEINTERPRET 6.016B



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
SP-SM (Fill)		110	Mohr-Coulomb	0	33	Water Surface
SC (Fill)		115	Mohr-Coulomb	0	32	Water Surface
SP		111	Mohr-Coulomb	0	34	Water Surface
ML		120	Mohr-Coulomb	0	31	Water Surface
GP		135	Mohr-Coulomb	0	36	Water Surface
Cantilever Retaining Wall		145	Infinite strength			None

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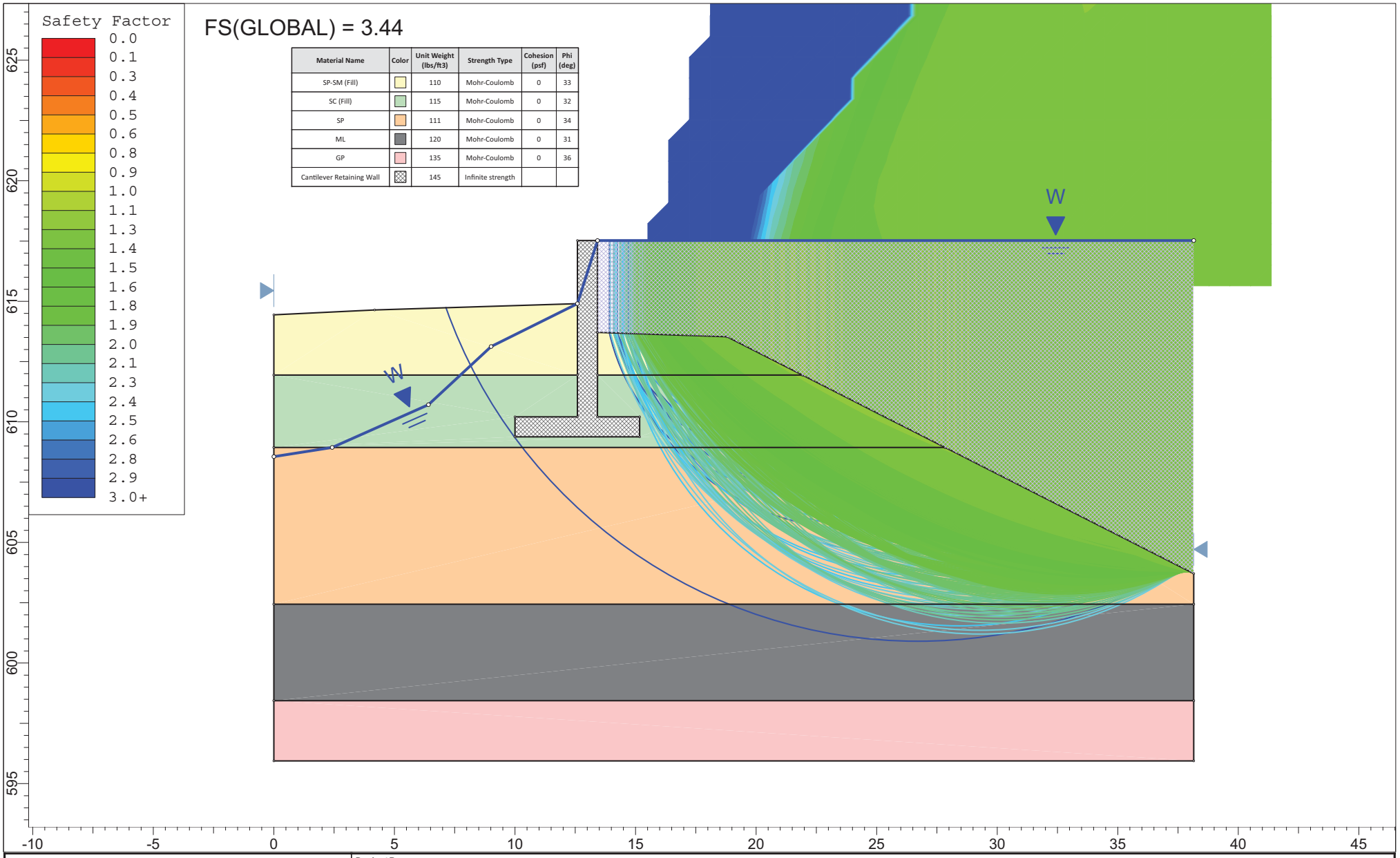
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section V7N--Sudden Drawdown (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012	File NameB	Section V7N--Sudden Drawdown (Waterside).slim



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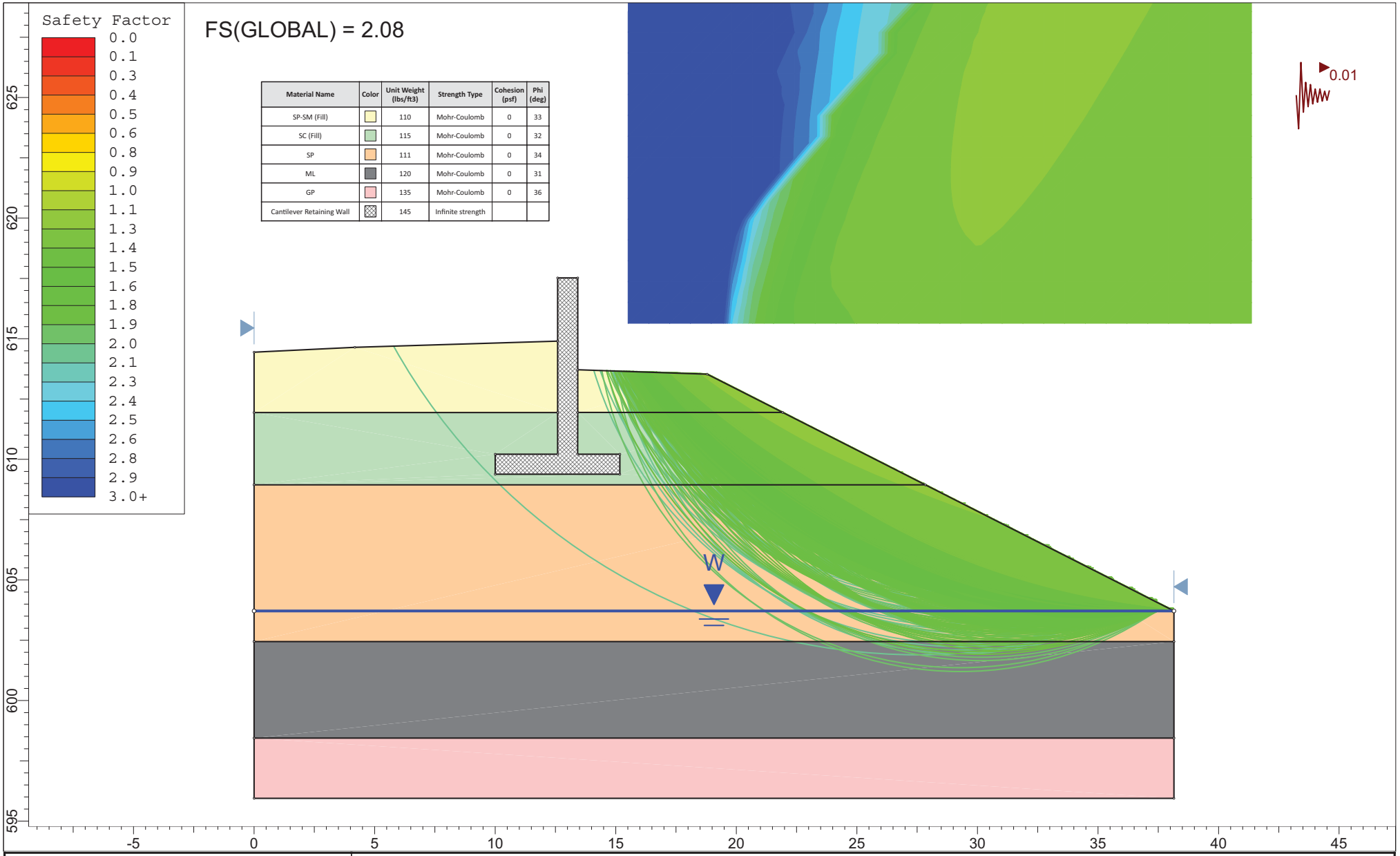
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section VI - Steady State Seepage Section VI - Base Flood (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8/16/2017 11/14/2012
File NameB	Section VI Steady State Seepage (Waterside).slim Case 3, Section VI Base Flood (Waterside).slim



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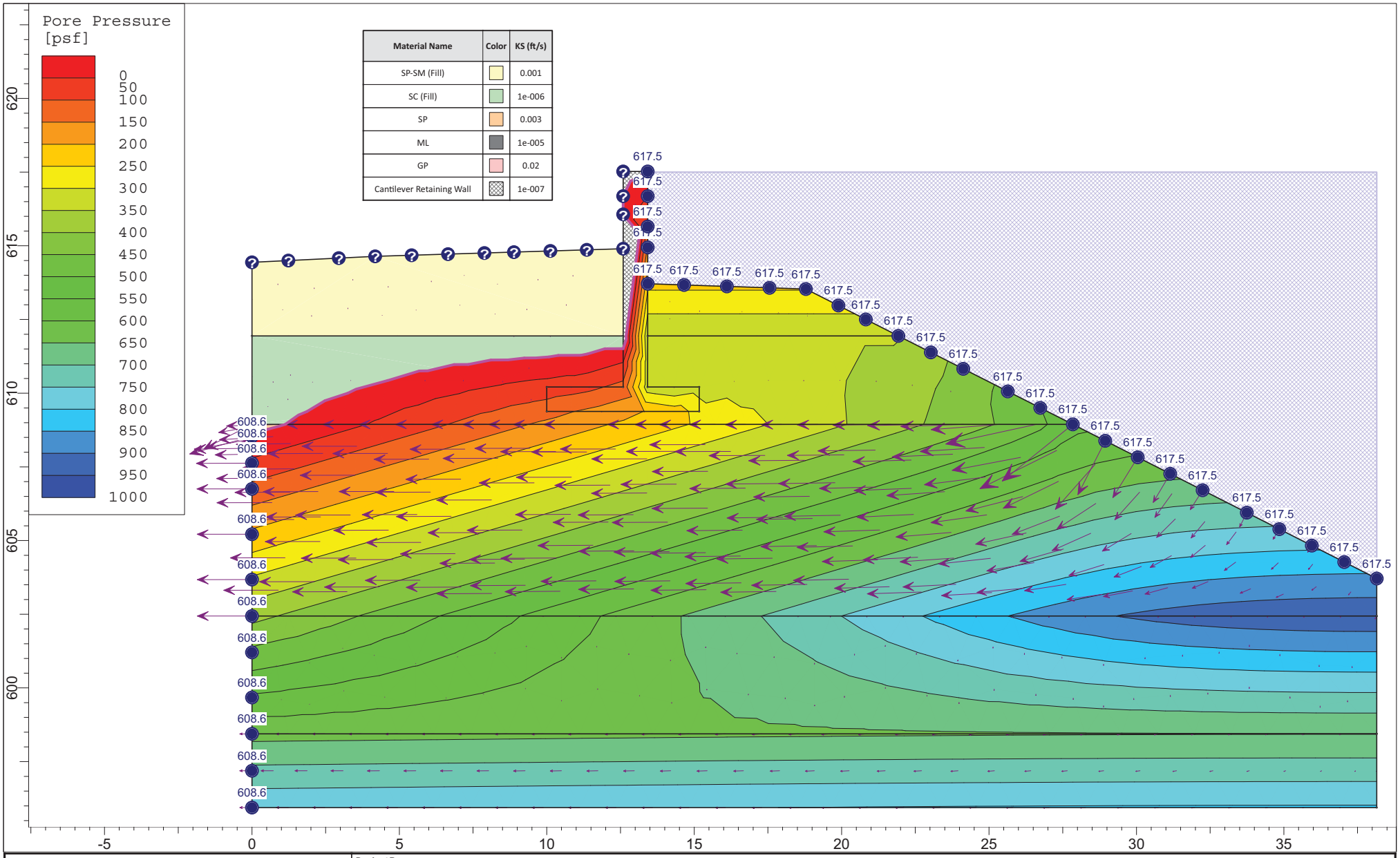
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 7N – Earthquake (Waterside)
Drawn ByB	TMB
DateB	8-10-2017 11/14/2012
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Section 7N Earthquake (Waterside).slim Case 4 Section 7N Earthquake



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 7N Steady State Seepage
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	12/18/2012B
File NameB	Section 7N - Steady State Seepage.slim

REACH W1, SECTION W1 FLOODWALL STABILITY SUMMARY.

Existing Condition

GW El = 608.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**5.2.**
Summation M (ft-lbs)	**12,460.**
Summation P (lbs)	**3,723.**
Eccentricity, e (ft)	**-0.76.**
q(max) (psf)	**83.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**17.88.**
FS (Sliding)	**9.05.**

Foundation bears upon loose granular soil overlying dense graveh

Ah loads and moments estimated are per foot of wallh

REACH W1, SECTION W1 FLOODWALL STABILITY SUMMARY.

Sudden Drawdown

GW El = 614.9

Plaster Creek El = 609.4

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**5.2.**
Summation M (ft-lbs)	**7,731.**
Summation P (lbs)	**2,878.**
Eccentricity, e (ft)	**-0.10.**
q(max) (psf)	**492.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**4.77.**
FS (Sliding)	**3.00.**

Foundation bears upon loose granular soil overlying dense graveh

Ah loads and moments estimated are per foot of wallh

REACH W1, SECTION W1 - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-6 (111266)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log \frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*
BOF El =		*Bottom of floodwall elevationh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP-SM, SC			
	Sand	SP-SM, SC			
	Silt	ML			
	Gravel	GP			

Soil Properties

Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		NAVFAC 7.1-237 C_s
			50+										

Settlement Analysis

Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	ΔH (in) Immediate	Primary	Secondary
				TOTAL (in).	**0.00.**		

Freeboard Summar

Existing Flood Protection El = .	**617.5.**
uture Flood Protection El = .	**617.5.**
BFE = .	**616.1.**

REACH W2

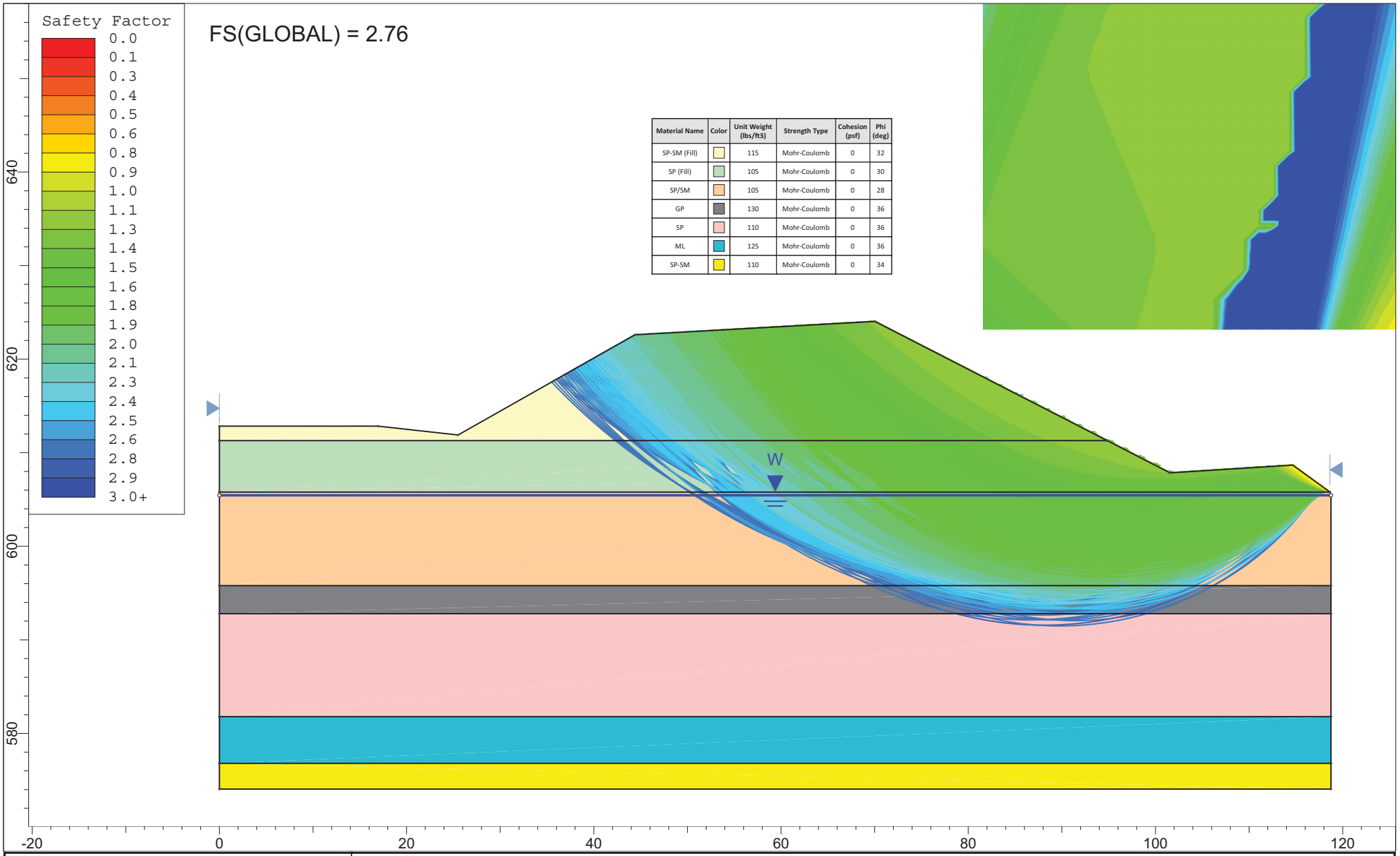
SECTION W2A PHOTOGRAPHS



Looking Northwest



Looking Northwest



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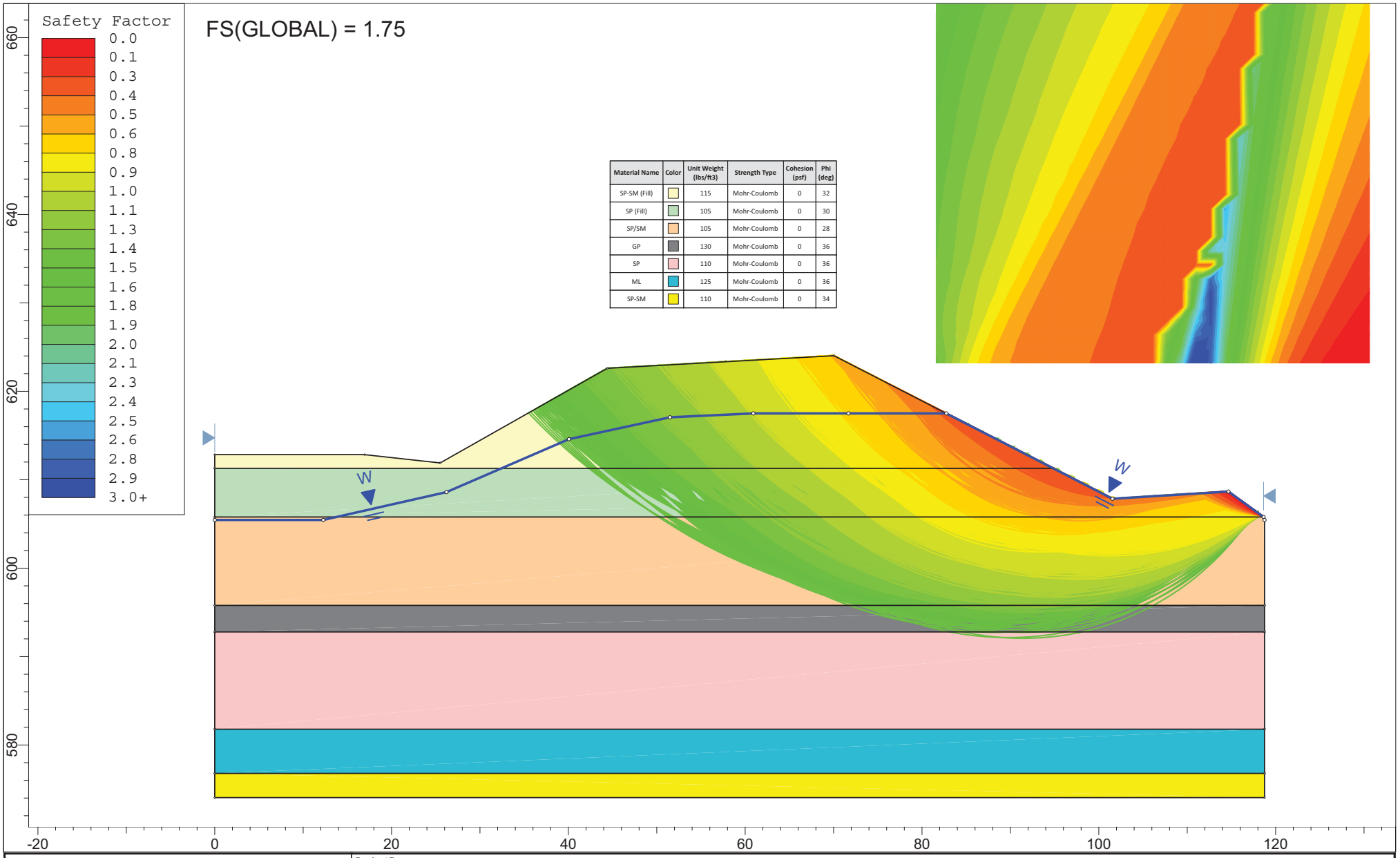
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2A - Existing Condition (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8/16/2012
File NameB	Case 1, Section W2A Existing Conditions (Waterside).slimB



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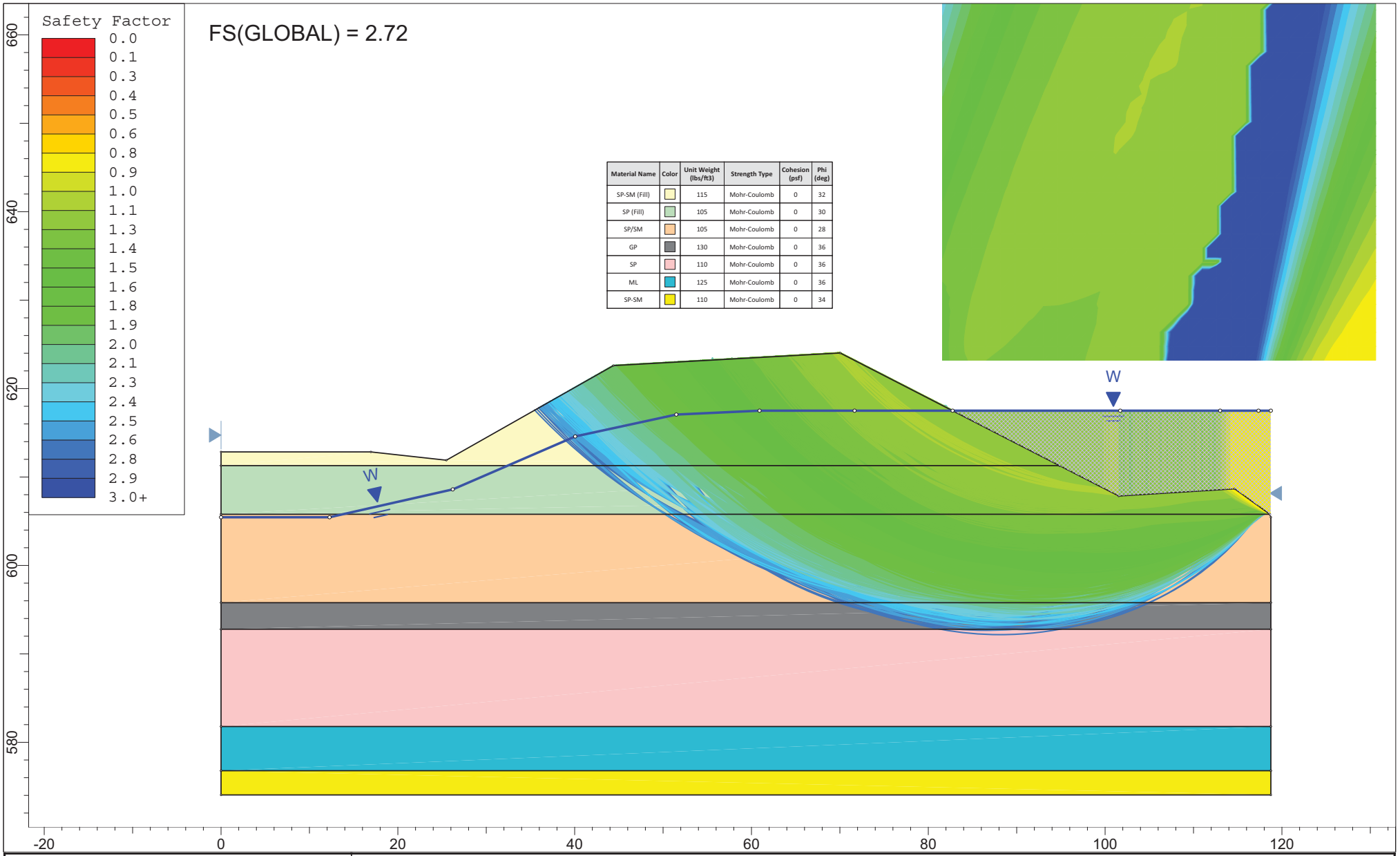
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2A - Sudden Drawdown
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8/16/2012
File NameB	Case 2 Section 2A Sudden Drawdown (Waterside).slim



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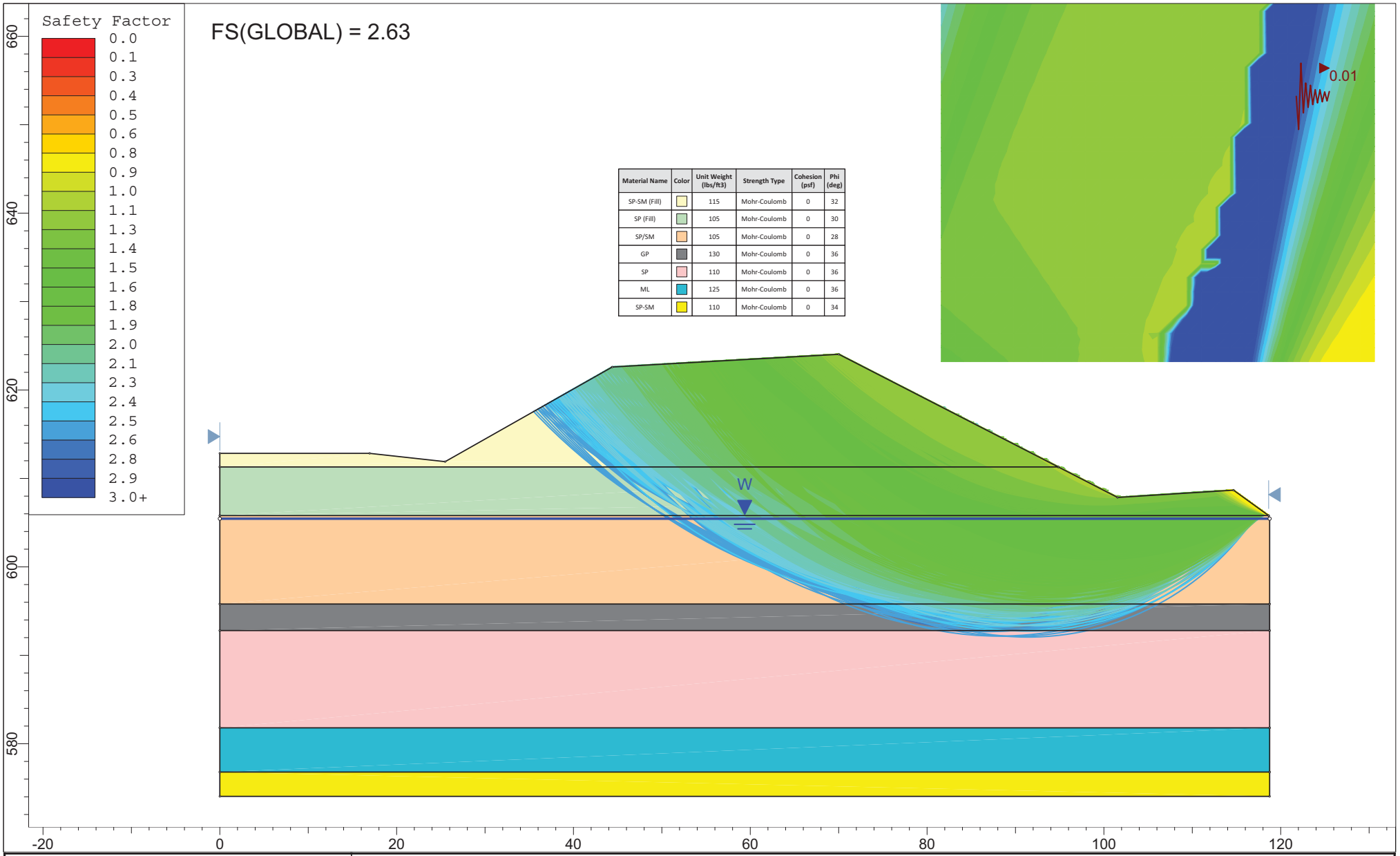
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 78A - Steady State Seepage Section 78 - Base Flood (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8-10-2017 8-10-2017
File NameB	Case 3 Section 78 Base Flood (Waterside).slim Section 78A - Steady State Seepage (Waterside).slim



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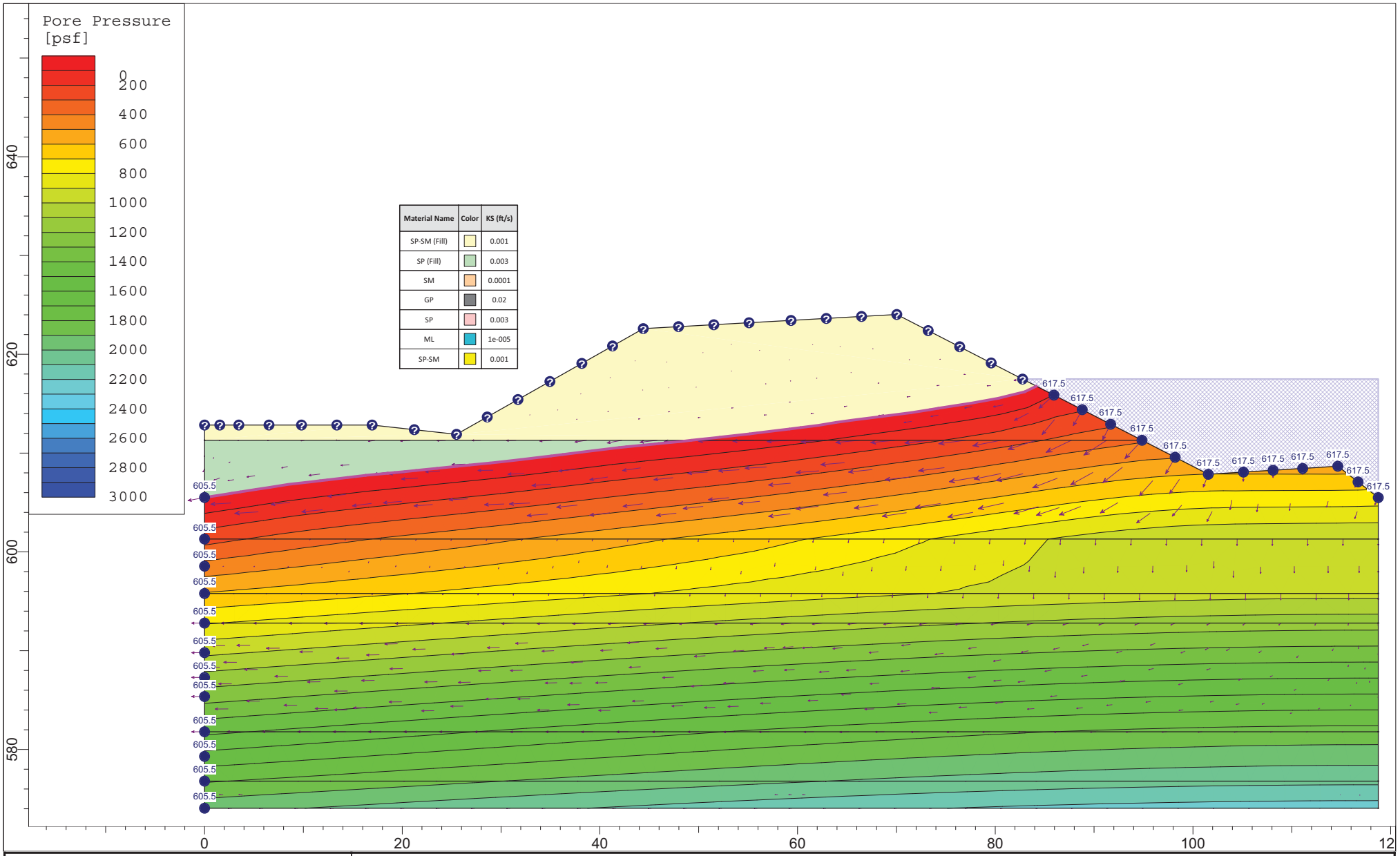
ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2A Earthquake (Waterside)
Drawn ByB	TMB
DateB	11/12/2012
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Section W2A - Earthquake (Waterside).slim

SLIDEINTERPRET 6.016B



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2A - Steady State Seepage
Drawn ByB	TMB
DateB	8-16-2017
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Section W2A Steady State Seepage.slim

REACH W2, SECTION W2A - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-5 (111266)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_s}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP, SP-SM			
	Sand				
	Sand and Gravel	SP, GP			
	Silt	ML			
	Sand	SP-SM			

Soil Properties

Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		NAVFAC 7.1-237 C_s

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**0.00.**		

Freeboard Summar

Existing Flood Protection El = .	**624.0.**
uture Flood Protection El = .	**624.0.**
BFE = .	**616.1.**

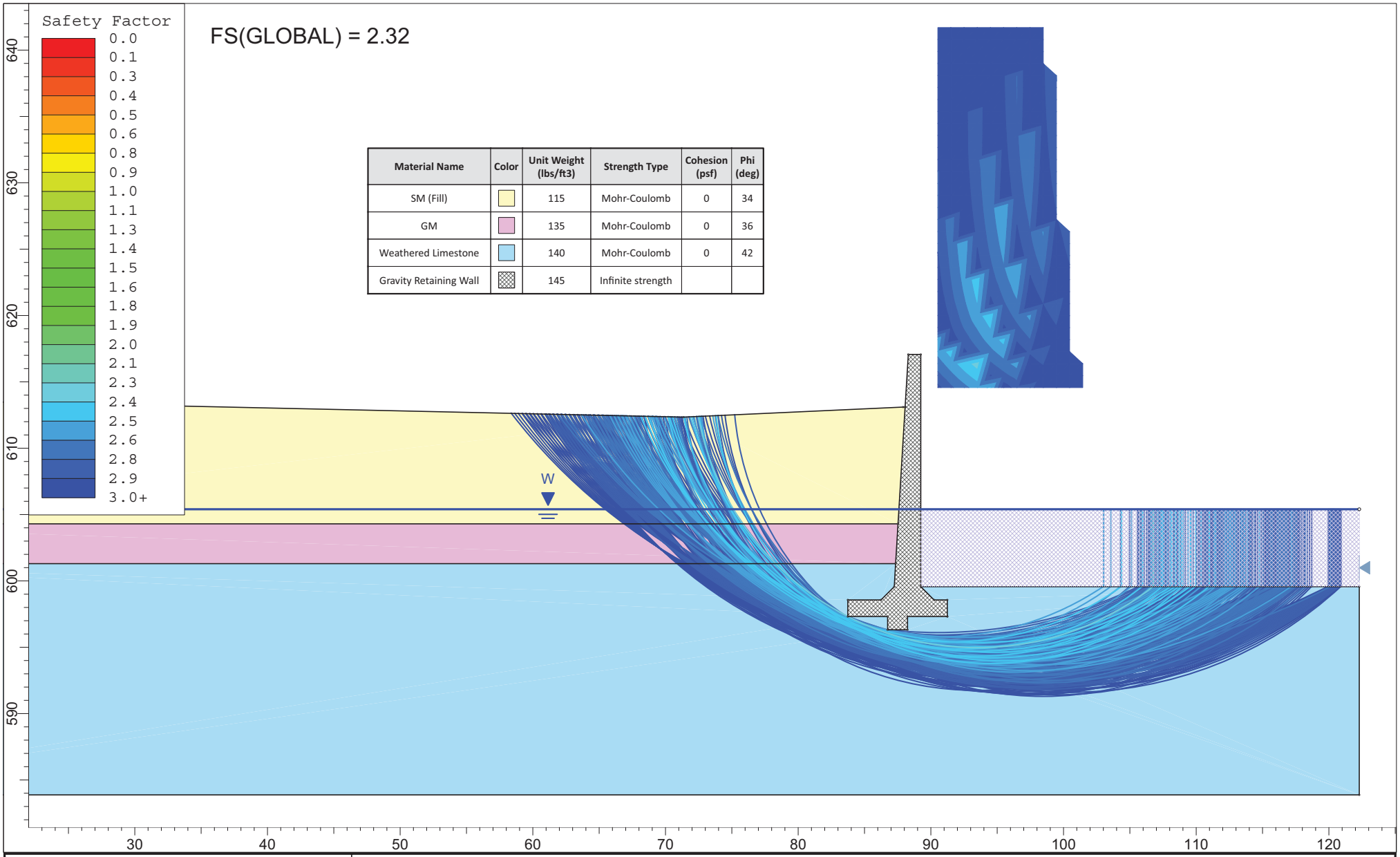
SECTION W2B PHOTOGRAPHS



Looking Northeast



Looking North



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	34
GM		135	Mohr-Coulomb	0	36
Weathered Limestone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	Infinite strength		

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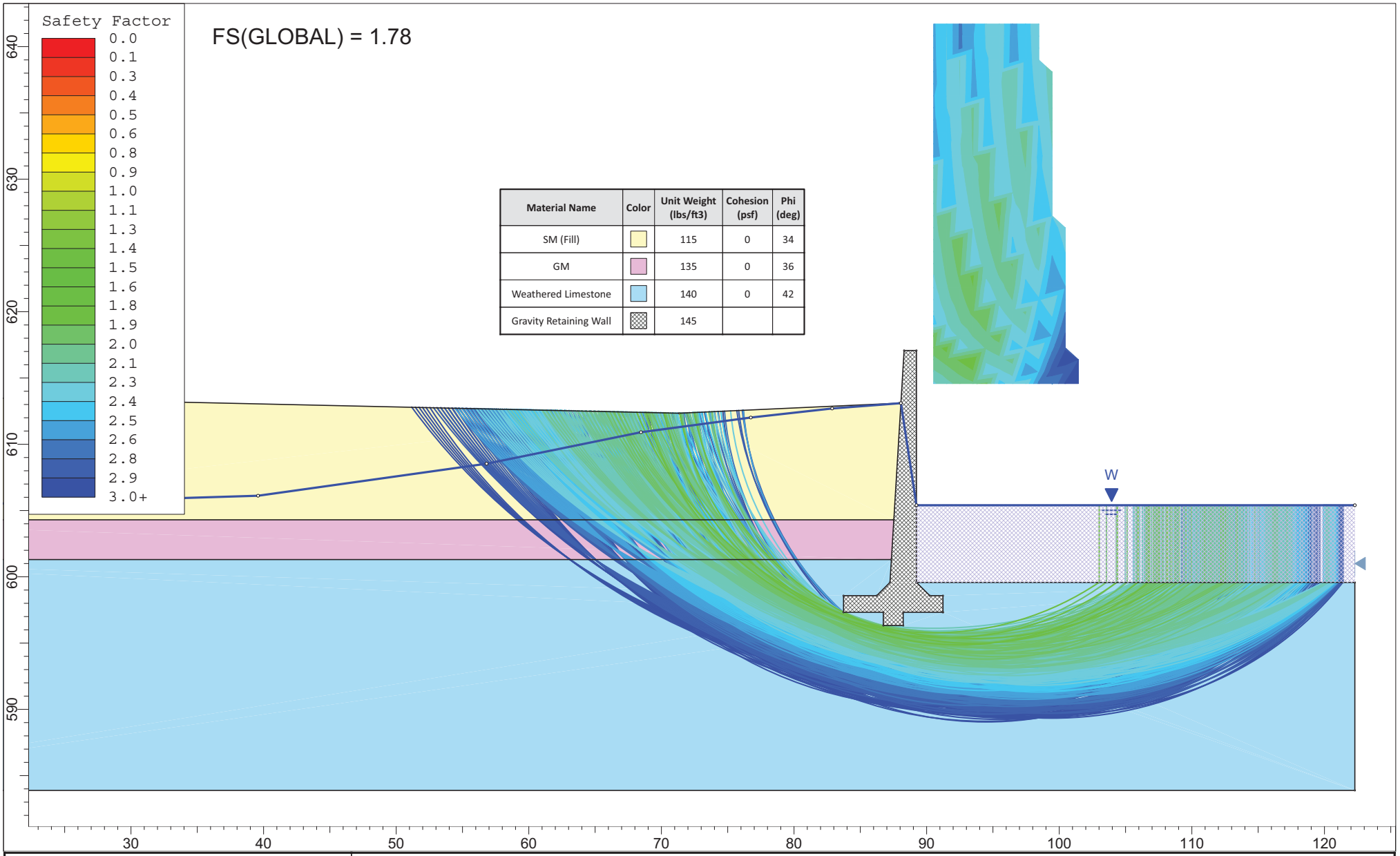
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section W2B - Existing Condition	Section 5A - Existing Conditions (Waterside)	
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012	File NameB	Case 1) Section 5A- Existing Conditions (Waterside).slimB

8/6/2017



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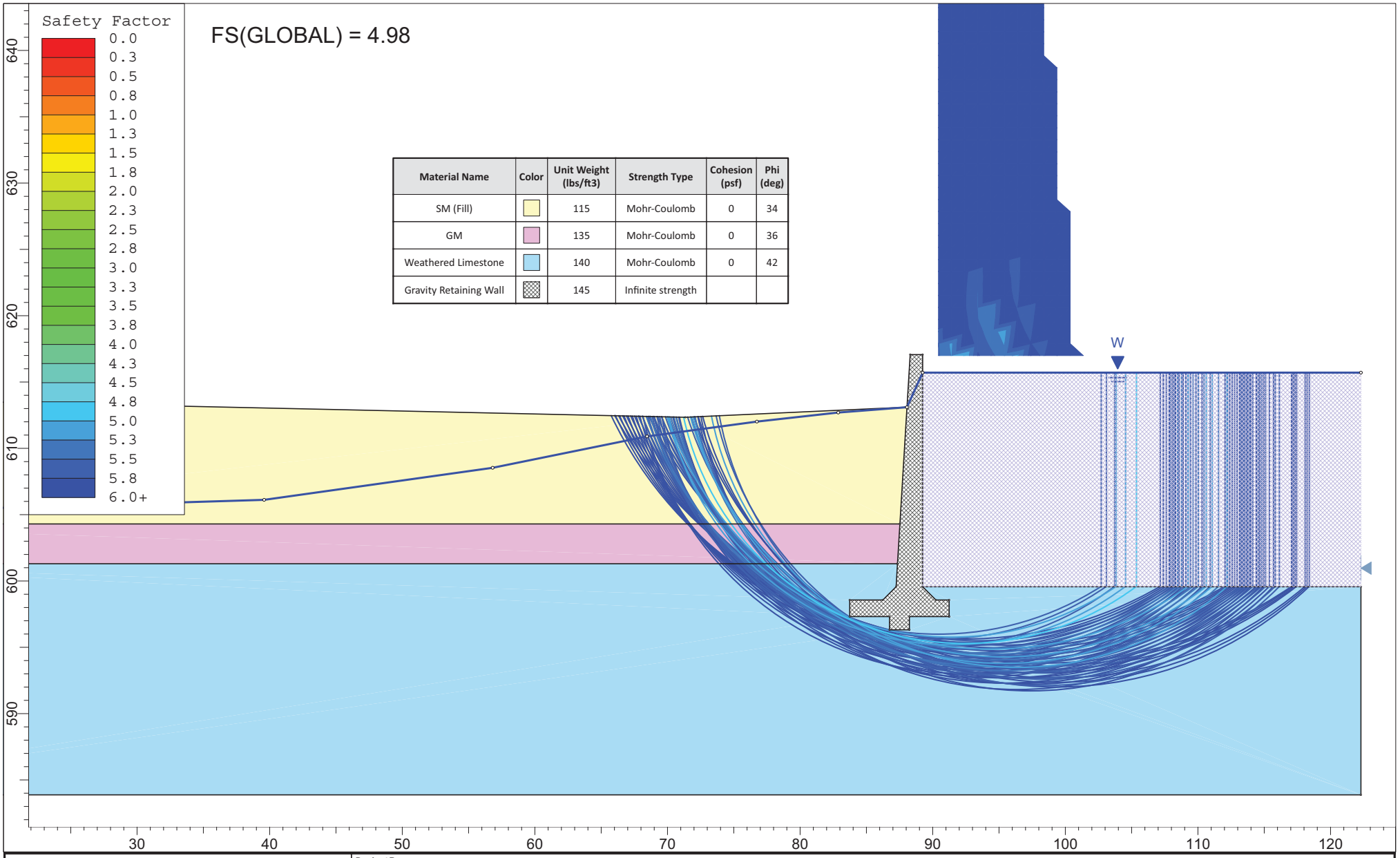
ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2B - Sudden Drawdown (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012
File NameB	Case 2, Section W2B Sudden Drawdown (Waterside).slim

SLIDEINTERPRET 6.016B



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	34
GM		135	Mohr-Coulomb	0	36
Weathered Limestone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	Infinite strength		

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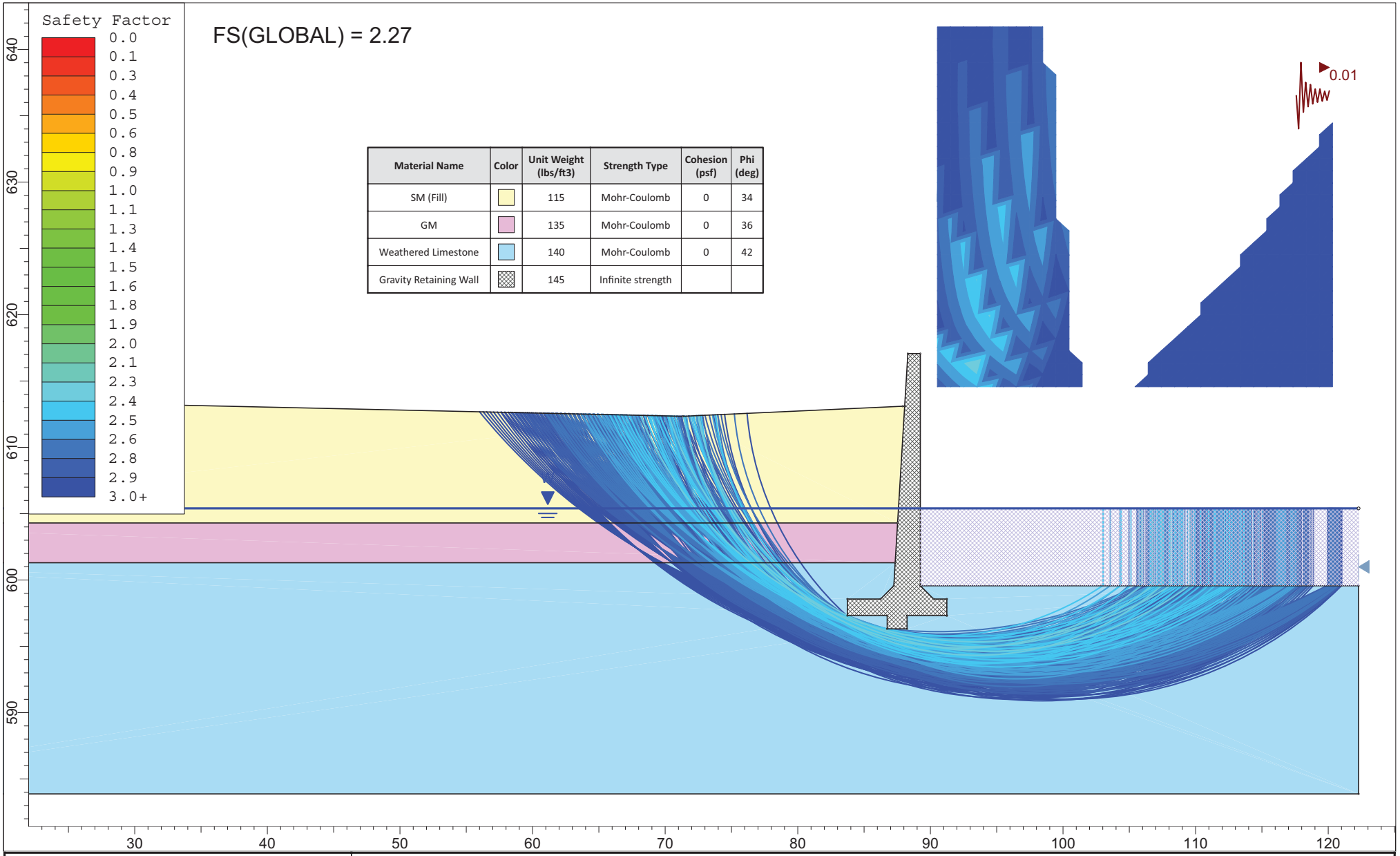
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section 5W2B Steady State (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012	File NameB	Case 3 / Section 5W1 Base Flood (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	34
GM		135	Mohr-Coulomb	0	36
Weathered Limestone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	Infinite strength		

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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2B - Earthquake Section 5W - Earthquake (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012 8-1/6-2/2017
File NameB	Case 4, Section 5W Earthquake Case 4, W2B - Earthquake (Waterside).slim

REACH W2, SECTION W2B FLOODWALL STABILITY SUMMARY

Existing Condition

GW El = 605.4

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**7.5.**
Summation M (ft-lbs)	**40,207.**
Summation P (lbs)	**7,664.**
Eccentricity, e (ft)	**-1.50.**
q(max) (psf)	**2,267.**
Base Area in Compression (%)	**90%.**
FS (Bearing)	**>3.**
FS (Overturning)	**6.35.**
FS (Sliding)	**2.44.**

Foundation bears upon weathered limestone bedrock

All loads and moments estimated are per foot of walh

REACH W2, SECTION W2B FLOODWALL STABILITY SUMMARY.

Sudden Drawdown

GW El = 605.4

Grand River El = 612.4

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**7.5.**
Summation M (ft-lbs)	**474.**
Summation P (lbs)	**4,929.**
Eccentricity, e (ft)	**3.65.**
q(max) (psf)	**4,553.**
Base Area in Compression (%)	**NA.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.01.**
FS (Sliding)	**1.19.**

Resultant within base area of footingh

Foundation bears upon weathered limestone bedrock

Ah loads and moments estimated are per foot of walh

REACH W2, SECTION W2B - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-1 (Z0737)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*
BOF El =		*Bottom of floodwall elevationh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill				
	Gravel	GM			
	Limestone	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s
			50+										
			50+										

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**0.00.**		

Freeboard Summar

Existing Flood Protection El = .	**616.1.**
uture Flood Protection El = .	**616.1.**
BFE = .	**615.3.**

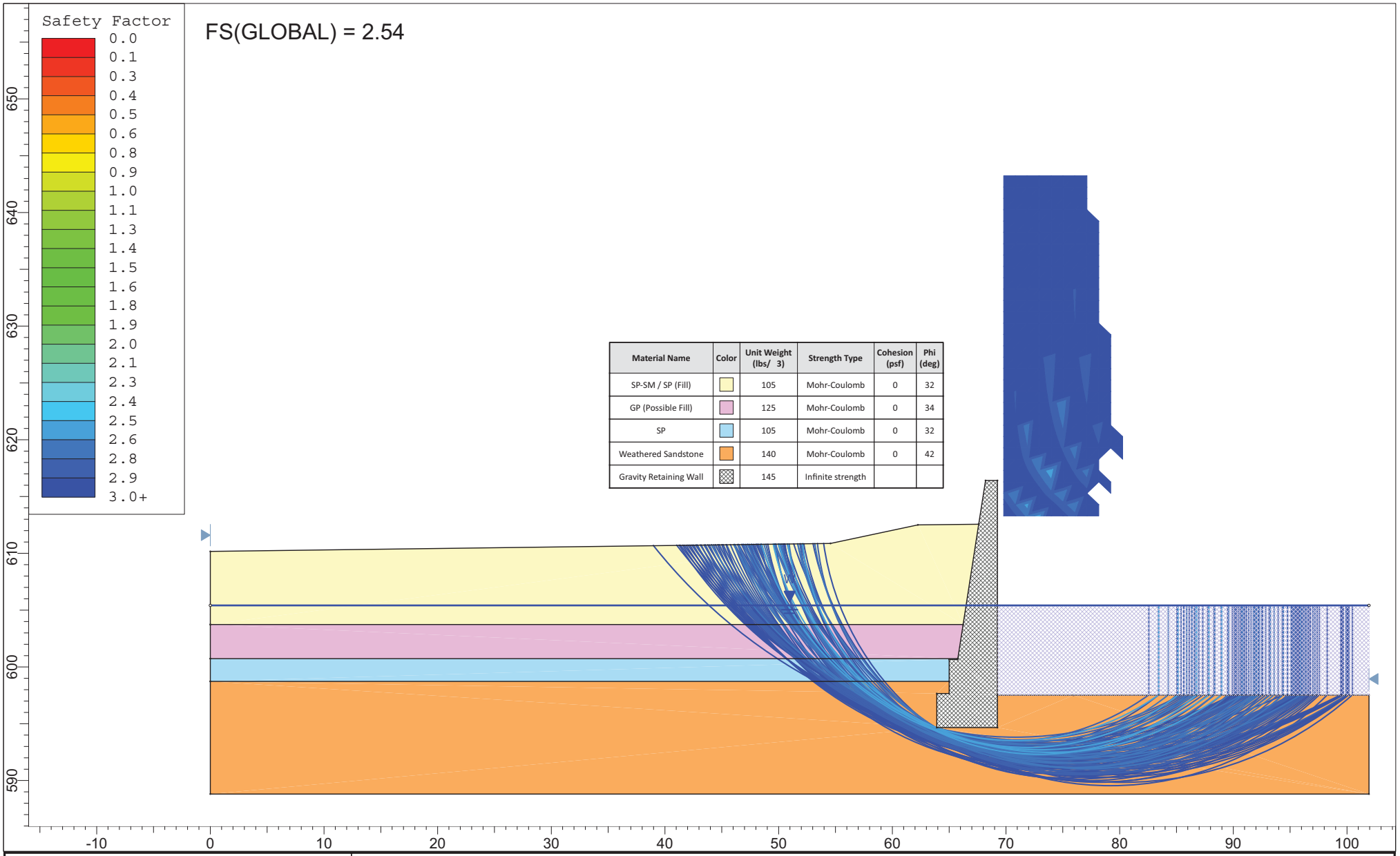
SECTION W2C PHOTOGRAPHS



Looking Northwest



Looking North



Material Name	Color	Unit Weight (lbs/ 3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM / SP (Fill)		105	Mohr-Coulomb	0	32
GP (Possible Fill)		125	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
Weathered Sandstone		140	Mohr-Coulomb	0	42
Gravity Retaining Wall		145	Infinite strength		

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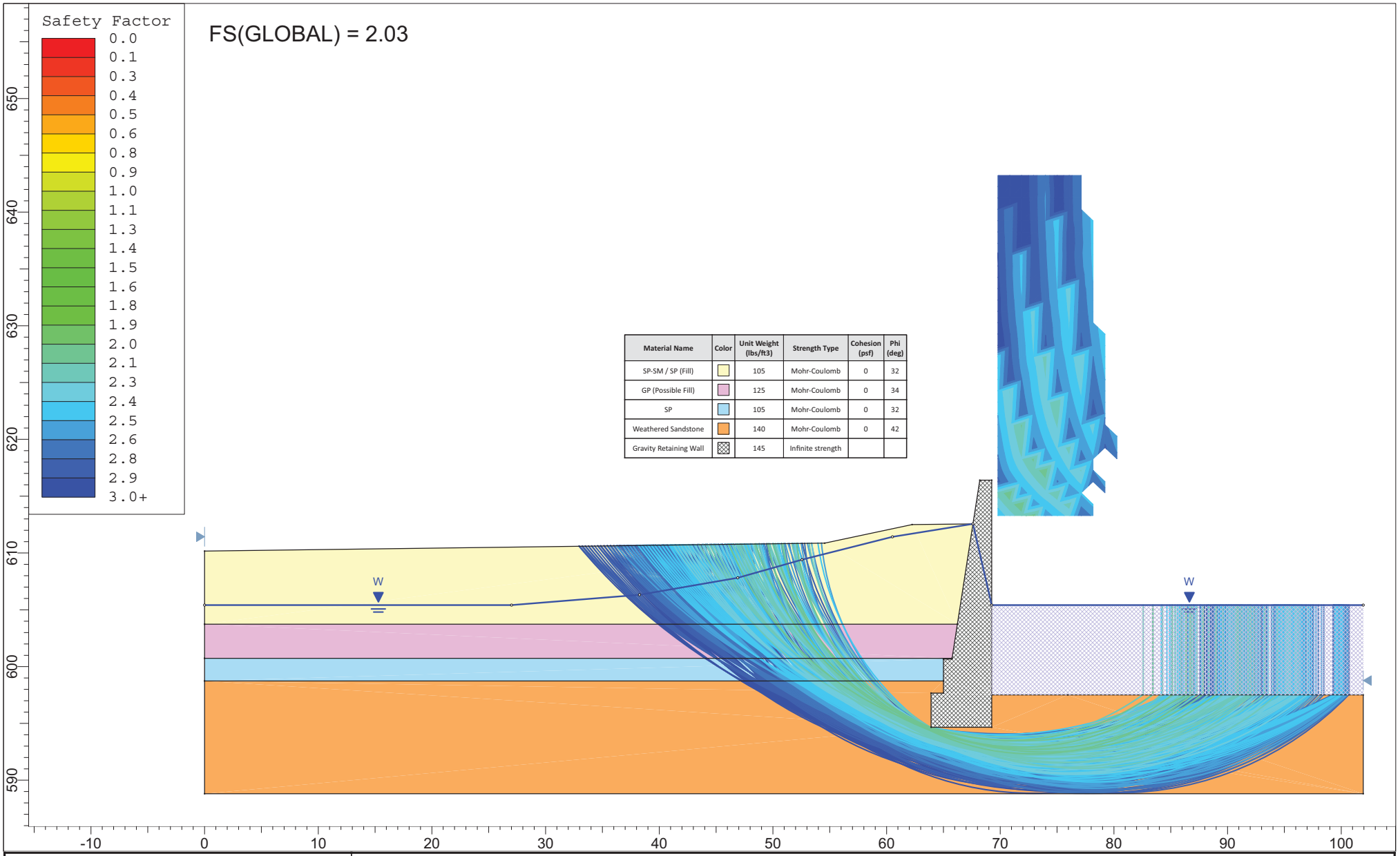
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section W2C - Existing Conditions (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012 8/16/2017	File NameB	Case 1, Section W2C - Existing Conditions (Waterside).slimB



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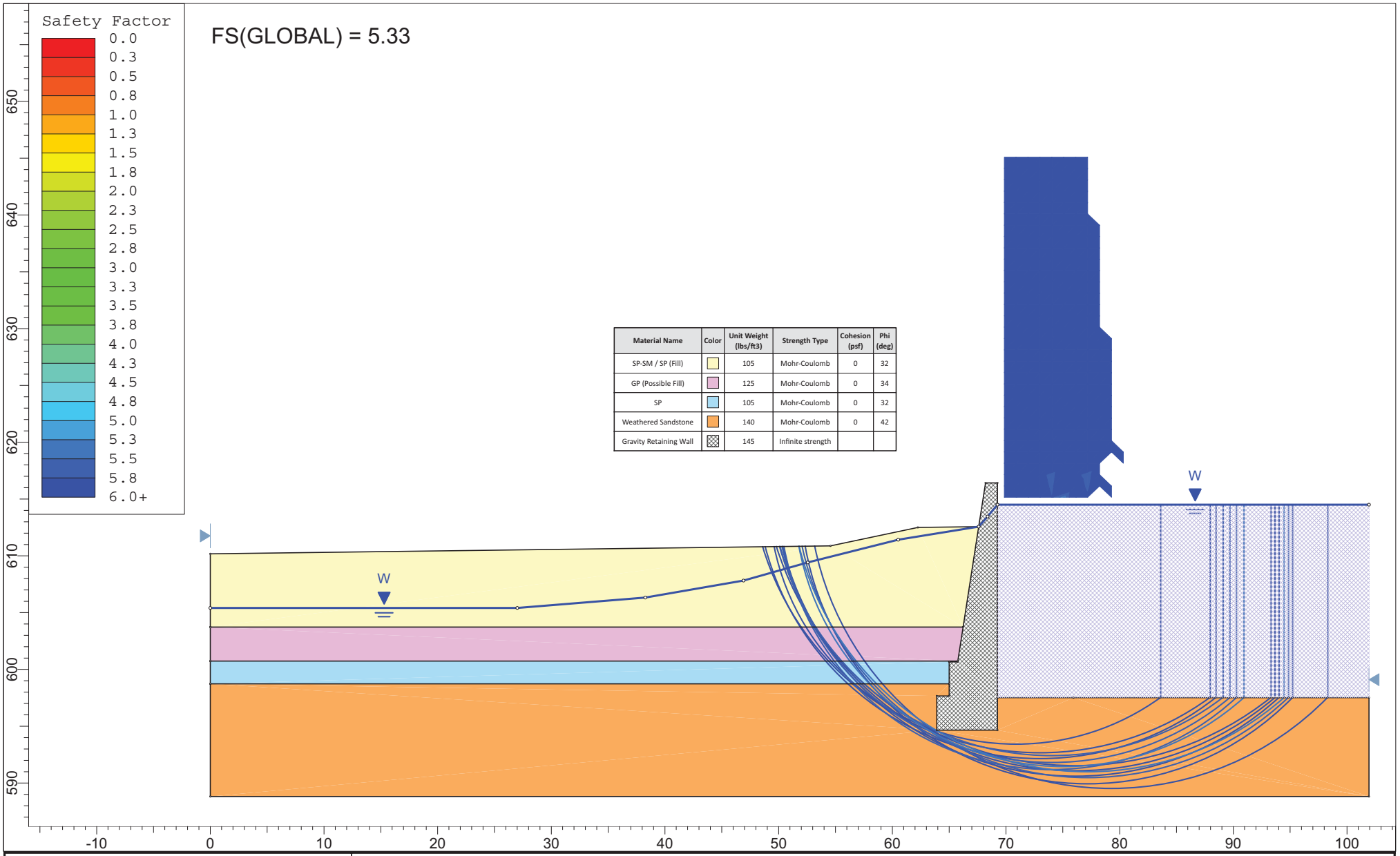
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 4W Drawdown (Waterside)
Drawn ByB	TMB
DateB	11/14/2012
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Case 2, Section 4W Drawdown (Waterside).slim



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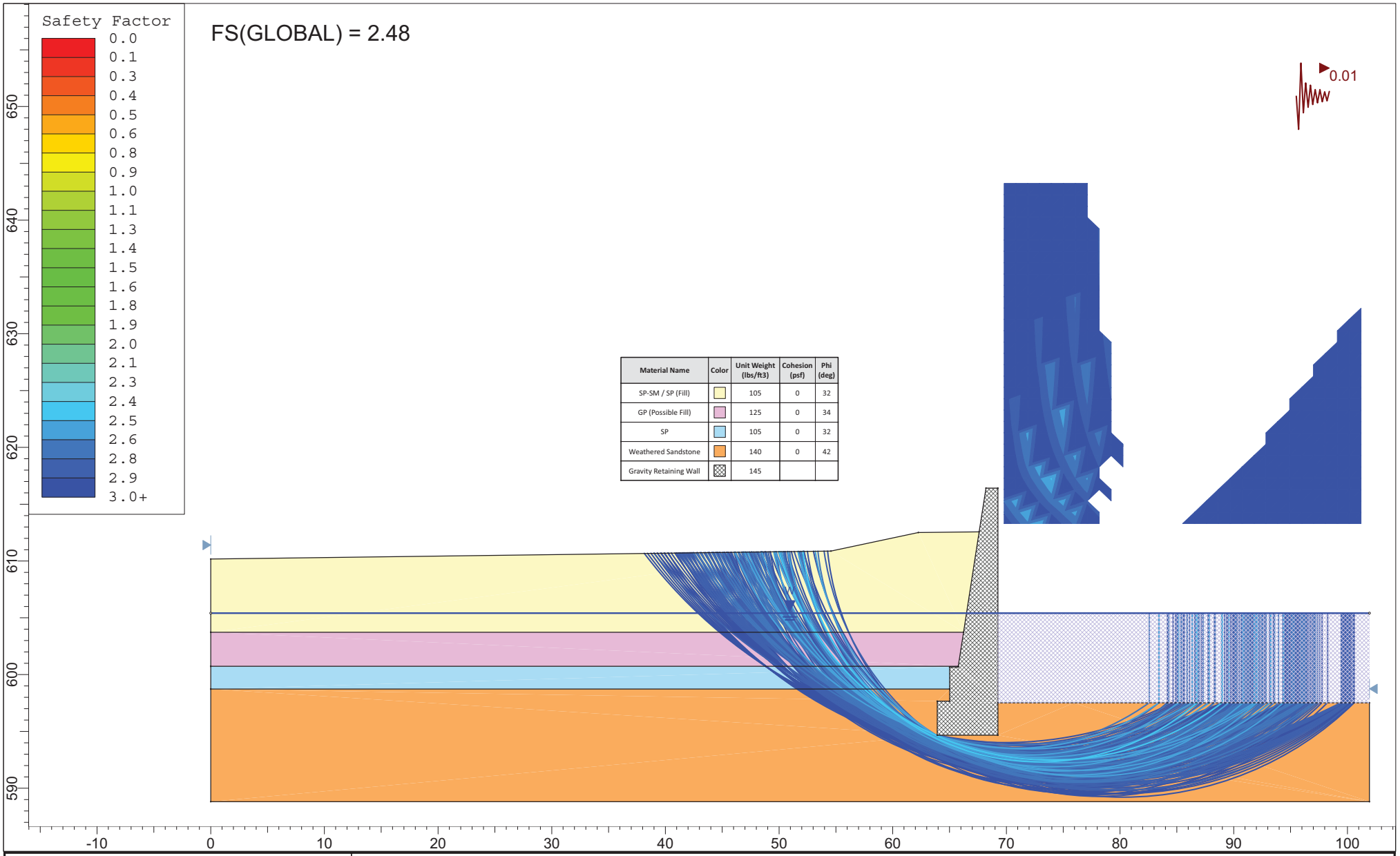
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2C - Steady State (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012
File NameB	Case 3, Section W Base Flood (Waterside).slim



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W2C - Earthquake (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012
File NameB	Section W2C - Earthquake (Waterside).slim

REACH W2, SECTION W2C FLOODWALL STABILITY SUMMARY.

Existing Condition

GW El = 605.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**5.3.**
Summation M (ft-lbs)	**14,398.**
Summation P (lbs)	**9,204.**
Eccentricity, e (ft)	**1.09.**
q(max) (psf)	**3,923.**
Base Area in Compression (%)	**89%.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.57.**
FS (Sliding)	**2.06.**

Foundation bears upon weathered sandstone bedrockh

All loads and moments estimated are per foot of wallh

REACH W2, SECTION W2C FLOODWALL STABILITY SUMMARY.

Sudden Drawdown

GW El = 605.0

Grand River El = 608.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*
		9319.		

Stability Summary

Footing Width, B (ft)	**5.3.**
Summation M (ft-lbs)	**156.**
Summation P (lbs)	**8,339.**
Eccentricity, e (ft)	**2.63.**
q(max) (psf)	**56,139.**
Base Area in Compression (%)	**NA.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.00.**
FS (Sliding)	**1.56.**

Resultant within base area of footingh

Foundation bears upon weathered sandstone bedrockh

All loads and moments estimated are per foot of wallh

REACH W2, SECTION W2C - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-2 (111266)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_s}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*
BOF El =		*Bottom of floodwall elevationh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP, SP-SM			
	Gravel, Fill	GP			
	Sand, Fill				
	Sandstone	Bedrock			

Soil Properties

Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		NAVFAC 7.1-237 C_s
			50+										

Settlement Analysis

Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	ΔH (in) Immediate	Primary	Secondary
				TOTAL (in).	**0.00.**		

Freeboard Summar

Existing Flood Protection El = .	**616.4.**
uture Flood Protection El = .	**616.4.**
BFE = .	**614.2.**

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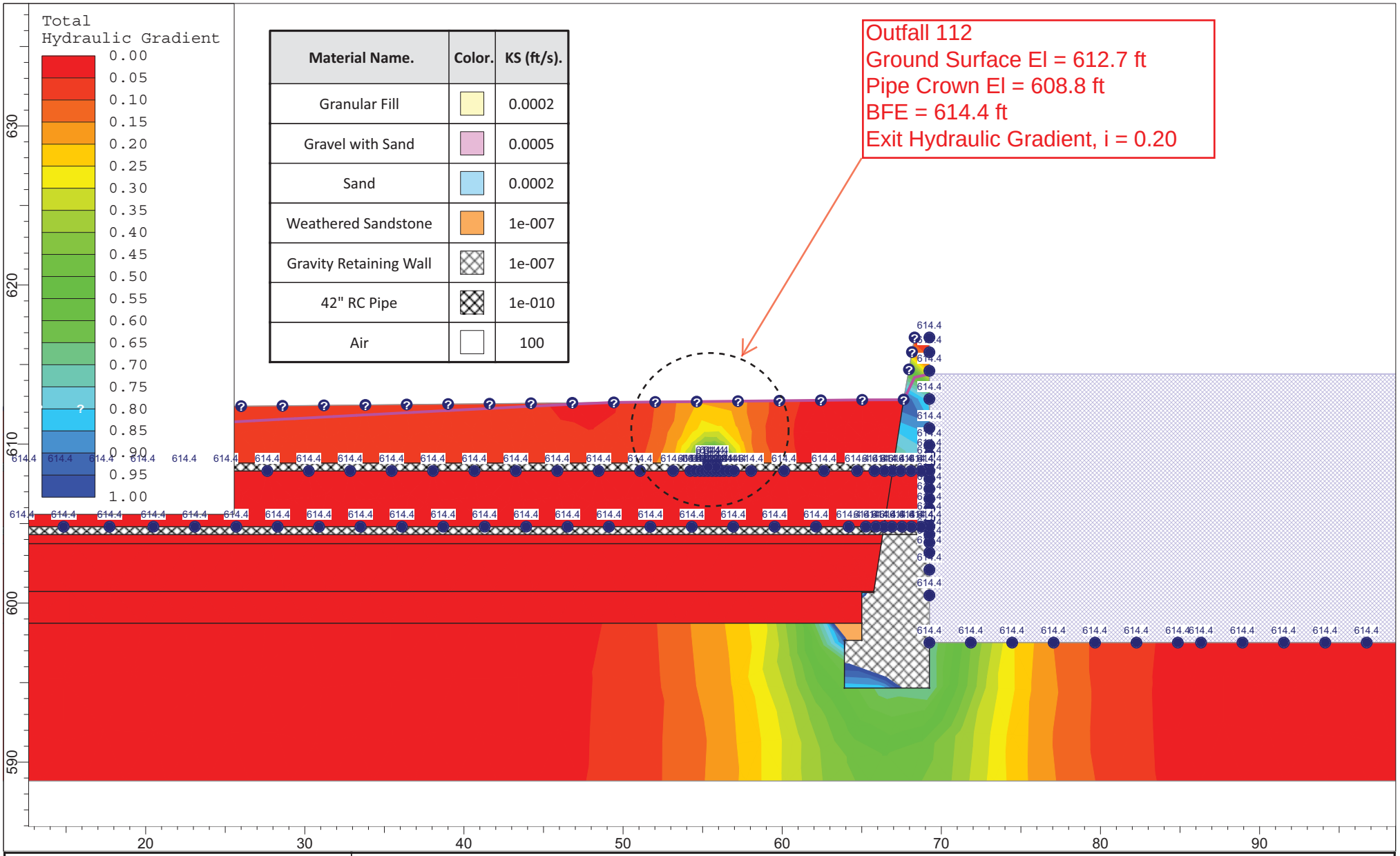
OUTFALL 112 PHOTOGRAPH





ProjectB	Grand Rapids Floodwalls and Embankments Study		
Analysis Description	Reach W2 - 42-inch RCP Outfall		
Drawn By	TM	Scale 1:100	Company MTC
Date	2-9-18B		File Name Reach W2 - 42-inch RCP Outfall.slimB

SLIDEINTERPRET 7.024B

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REACH W3

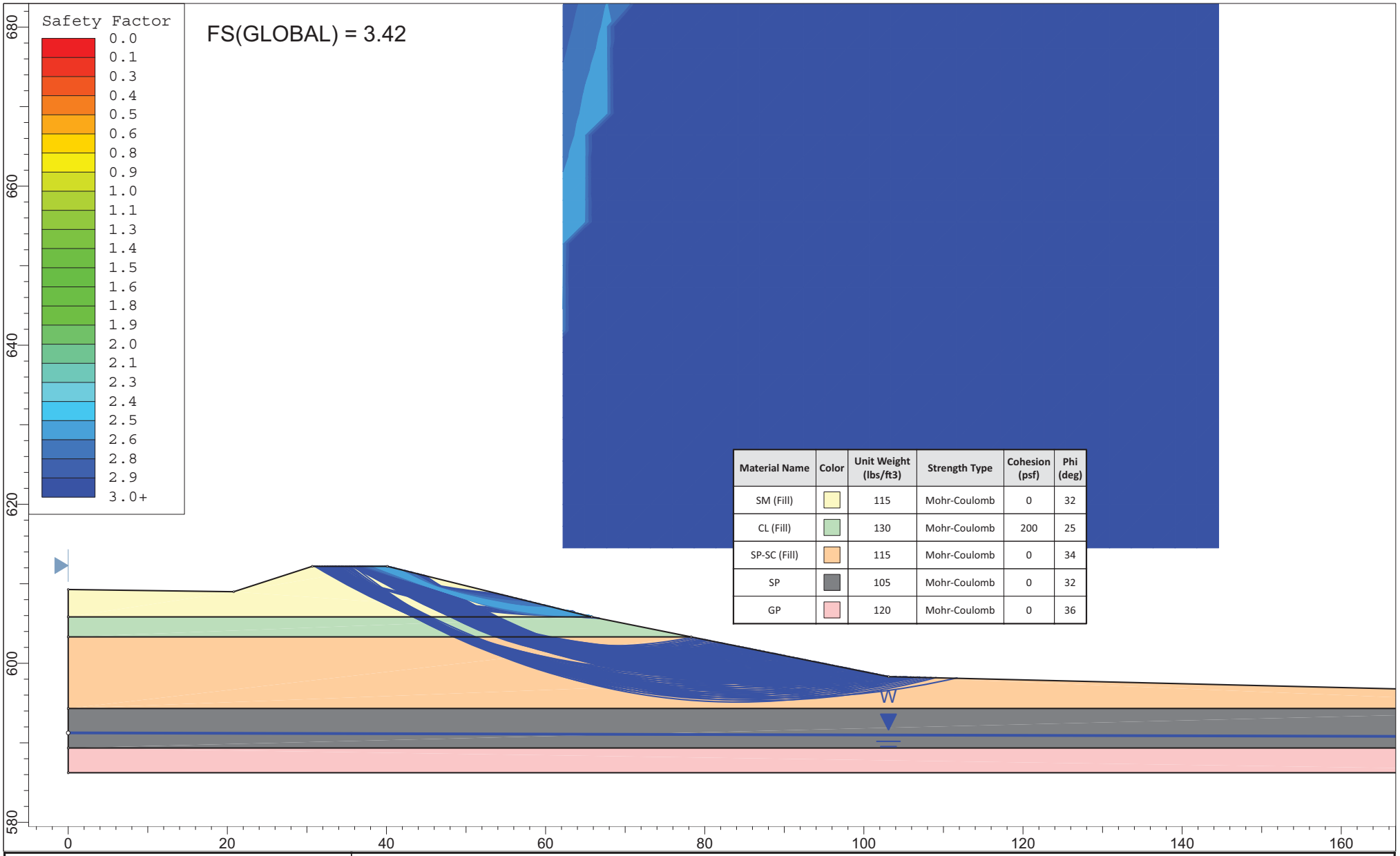
SECTION W3 PHOTOGRAPHS



Looking North



Looking Northeast



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	200	25
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

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SLIDEINTERPRET 6.016B

ProjectB: Grand Rapids Floodwalls and Embankments StudyB

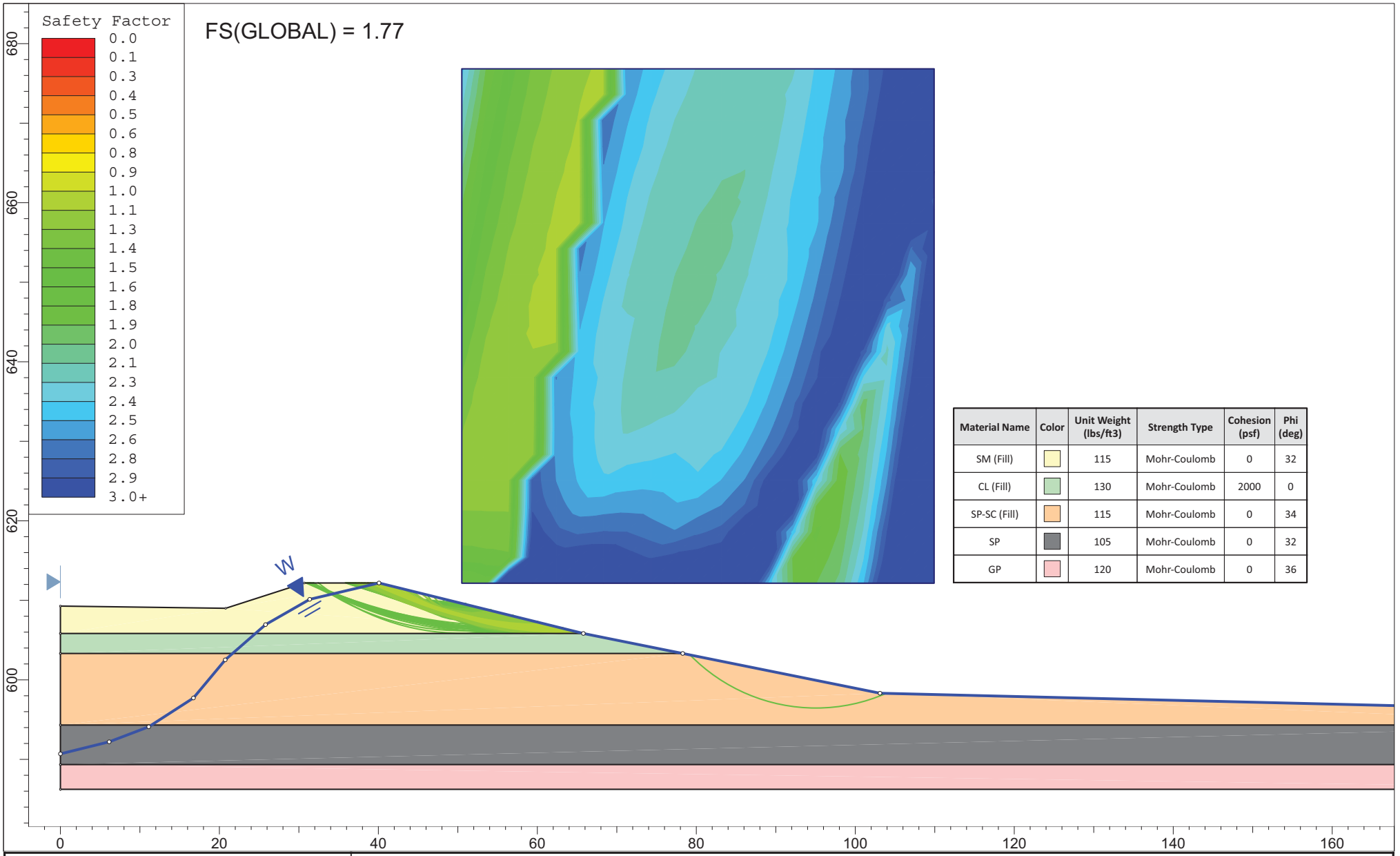
Analysis DescriptionB: Section SW - Existing Conditions (Waterside)

Drawn ByB: TMB

ClientB: Fishbeck, Thompson, Carr & Huber, Inc.B

DateB: 8-16-2012

File NameB: Case 1, Section SW Existing Conditions (Waterside).slimB



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

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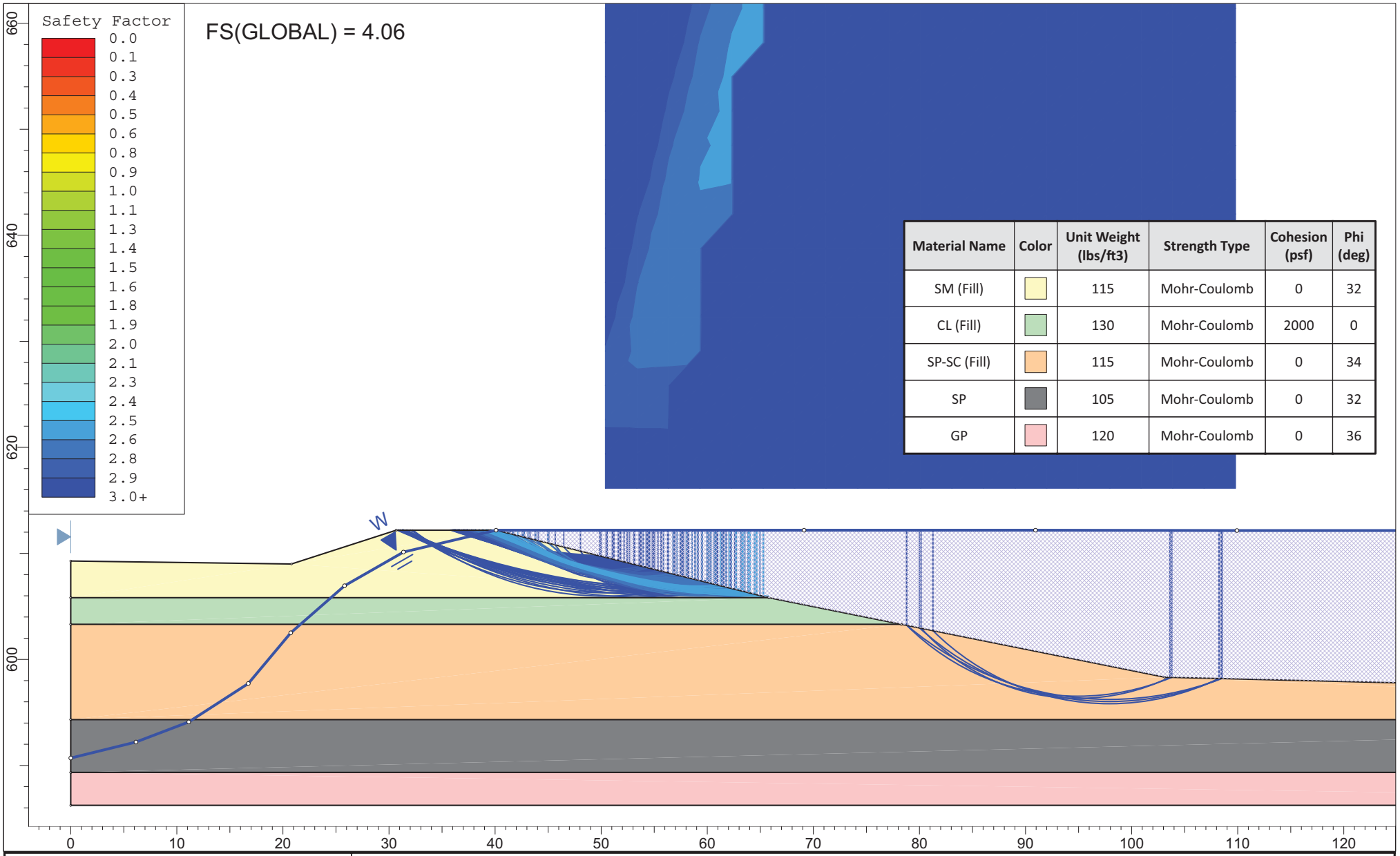
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section W3 - Drawdown (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012	File NameB	Case 2, Section 3W Drawdown (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

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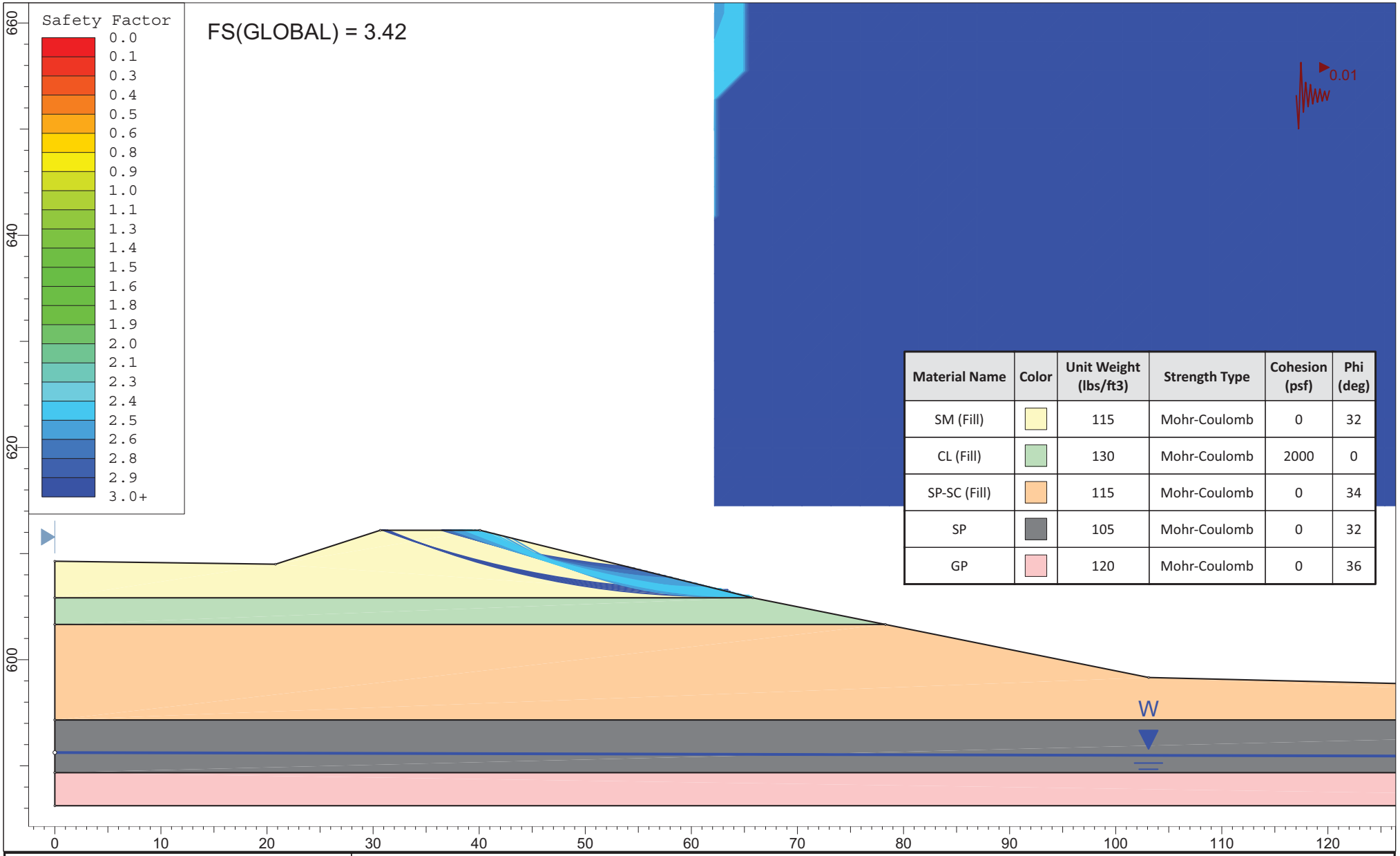
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 3W--Steady State (Waterside) Section 3W - Base Flood (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8-16-2012
File NameB	Section 3W - Steady State (Waterside).slim Case 3, Section 3W Base Flood (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SM (Fill)		115	Mohr-Coulomb	0	32
CL (Fill)		130	Mohr-Coulomb	2000	0
SP-SC (Fill)		115	Mohr-Coulomb	0	34
SP		105	Mohr-Coulomb	0	32
GP		120	Mohr-Coulomb	0	36

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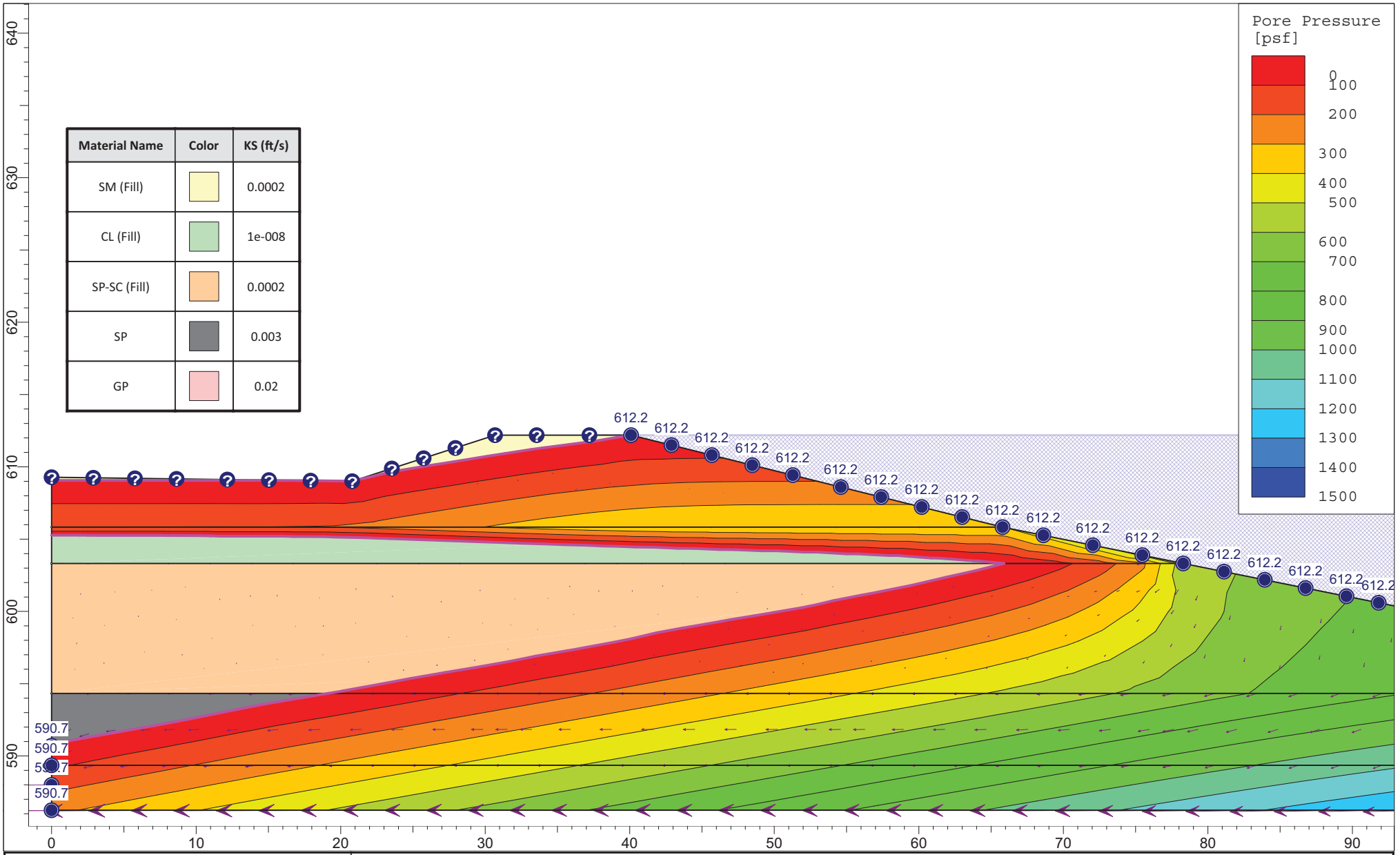
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W3 - Earthquake (Waterside)
Drawn ByB	TMB
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8-16-2012
File NameB	Case 4, Section W3 - Earthquake (Waterside).slim



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 3W Steady State Seepage
Drawn ByB	TMB
DateB	8/16/2017
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
File Name	Section 3W Steady State Seepage.slim

REACH W3, SECTION W3 - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-1 (111266)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log \frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increase, berm height increased to el 612.5, 1.5 ft of new fill placedh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill				
	Clay, Fill	CL			
	Sand, Fill	SP-SC			
	Sand				
	Gravel	GP			

Soil Properties

Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		NAVFAC 7.1-237 C_s

Settlement Analysis

					ΔH (in)		
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary
				TOTAL (in).	**0.57.**		

Freeboard Summar

Proposed Flood Protection El = .	**612.5.**
uture Flood Protection El = .	**612.5.**
BFE = .	**611.9.**

REACH W4

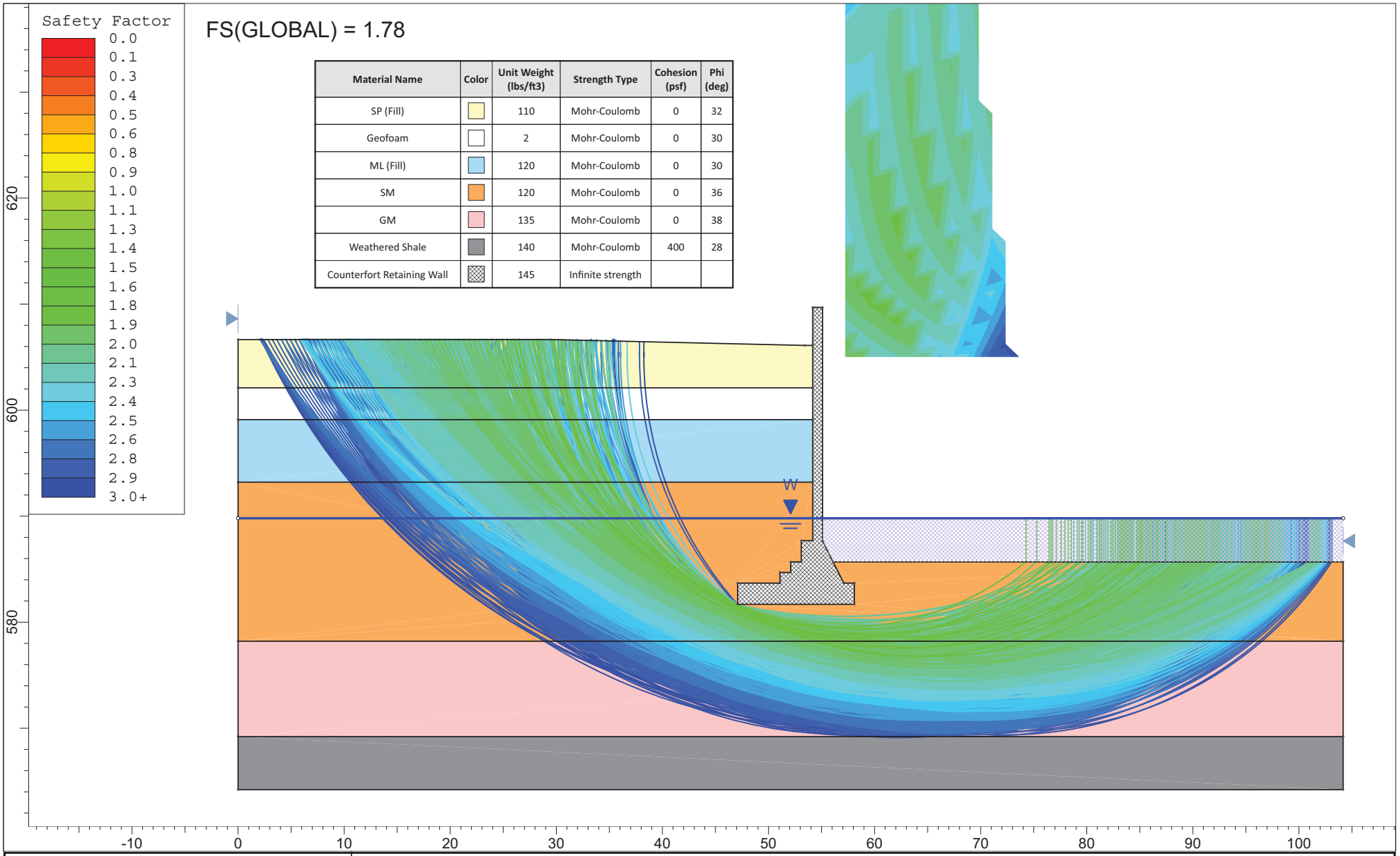
SECTION W4A PHOTOGRAPHS



Looking Southwest



Looking Northeast



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP (Fill)		110	Mohr-Coulomb	0	32
Geofoam		2	Mohr-Coulomb	0	30
ML (Fill)		120	Mohr-Coulomb	0	30
SM		120	Mohr-Coulomb	0	36
GM		135	Mohr-Coulomb	0	38
Weathered Shale		140	Mohr-Coulomb	400	28
Counterfort Retaining Wall		145	Infinite strength		

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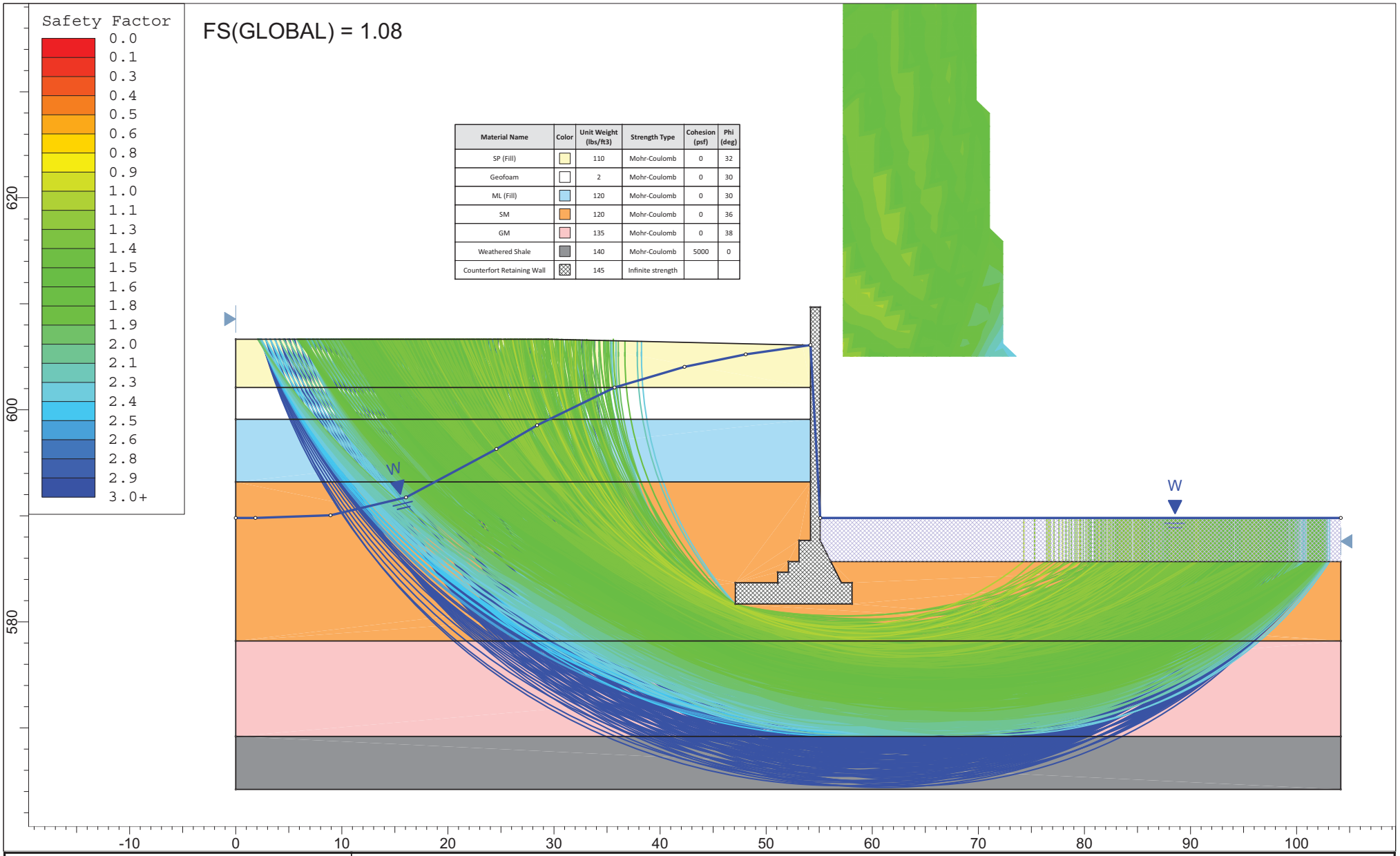
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W4A - Existing Conditions (Waterside)
Drawn ByB	TMB
DateB	11/14/2012
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Case 1, Section W4A, Existing Conditions (Waterside).slimB



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP (Fill)		110	Mohr-Coulomb	0	32
Geofoam		2	Mohr-Coulomb	0	30
ML (Fill)		120	Mohr-Coulomb	0	30
SM		120	Mohr-Coulomb	0	36
GM		135	Mohr-Coulomb	0	38
Weathered Shale		140	Mohr-Coulomb	5000	0
Counterfort Retaining Wall		145	Infinite strength		

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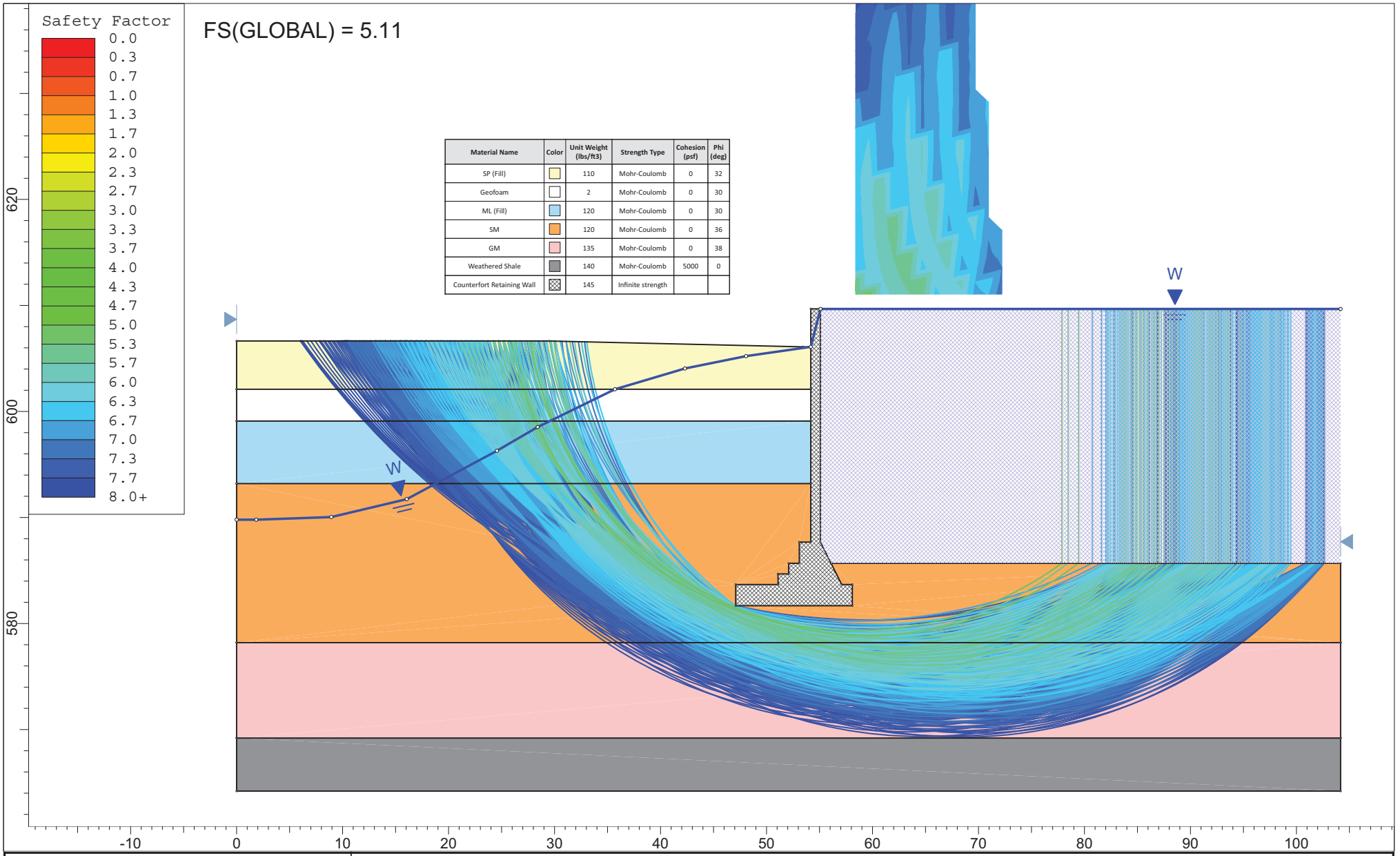
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section W4A - Sudden Drawdown Section 2W - Drawdown (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8/16/2007 8/14/2012	File NameB	Section W4A - Sudden Drawdown Case 2, Section 2W Drawdown (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP (Fill)		110	Mohr-Coulomb	0	32
Geofoam		2	Mohr-Coulomb	0	30
ML (Fill)		120	Mohr-Coulomb	0	30
SM		120	Mohr-Coulomb	0	36
GM		135	Mohr-Coulomb	0	38
Weathered Shale		140	Mohr-Coulomb	5000	0
Counterfort Retaining Wall		145	Infinite strength		

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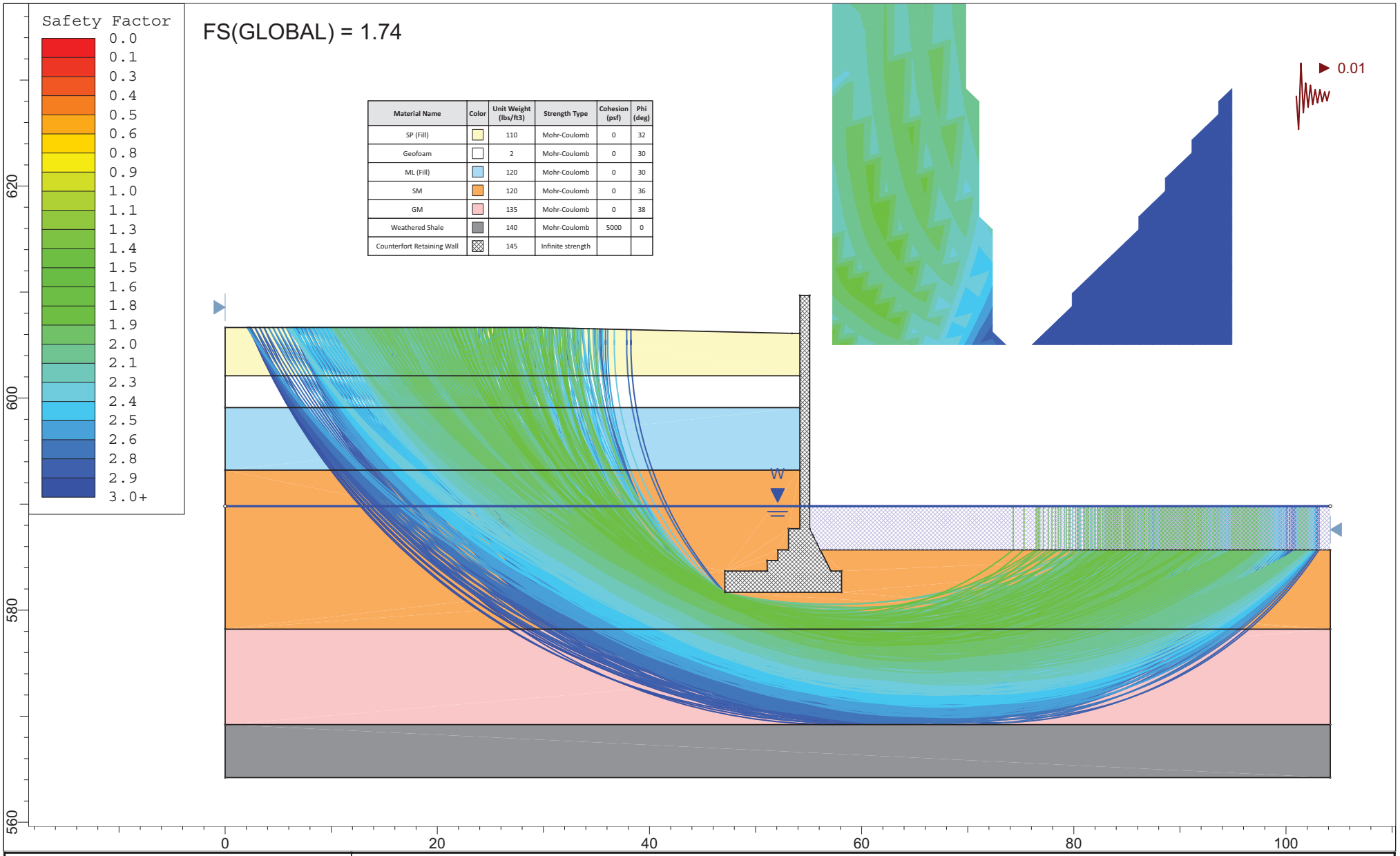
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section 2W Base Flood (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/6/2012	File NameB	Case 5, Section 2W Base Flood (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP (Fill)		110	Mohr-Coulomb	0	32
Geofoam		2	Mohr-Coulomb	0	30
ML (Fill)		120	Mohr-Coulomb	0	30
SM		120	Mohr-Coulomb	0	36
GM		135	Mohr-Coulomb	0	38
Weathered Shale		140	Mohr-Coulomb	5000	0
Counterfort Retaining Wall		145	Infinite strength		

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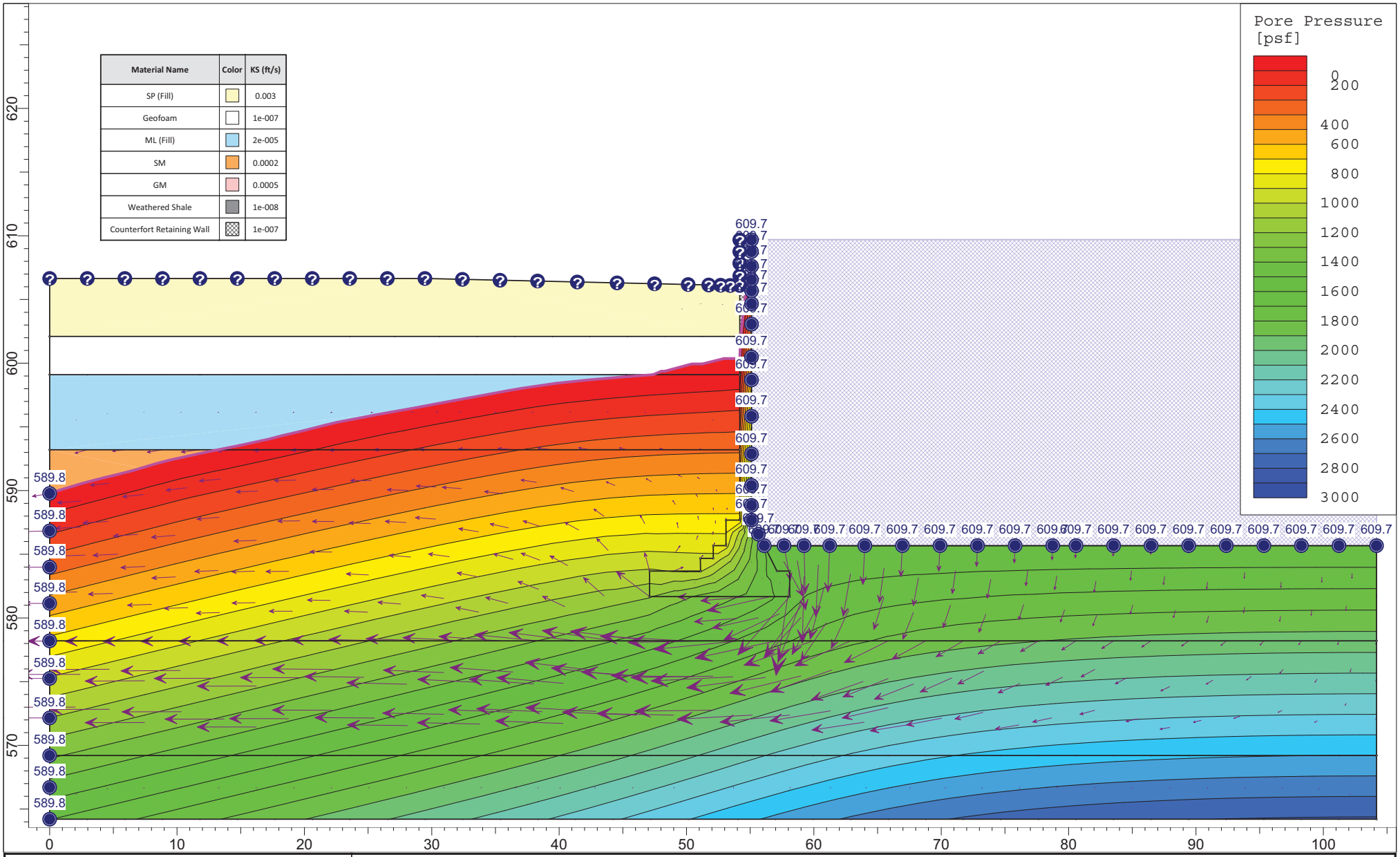
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section 2W - Earthquake (Waterside)		
Drawn ByB	TMB	Client	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/14/2012B	File Name	Case 4, Section 2W Earthquake (Waterside).slim



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section W4W--Steady State Seepage
Drawn ByB	TMB
Client	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	12/18/2012B
File Name	Section W4W--Steady State Seepage.slim

REACH W4, SECTION W4A FLOODWALL STABILITY SUMMARY

Existing Condition

GW El = 590.0

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**11.0.**
Summation M (ft-lbs)	**104,907.**
Summation P (lbs)	**19,914.**
Eccentricity, e (ft)	**0.23.**
q(max) (psf)	**2,039.**
Base Area in Compression (%)	**100%.**
FS (Bearing)	**>3.**
FS (Overturning)	**4.55.**
FS (Sliding)	**1.86.**

Foundation bears upon medium dense to dense granular soil overlying weathered shale bedrockh

Ah loads and moments estimated are per foot of walh

REACH W4, SECTION W4A FLOODWALL STABILITY SUMMARY

Sudden Drawdown

GW El = 590.0

Grand River El = 598.3

Loads, Moment Arms and Moments

Driving Loads (Active)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Passive)	*Wall Frictionh δ (deg)h*	*Wall Slopeh α (deg)h*	*Pult (lbs)h*	*Px (lbs)h*	*Py (lbs)h*	*MAx (ft)h*	*MAy (ft)h*	*Mx (ft-lbs)h*	*My (ft-lbs)h*

Resisting Loads (Weight)	*A (ft^2)h*	*γ' (pcf)h*	*Wult (lbs)h*	*MAy (ft)h*	*My (ft-lbs)h*

Stability Summary

Footing Width, B (ft)	**11.0.**
Summation M (ft-lbs)	**40,736.**
Summation P (lbs)	**15,675.**
Eccentricity, e (ft)	**2.90.**
q(max) (psf)	**4021.**
Base Area in Compression (%)	**71%.**
FS (Bearing)	**>3.**
FS (Overturning)	**1.61.**
FS (Sliding)	**1.00.**

Foundation bears upon medium dense to dense granular soil overlying weathered shale bedrockh

Ah loads and moments estimated are per foot of walh

REACH W4, SECTION W4A - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-1 (091437)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log\frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increase, floodwall cap raised by approximately 12 inches to increase freeboardh*
BOF El =		*Bottom of floodwall elevationh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill	SP, SC, SM			
	Silt, Fill	ML			
	Sand and Gravel	SP, GM			
	Shale	Bedrock			

Soil Properties

Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		NAVFAC 7.1-237 C_s
		-60.4											
			50+										

Settlement Analysis

Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	ΔH (in) Immediate	Primary	Secondary
				TOTAL (in).	**0.04.**		

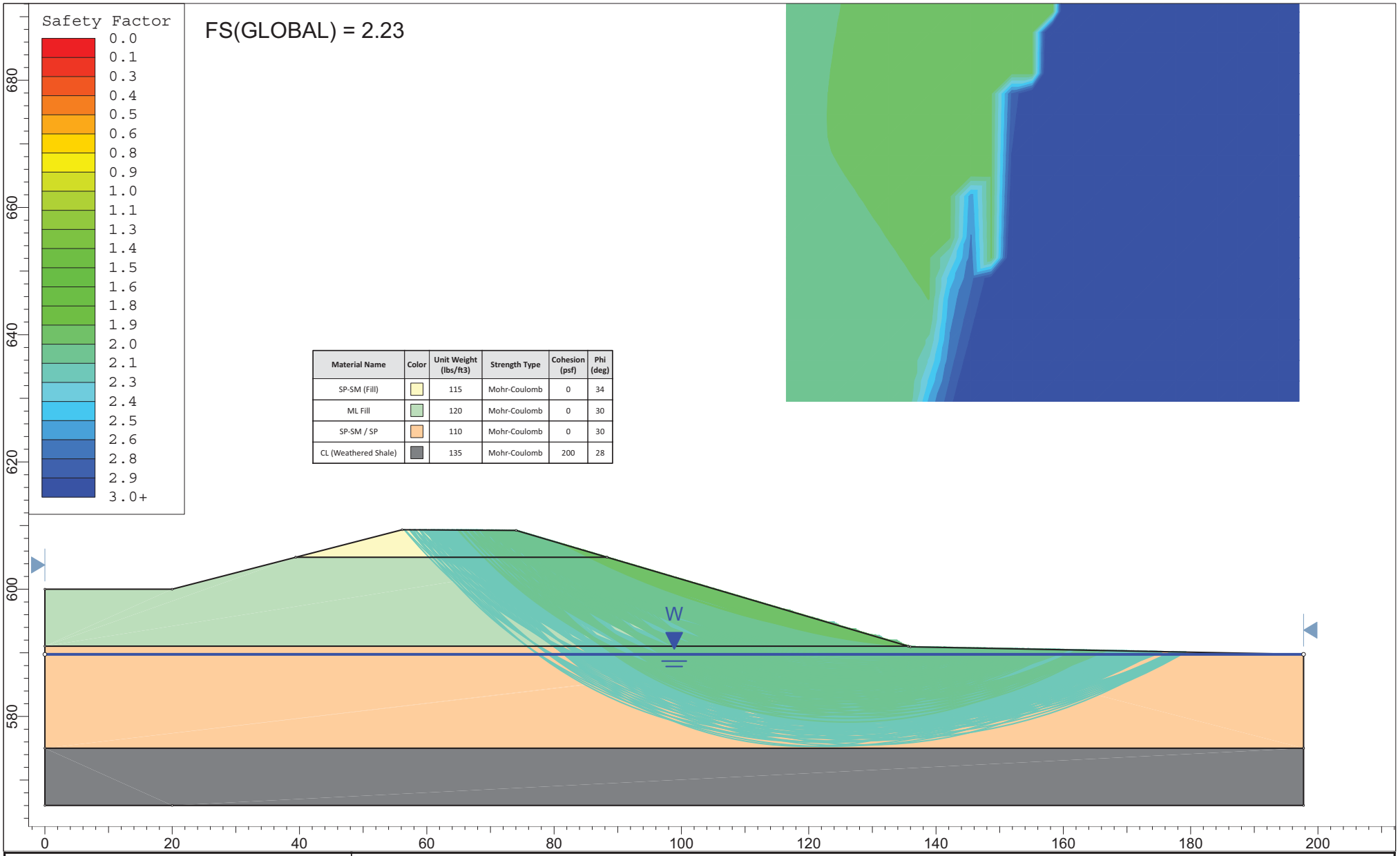
Freeboard Summar

Proposed Flood Protection El = .	**610.5.**
uture Flood Protection El = .	**610.5.**
BFE = .	**609.7.**

SECTION W4B PHOTOGRAPHS



Looking Northwest



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		115	Mohr-Coulomb	0	34
ML Fill		120	Mohr-Coulomb	0	30
SP-SM / SP		110	Mohr-Coulomb	0	30
CL (Weathered Shale)		135	Mohr-Coulomb	200	28

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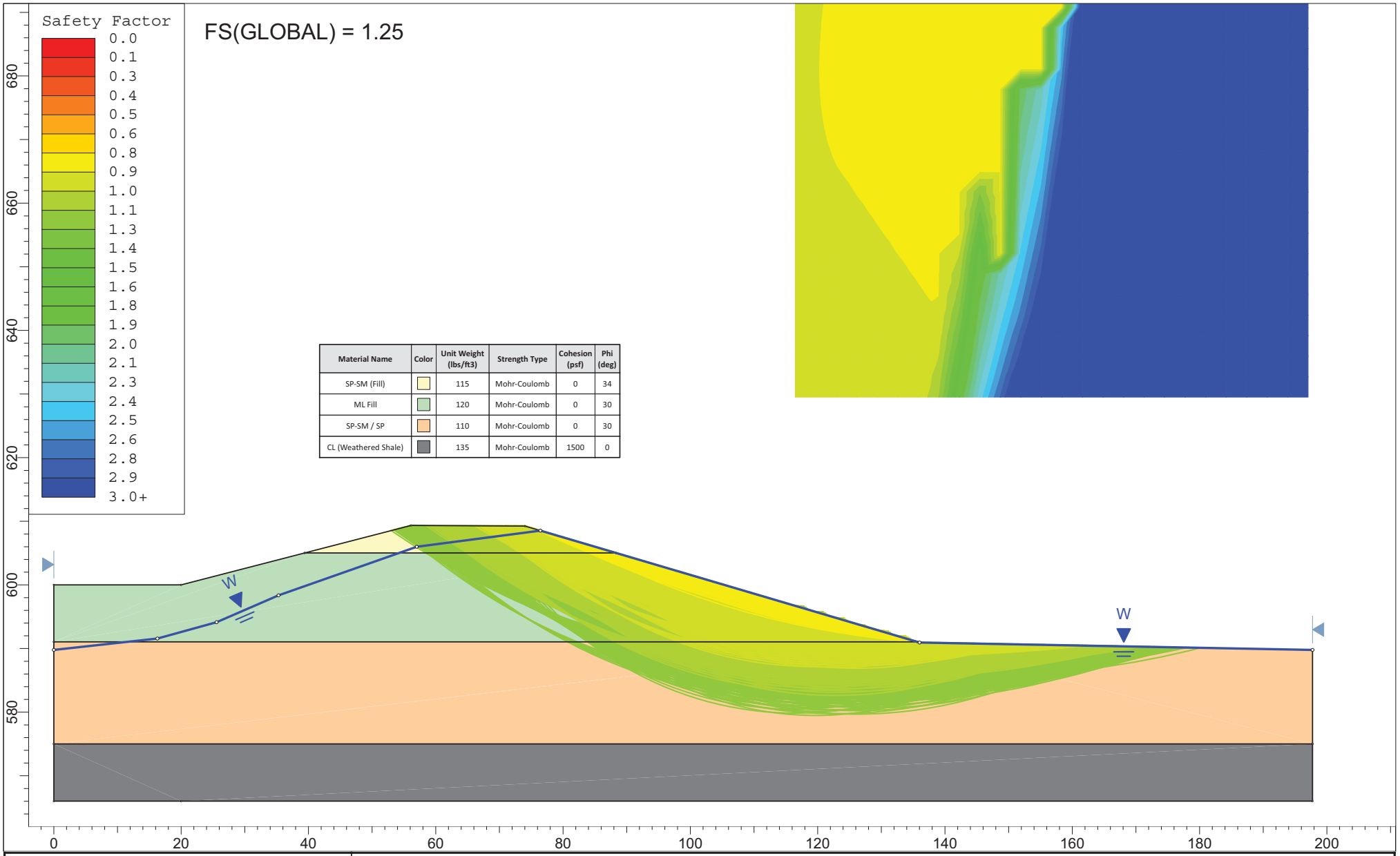
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 1WB - Existing Conditions (Waterside)
Drawn ByB	TMB
DateB	8/10/2017
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Case 1, Section 1WB - Existing Conditions (Waterside).slimB



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		115	Mohr-Coulomb	0	34
ML Fill		120	Mohr-Coulomb	0	30
SP-SM / SP		110	Mohr-Coulomb	0	30
CL (Weathered Shale)		135	Mohr-Coulomb	1500	0

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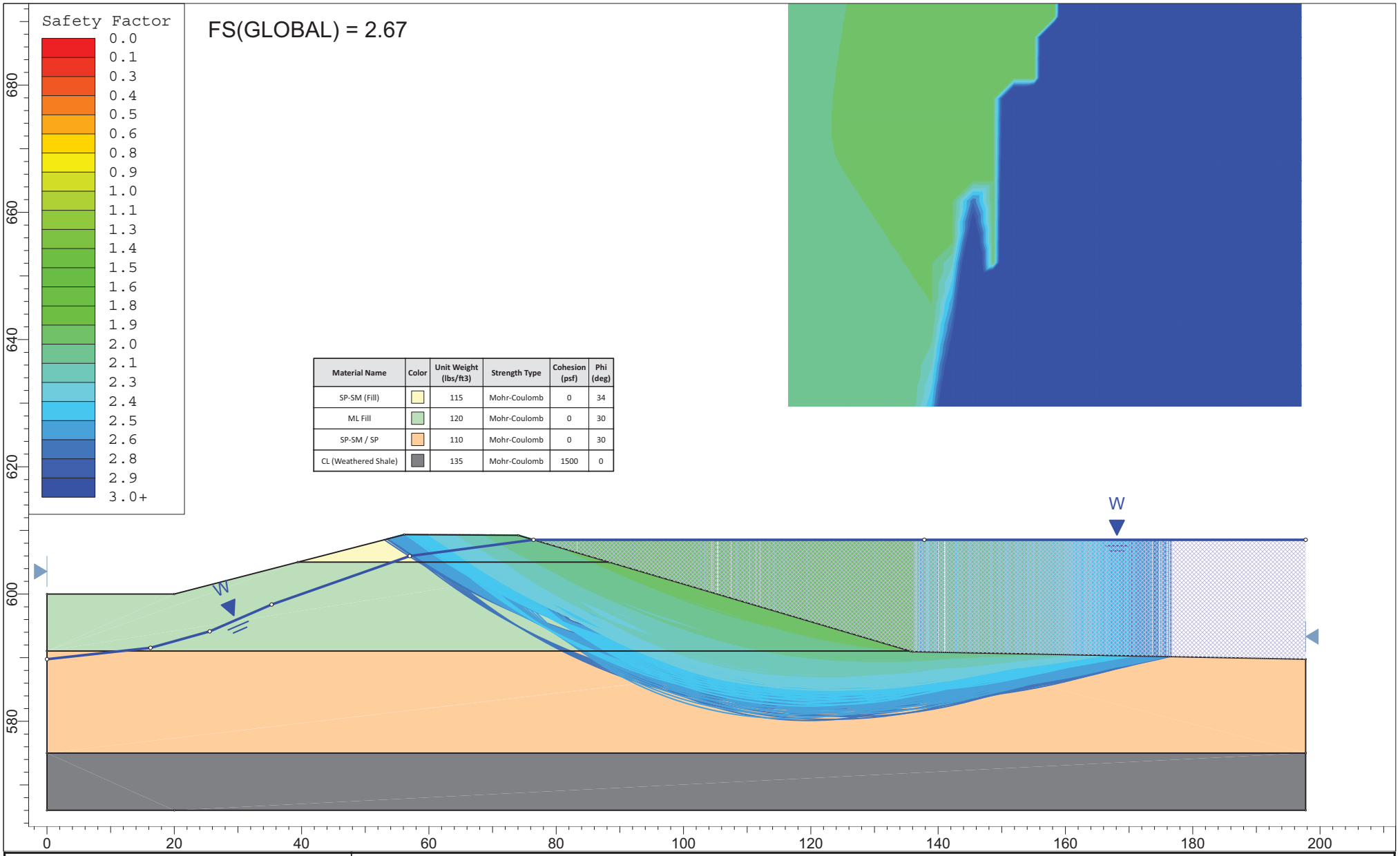
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB
Analysis DescriptionB	Section 1W - Drawdown (Waterside)
Drawn ByB	TMB
DateB	11/12/2012
ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
File NameB	Case 2, Section 1W Drawdown (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		115	Mohr-Coulomb	0	34
ML Fill		120	Mohr-Coulomb	0	30
SP-SM / SP		110	Mohr-Coulomb	0	30
CL (Weathered Shale)		135	Mohr-Coulomb	1500	0

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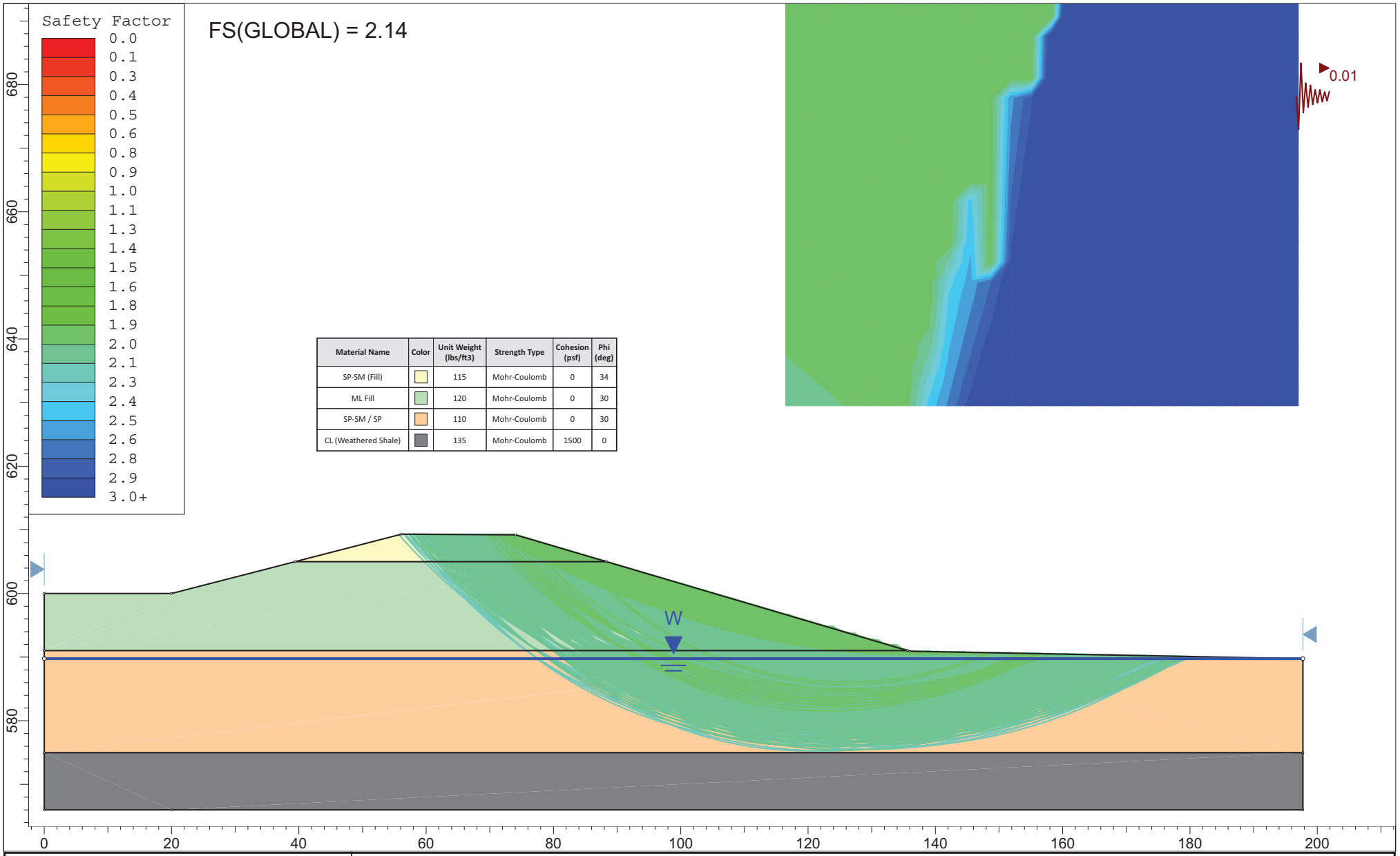
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section 1W - Steady State Seepage Section 1W - Base Flood (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8-1/6-2/2012	File NameB	Case 3, Section 1W, Base Flood (Waterside).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
SP-SM (Fill)		115	Mohr-Coulomb	0	34
ML Fill		120	Mohr-Coulomb	0	30
SP-SM / SP		110	Mohr-Coulomb	0	30
CL (Weathered Shale)		135	Mohr-Coulomb	1500	0

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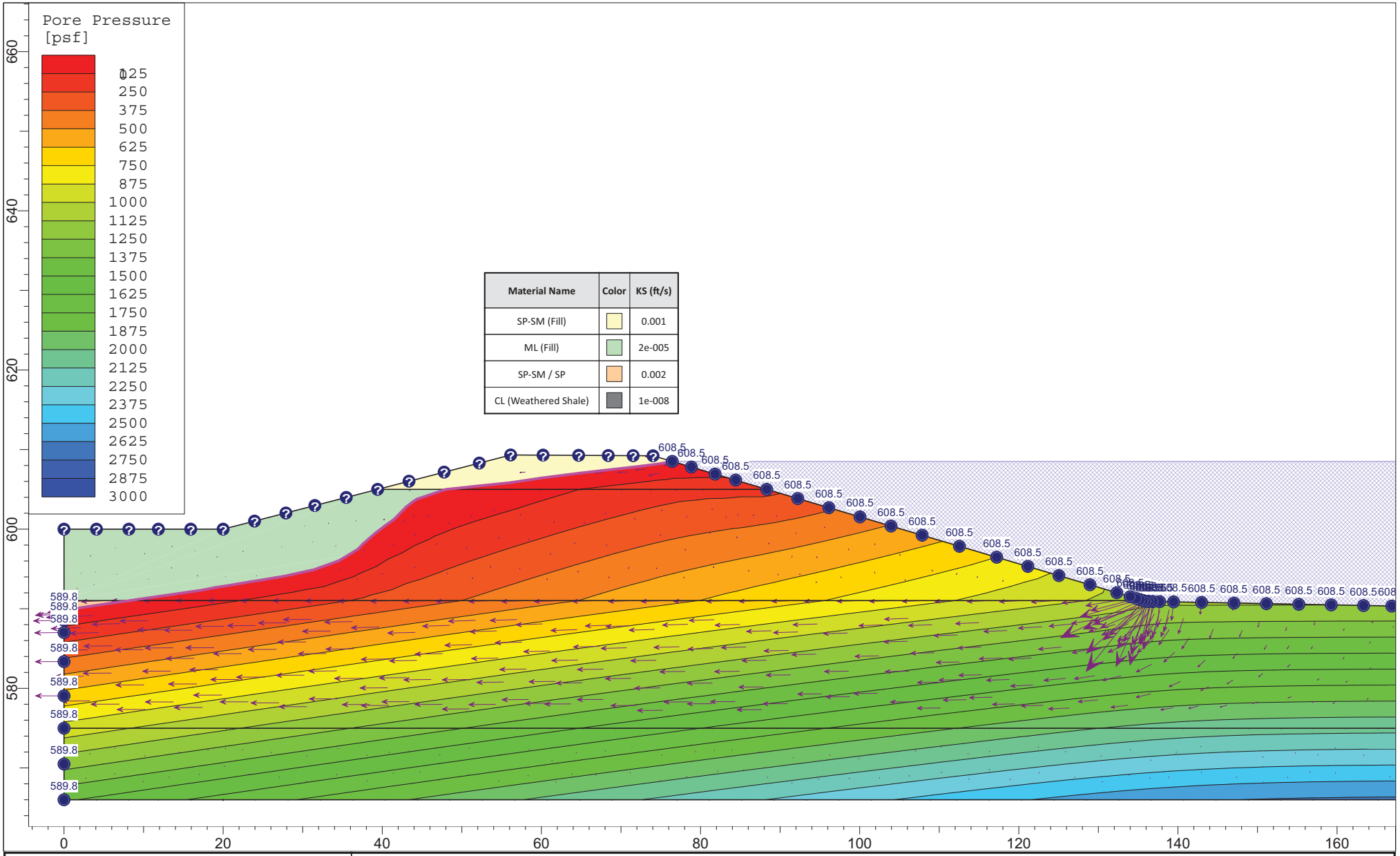
SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section 1W - Earthquake (Waterside)		
Drawn ByB	TMB	ClientB	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	11/4/2012	File NameB	Case 4, Section 1W, Earthquake (Waterside).slim



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SLIDEINTERPRET 6.016B

ProjectB	Grand Rapids Floodwalls and Embankments StudyB		
Analysis DescriptionB	Section 1W Steady State Seepage		
Drawn ByB	TMB	Client	Fishbeck, Thompson, Carr & Huber, Inc.B
DateB	8-10-2017	File Name	Section 1W Steady State Seepage.slim

REACH W4, SECTION W4B - SETTLEMENT ANALYSIS.
Proposed Condition
Boring B-900 (583P)

Immediate Settlement - Granular Soil (Hough Method)h

$$\Delta H_i = H_c \frac{1}{C'} \log\left(\frac{\sigma'_o + \Delta\sigma_v}{\sigma'_o}\right)$$

Primary Consolidation - Cohesive Soil (One-dimensional consolidation theory)h

$$S_c = \left[\frac{H_c}{1+e_o}\right]\left[C_c \log \frac{\sigma'_f}{\sigma'_p}\right]$$

Secondary Consolidation - Organic Soilh

$$S_s = \frac{C_\alpha}{1+e_p} H_s \log\left(\frac{t_2}{t_1}\right)$$

Organic Decompositionh
Consider settlement percentage due to decomposition of organic material equal to loss of 1/2 percent of organics by weigh

GW EL =		*Groundwater elevationh*
σ (psf) =		*Proposed load increaseh*

Soil Strata

Layer	Soil Type	Soil Classification	Top El (ft)	Bottom El (ft)	Thickness (ft)
	Sand, Fill				
	Silt	ML			
	Sand with Marl	SM, OH			
	Shale	Bedrock			

Soil Properties

													NAVFAC 7.1-237
Layer	γ (pcf) total	γ' (pcf) effective	field		C		C'	Su (avg), psf	m(%)	Organic (%)	Cc		C_s

Settlement Analysis

					ΔH (in)			
Layer	σ (psf)	u (psf)	σ' (psf)	Δσ' (psf)	Immediate	Primary	Secondary	Organics
				TOTAL (in).	**4.36.**			

Freeboard Summar

Existing Flood Protection El = .	**609.3.**
uture Flood Protection El = .	**608.9.**
BFE = .	**608.5.**

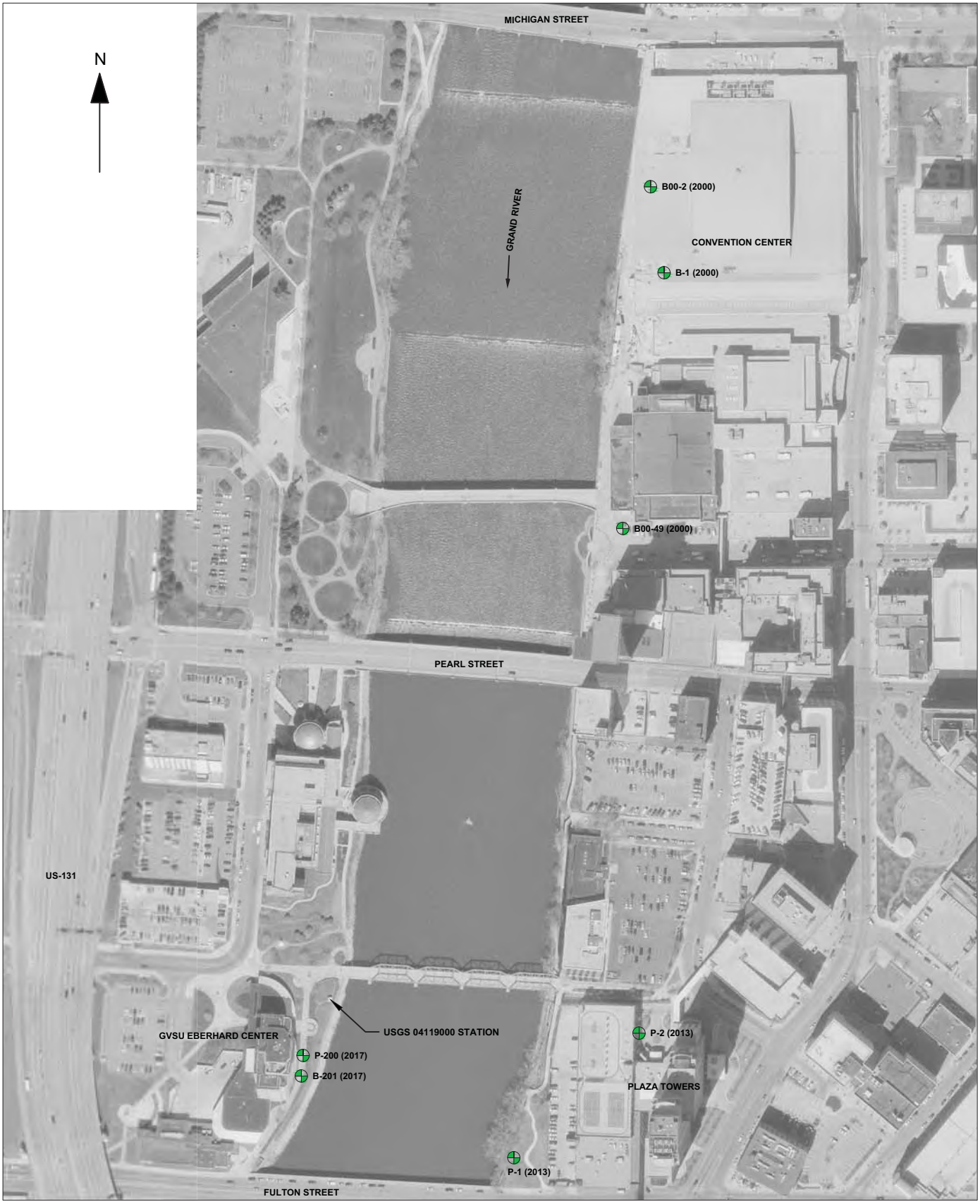
APPENDIX C – Historic Water Level Data

- **Piezometer Location Plan (Figure C-1) p**
- **onvention Center Water Level Readings (Figure C-2) p**
- **Plaza Towers Water Level Readings (Figure C-3) p**
- **GVSU Eberhard Water Level Readings (Figure C-4) p**

p

p

p



LEGEND

⊕ = PIEZOMETER LOCATION (TYP)

NOTE: AERIAL IMAGES PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.

TITLE: PIEZOMETER LOCATION PLAN			PROJECT: GR FLOODWALLS AND EMBANKMENTS STUDY
SCALE: 1" = 300'	DATE: 1-17-2018	PROJECT NO.: 111266	**Materials Testing Consultants, INC.**
FIG. NO.: C-1	DR. BY: TM	REV. BY: SE	

Figure C-2: Convention Center -.2000 Water Level Readings .

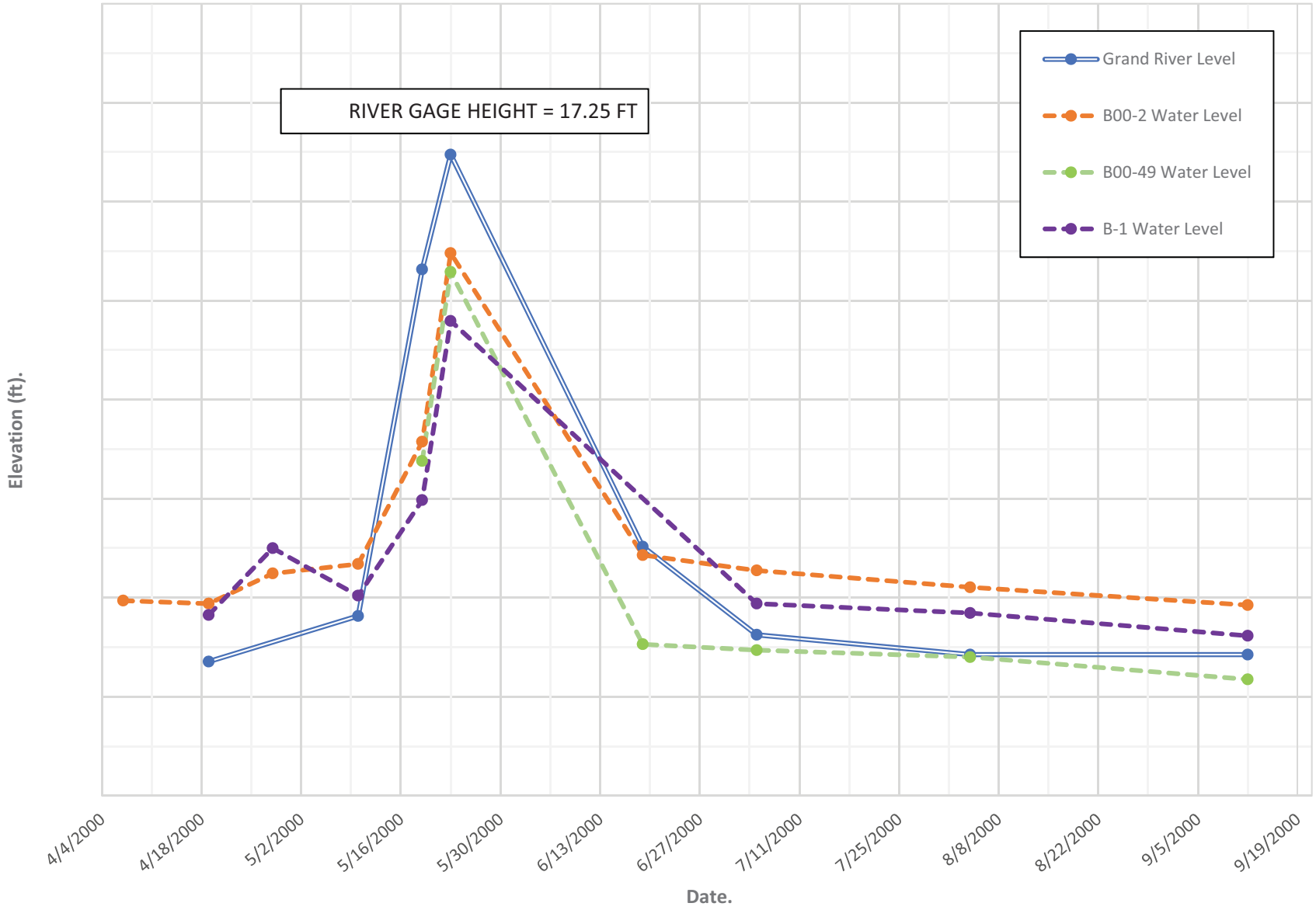


Figure C-3: Plaza Tower. -.2013 Water Level Readings .

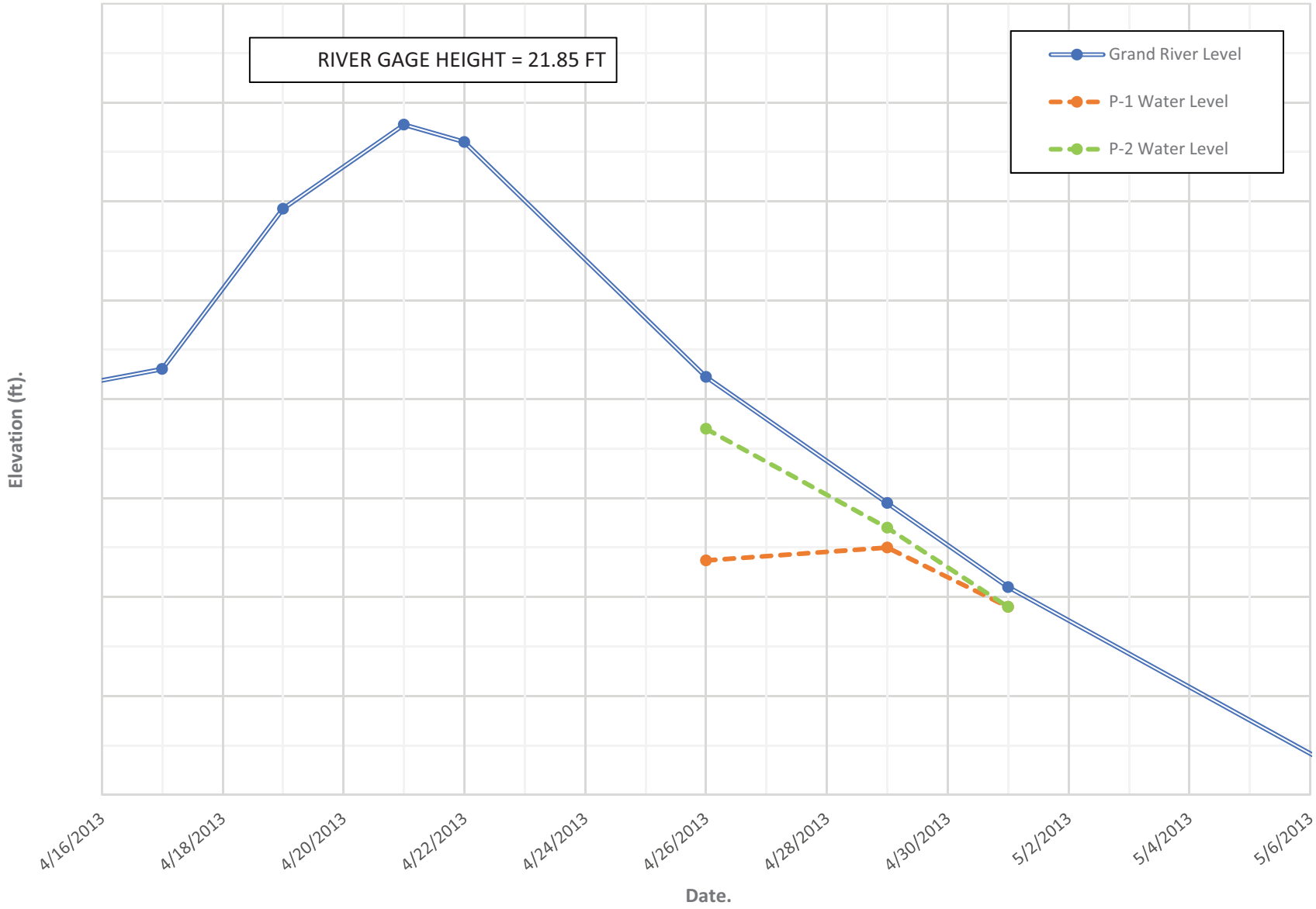
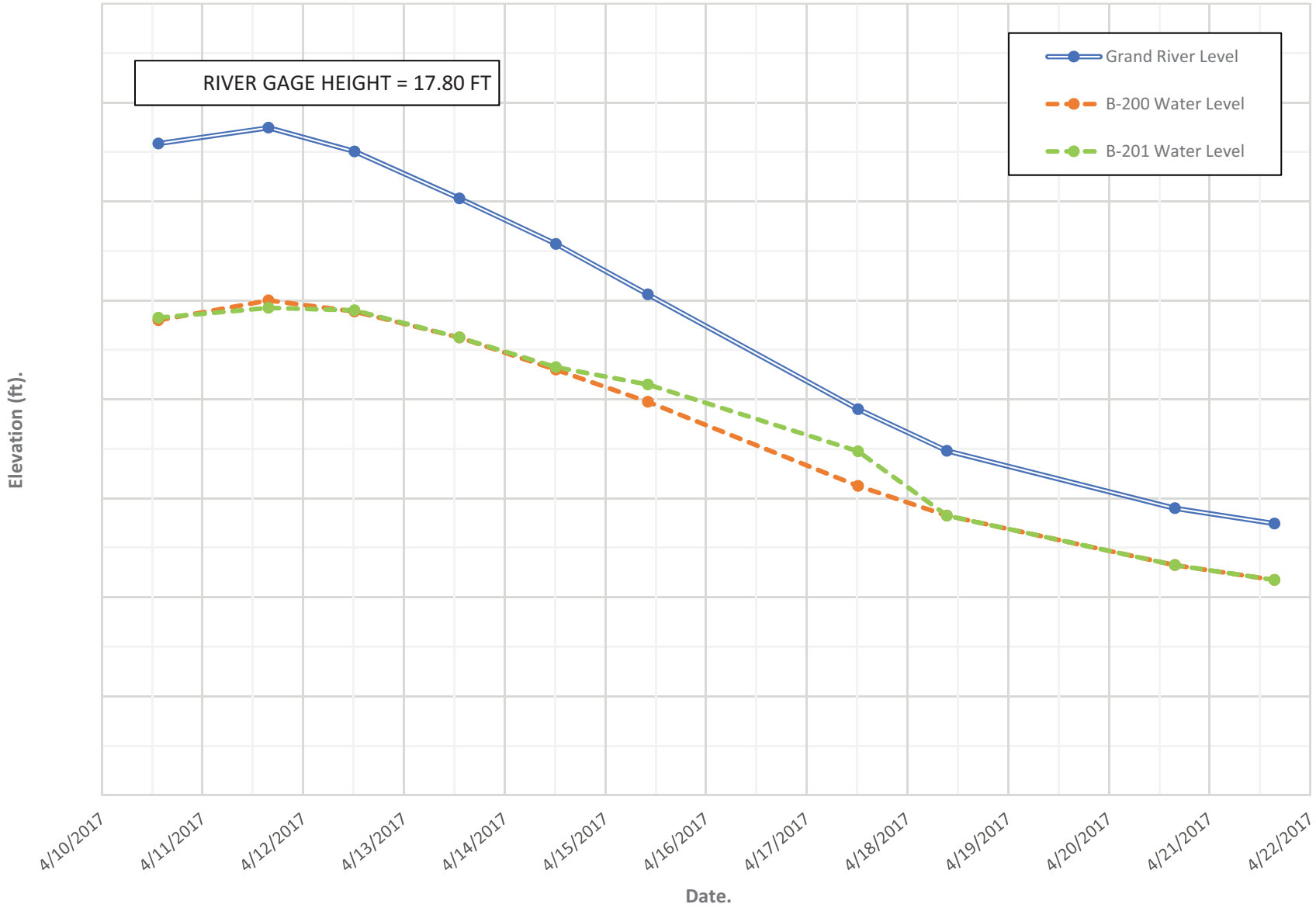


Figure C-4: GVSU Eberhard -.2017 Water Level Readings .



2020 FEMA Documents
File 2 of 2

Grand River Flood Protection System
44 CFR 65.10 (b)(6)
Interior Drainage Analysis

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

fishbeck
Engineers | Architects | Scientists | Constructors

44 CFR 65.10 (b) (6) Tab

(6) *Interior drainage.* An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.

P.E. Signature: Peter W. Soltys

Non Applicable: _____

P.E. Name: Peter W. Soltys

P.E. License Number and State: 037935 Michigan

44 CFR 65.10 (b) (7) Tab

(7) *Other design criteria.* In unique situations, such as those where the levee system has relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA will also provide the rationale for requiring this additional information.

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Grand River Flood Protection System
44 CFR 65.10 (b)(6)
Interior Drainage Analysis

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Appendix 1 Hydrologic Analysis WinTR-55

List of Abbreviations/Acronyms

City	City of Grand Rapids
BFE	base flood elevation
cfs	Cubic feet per second
GPS	gallons per minute
GRFPS	Grand Rapids Flood Protection System
NRCS	Natural Resources Conservation Service
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WRRF	Water Resources Recovery Facility
WSS	Web Soil Survey

Introduction

The construction of flood protection works along the Grand River in Grand Rapids, Michigan began as early as 1899 with a floodwall constructed to protect the City lighting plant and crematoria. Following the flood of record in March 1904 and another flood in June 1905, the City of Grand Rapids (City) funded construction of flood walls including a wall that extended from a point 3/4 mile north of Leonard Street to the south end of Market Avenue on the east side of the river and from north of Leonard Street to the Wealthy Street Bridge on the west side. This construction occurred in the period 1907 through 1910. Over the years since then, a variety of floodwalls, earth berms, storm water collection systems and pump stations, and backflow prevention measures have been constructed along both banks of the Grand River within the City limits. The most recent floodwall improvements were made in the period 1998 to 2008, and the most recent pump station improvements were made to the Market Avenue Pump Station in 2008. For levee/floodwall certification under the provisions of 44 CFR 65.10, the Grand Rapids Flood Protection System (GRFPS) was divided into a series of reaches as shown in Figure 1. Note that Reach W1 extends into the City of Walker that drains, in part, to the Indian Mill Creek Pump Station in Grand Rapids. Improvements to the Turner Avenue road grade, storm sewers, and backflow prevention devices on pipes that penetrate Turner Avenue were made in 2016 to provide flood protection to the interior areas of Walker.

The Grand Rapids storm water collection system consists of various drains and street inlets, storm sewers, and pipe penetrations through the earth levee and concrete floodwall portions of the project. Backflow through the majority of the active drain pipes is prevented by flap gates, duckbill valves, and sluice gates on the outlet ends of the pipes or in upstream manholes and in a few cases by manual closure methods that are incorporated into the GRFPS Emergency Action Plan. There are several outfall pipes without flap gates or other backflow prevention measures at the outfall locations because they serve only upland areas above the base flood elevation (BFE). In these cases, manholes located downstream of the upland areas have bolt-down manhole lids to prevent flood waters from lifting the covers causing street flooding. When storm water runoff cannot fully drain from the collection system due to flood levels on the Grand River it backs up into the wet wells of six storm water pump stations or is stored in the collection system until the river level has receded. Figures 11 through 19 show the collection system drainage area upstream of each of the 9 designated reaches along the east and west banks of the Grand River and the downstream portion of Indian Mill Creek.

Note that the City is currently seeking freeboard deficient reach status for all but Reach E5, as provided by the Federal Emergency Management Agency's (FEMA) Analysis and Mapping Procedures for Non-Accredited Levee Systems, dated July 2013. Therefore, all drainage pipes listed in the Closure Analysis Report as having "inlets above the BFE" have no inlets below base flood elevation, but the inlet elevations may not always meet the freeboard requirements of 44 CFR 65.10.

Fishbeck prepared this analysis of the interior drainage system for the GRFPS on behalf of the City. Because the topography of Grand Rapids and levels in the Grand River vary so much dependent upon location, each of the pump station service areas were analyzed as a separate drainage basin having its own unique flood frequency dependent on high water levels. The analysis was prepared in accordance with the methodology presented in the U.S. Army Corps of Engineers (USACE) Engineering and Design Manual EM 1110-2-1413 Hydrologic Analysis of Interior Areas dated January 15, 1987.

Flood Prone Areas

The GRFPS serves approximately 1,420 acres on the right (west) bank and 195 acres on the left (east) bank of residential, commercial, institutional, and industrial properties within the City boundaries from high water in the Grand River. The protection system also provides pumping capacities, storm water interceptors, and gravity outfalls to discharge interior runoff during a rainfall event. Except for small areas with shallow flooding less than 1 foot of depth, all flood prone areas are served by a storm water pump station. These are:

- Wealthy Street Pump Station – On the right (west) bank downstream of the Oxford Street Trail Bridge.
- Market Avenue Pump Station – On the left (east) bank immediately north of the Oxford Street Trail Bridge.
- Front-Scribner Pump Station – On the right (west) bank immediately upstream of the Interstate Route 196 (I-196) Bridge and just downstream of the 6th Street Dam and fish ladder.
- Caledonia Street Pump Station – On the left (east) bank between the Grand River and Monroe Avenue at Caledonia Street extended.
- Palmer Street Pump Station – On the left (east) bank between the Grand River and Monroe Avenue at Palmer Street extended.
- Indian Mill Creek Pump Station – On the left (north) bank of Indian Mill Creek on the south side of Ann Street and just east of the intersection of Will Avenue and Ann Street.

Table 1 shows the individual pump capacity for each of these pump stations.

Table 1
Grand Rapids Flood Protection System
Pump Characteristics

Pump Station	Number of Pumps	Single Pump Capacity (gpm)	Station Capacity (cfs)	Station Capacity Return Interval (years)*
Indian Mill Creek	3	4500	30	25
Palmer Street	3	4500	30	100
Caledonia Street	3	4500	30	10
Front & Scribner	6	53125	710	50
Wealthy Street	10	53125	1184	100
Market Avenue	4	10770	96	10
* Refer to Table 4 for peak storm water runoff estimates for each pump station drainage basin.				

Because the topography of Grand Rapids and levels in the Grand River vary dependent upon location, each of the pump station service areas were analyzed as a separate drainage basin. Each of the pump stations is automatically controlled and begins pumping when water in its respective wet well reaches a float activator at a pre-set level. Under normal (non-flood) conditions, storm water flows through each pump station without overflowing into the pump station wet wells. When water levels in the Grand River rise, flap gates on the various storm sewer outlets along the floodwalls and levees of the GRFPS as well as the flow through conduits in the pump stations close causing water to back up into the pump station wet wells. Each pump discharge line also has a check valve to prevent backflow through the pump. Figures 11 through 19 show the pump station service areas.

Storm water runoff in each drainage basin was assumed to flow through levees and floodwalls in the existing drainage pipes until the Grand River level reached top of pipe elevation at the outlet thereby shutting the flap gates. When the flow in the drainage pipes backed up due to flap gate closure, the pump station was assumed to run. The invert elevations for each of the storm water outfalls along the Grand River in each pump station watershed and the 1 percent annual chance flood elevation at the outfalls are shown in Table 2. The storm water outfall locations are shown on Figures 2 through 10.

A comparison of the invert elevations (plus the outfall/flap gate vertical dimension) to the 1 percent annual chance flood elevation (base flood elevation) for each outfall in Table 2 indicates that all the pump station bypass pipes and storm sewer outfalls along the Grand River will be closed for the base flood except for those outfalls serving only upland areas above the base flood elevation.

Table 2
Base Flood and Backflow Prevention Operations Elevations

Outfall Identification Number	Number of Flap Gates*	Outfall/Flap Gate Size	1 Percent Annual Chance Flood Elevation (feet, NAVD88)	Flood Gate Invert Elevation (feet, NAVD88)
Wealthy Street Pump Station Watershed – Reach W4				
72G Pump Station Bypass Conduits	3	8 feet x 8 feet	608.34	585.34
72G Pump Station Discharge Conduits	10	54-inch diameter	608.34	598.75
96	1	30-inch diameter	610.09	591.87
105A	1	24-inchdiameter	612.18	591.73
Market Avenue Pump Station Watershed – Reach E4				
---	0	**	608.54	595.87
** All storm water in the watershed is routed to an outflow chamber adjacent to the pump station. When the Grand River exceeds elevation 596.00 feet, storm water flowing into the siphon outlet for the outflow chamber exceeds the crest elevation of a weir wall that separates the storm water outflow chamber from the pump station wet well. At this point, a sluice gate in the outflow chamber closes preventing river water from entering the wet well. All of the storm water then flows into the pump station wet well to be pumped into the portion of the outflow chamber that discharges into the siphon outlet.				
Front/Scribner Pump Station Watershed – Reach W2				
107B Pump Station Bypass Conduits	3	6 feet x 6 feet	612.80	595.27
107B Pump Station Discharge Conduits	6	54-inch diameter	613.80	604.00
112	1	42-inch diameter	614.37	604.16
113	0	30” RCP	614.39	
117	1	36-inch diameter	614.90	605.10
123	0	30-inch diameter	615.39	606.16
124	1	24-inch diameter	615.39	606.36
138	1	30” RCP	616.18	607.67

Table 2
Base Flood and Backflow Prevention Operations Elevations

Outfall Identification Number	Number of Flap Gates*	Outfall/Flap Gate Size	1 Percent Annual Chance Flood Elevation (feet, NAVD88)	Flood Gate Invert Elevation (feet, NAVD88)
Caledonia Street Pump Station Watershed – Reach E1				
55	1	48-inch diameter	615.03	604.06
56B Pump Station Bypass Conduit	1	36-inch diameter	615.41	606.36
56B Pump Station Discharge Conduits	3	36-inch diameter	615.54	611.87
Palmer Street Pump Station Watershed – Reach E1				
61 Pump Discharge Conduits	3	36-inch diameter	616.27	611.87
61A Pump Station Bypass Conduit	1	36-inch diameter	616.27	605.28
64	1	24-inch diameter	616.45	604.57
Indian Mill Creek Pump Station Watershed – Reach W1				
136A	1	24-inch diameter	616.18	605.87
137A	3	36-inch diameter	616.18	611.87
137B Pump Station Bypass Conduit	1	36-inch diameter	616.18	606.67

*For outfalls with 0 flap gates, the manholes along the drainage pipe network upstream of the outfall have bolt-down castings to prevent overflow onto the streets to the point where the pipe inverts are above the 1 percent annual chance flood elevation.

Reach E1, which includes the Caledonia Street and Palmer Street Storm Water Pump Stations which discharge to the Grand River through Outfalls 56B, 61 and 61A also has outfalls that serve small localized areas that do not drain to the pump stations. Of these outfalls, 54A, 55A, 55B, 57, 58, 59, 60, 62, 63, 64A, 64B, 64C, and 66A, are protected by flap gates. Outfalls 55, 56, 65, and 66 serve only upland areas but have bolt down castings on manholes within downstream flood prone areas. Outfall 56A is controlled by a manual valve and is only used as a relief for a nearby water tank.

Reach E2 does not have storm water pump stations; however, it does have a 54-inch relief sewer (Outfall 49A) that discharges downstream of the 4th Street Dam where the flood profiles drops. Outfalls 49B and 49C have flap gates and are connected directly the 54-inch relief sewer. Outfalls 53 and 53A discharge to the river until their flap gates close. At this point they overflow to the 54" relief sewer that discharges downstream of the 4th Street dam. Outfall 49 serves only on two catch basins, discharges directly to the Grand River and has a flap gate on the floodwall. The outfalls 48, 53C, 54, and 54A serve only upland areas but have bolt down castings on manholes that are within downstream flood prone areas. Outfall 54A also has a flap gate mounted to the Leonard Street bridge abutment. The Reach E2 storm water collection system has capacity to discharge the 1-year, 24-hour rain event to the Grand River at the BFE without causing localized flood greater than 1 foot in depth.

Reach E3 does not have storm water pump station. Outfalls 23, 29, 31, 32A, 33, 34, 35, 36, 37, and 38 discharge directly to the Grand River and have flap gates mounted either on the existing floodwall or in upstream manholes. Outfalls 21A, 21B, 21C, 22A, 29A, and 31A serve only upland areas but have bolt down castings on manholes

within downstream flood prone areas. Outfall 22 has a sluice gate that has been permanently closed. The Reach E3 storm water collection system has capacity to discharge the 1-year, 24-hour rain event to the Grand River at the BFE without causing localized flood greater than 1 foot in depth.

Reach E4, which includes the Market Avenue Storm Water Pump Station that discharges at Outfall 7C, has outfalls that serve small localize areas that drain directly to the Grand River and not to the pump station. Of these outfalls, 11, 12A, 12B, 15, 16, and 20A have flap gates mounted either on the existing floodwall or in upstream manholes. The inlets for outfalls 6, 7A, 7B, 13, 14, 18A, 19, 21A, 21B, and 21C serve only upland areas but have bolt down castings on manholes within downstream flood prone areas.

Reach E5, which includes the ring levee around the WRRF, does not have a pump station solely dedicated to storm water; however, screw pumps within the facility can be used in conjunction with outfall 3B to drain storm water and treated wastewater that is trapped inside the levee during a high-water event on the Grand River. Both outfalls 3A and 3B have sluice gates to prevent backflow into the WRRF. Outfalls 3C, 3D, 3E and 3F drain into the WRRF from the south. Each of these four outfalls has a gate valve that is closed during high water events. The outfalls 4 and 5 serve only small upland areas. Neither require bolt down castings on manholes.

Reach W1, which includes area north of Mill Creek, includes storm water drainage from both Grand Rapids and the City of Walker. The area is serviced by the Mill Creek Storm Water Pump Station that discharges to the Grand River through outfalls 137A and 137B. Outfalls 135A, 135B1, 135C1, 135C2, 135C3, 135C4, 135F and 136A have flap gates and are served by the pump station. Outfalls 135B, 135C, 135D, 135E are culverts under US-131 that are completely within the floodplain. They require no protection. Outfalls 133B, 134, 134A, and 135 along the Grand River and 136C and 139 along Indian Mill Creek serve only upland areas and are not within the official Reach W1 limits.

Reach W2, which includes areas south of Indian Mill Creek and north of I-196, is served by the Front-Scribner Storm Water Pump Station (Outfall 107B). Outfalls 109, 112, 117, 118, 119, 120, 121, 122 and 138 discharge directly to the Grand River and have flap gates. If the flap gates close flow is diverted to Outfall 107B. Outfalls 124, 125, 127A, 128, 131, 132, 133, and 133A discharge directly to the Grand River and have flap gates. These outfalls do not directly overflow to Outfall 107B when the flap gates close. However, flooding would be less than 1 foot of deep should the 1-year, 24-hour rainfall event occur when the river is at the BFE. Outfall 109D has no flap gate but is manually plugged by the City during flood events (see GRFPS Emergency Action Plan, Table 4). Outfall 109C is manually plugged by the 678 Front building owner. Outfall 108 is completely within the floodplain and does not require protection. Outfalls 109A, 109B, 110A and 111 serve only roof drains and discharge directly to the Grand River. Outfalls 113 and 123 drain only upstream areas (US-131) but have bolt down castings on manholes in downstream flood prone areas.

Reach W3 does not have a storm water pump station. All storm water drainage flows discharge at outfalls on the Grand River. Outfalls 96 and 103 have headwall mounted flap gates. When the flap gates close flow is diverted to the Wealthy Street Storm Water Pump Station via overflow pipes. Outfalls 105A, 105B, 105C, 107, and 107A have inlets above the BFE and do not required bolt down castings on downstream manholes. Outfalls 97, 99, 99A, 100, 102, 104 and 105 have inlets within the floodplain and require no protection.

Reach W4, which includes the Wealthy Storm Water Pump Station (Outfall 72G), has small localized areas that drain directly to the Grand River and not directly to the pump station. Outfalls 72, 72A, 72B, 72C, 72E, 72F, 72H, 72I, 72J, 83, 83A, 83B, 83D, 84, and 86. All of these outfalls are protected by flap gates except for Outfall 72A that has a manually operated sluice gate, Outfall 72H that is protected by a duckbill valve, and Outfall 83D that is manually plugged (see GRFPS Emergency Action Plan, Table 4). Outfalls 81A, 83C, 86A, and 87 serve upland areas and do not required bolt down castings on downstream manholes.

Joint Probability of Flooding

Joint probability of flooding for flood protection systems refers to the chance that interior (landward) flooding occurs while exterior (Grand River) flooding impedes the interior drainage system. The factors included in these analyses are time to peak discharge (interior and exterior), duration of flood gate closure, and the probability of an interior precipitation event.

Hydrologic Analysis

The volume of storm water runoff flowing to the pump stations was estimated using the methodology presented in Natural Resources Conservation Service (NRCS) *Technical Release 55, Urban Hydrology for Small Watersheds* as presented in the *WinTR-55* program (NRCS, 2009). The areas that drain to the individual pump stations were determined using topographic mapping provided by the Kent County Bureau of Equalization and storm sewer maps provided by the City Department of Environmental Services. The runoff curve numbers were developed using land uses determined from an evaluation of aerial photography available from the Kent County. Soil types used in the development of runoff curve numbers was determined using the NRCS Web Soil Survey (WSS) information for Kent County, Michigan, available on the internet.

Because of the size and complexity of the drainage system for each pump station, the time of concentration for each watershed was determined based on the topographic information provided by Kent County and the following time of concentration equation developed by the Federal Aviation Administration:

$$t_c = \frac{1.8(1.1 - C)L^{0.50}}{S^{0.333}}$$

where t_c = time of concentration (minutes)

C = average runoff coefficient

L = flow length (feet)

S = average slope

To simplify the calculations, it was assumed that all the storm water runoff would flow unimpeded to the pump stations. Table 3 summarizes the areas within the GRFPS that drain to each pump station, the runoff curve numbers, and times of concentration used in the TR-55 analysis. Because the time of concentration for the Wealthy Street Pump Station exceeded 10 hours, the peak storm water runoff was determined using the USACE HEC-HMS Hydrologic Modeling System program. Appendix 1 contains the full output listing from the WinTR-55 and HEC-HMS programs. The hydrologic analysis evaluated the storm water runoff resulting from the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year return interval, 24-hour duration storms included in the data sets pre-programmed into the WinTR-55 and HEC-HMS programs. The rainfall was temporally distributed using the NRCS Type II rainfall distribution and the watersheds were assumed to have an average antecedent runoff condition. Table 4 summarizes the total precipitation and peak rainfall runoff for each storm.

Table 3
Watershed Characteristics
Grand Rapids Flood Protection System Interior Area

Drainage Area Name	Drainage Area (Acres)	Time of Concentration (Hours)	Curve Number
Indian Mill Creek Pump Station	33	1.96	88
Palmer Street Pump Station	43	3.84	76
Caledonia Street Pump Station	141	5.25	80
Front & Scribner Pump Station	1154	2.49	78
Wealthy Street Pump Station	2,162	12.33	73
Market Avenue Pump Station	213	3.31	82

Table 4
Grand Rapids Flood Protection System Interior Area
Precipitation and Peak Storm Water Runoff

Return Interval (Years)	Precipitation Depth (Inches)	Peak Storm Water Runoff (cfs)					
		Indian Mill Creek Pump Station (30 cfs capacity)	Palmer St. Pump Station (30 cfs capacity)	Caledonia St. Pump Station (30 cfs capacity)	Front & Scribner Pump Station (710 cfs capacity)	Wealthy St. Pump Station (1,184 cfs capacity)	Market Avenue Pump Station (96 cfs capacity)
1	1.95	10	3	10	123	47	27
2	2.37	14	5	16	203	67	41
5	3.00	20	8	26	343	143	64
10	3.52	25	11	36	472	203	85
25	4.45	35	18	53	718	322	124
50	5.27	43	23	69	947	437	159
100	6.15	52	30	87	1198	567	198

The watershed area of the Grand River upstream of the U.S. Geological Survey (USGS) stream gage station no. 04119000 “Grand River at Grand Rapids, Michigan” is 4,900 square miles. The six pump station watersheds in Grand Rapids are relatively small in comparison to the overall Grand River Watershed upstream of Grand Rapids as shown in Table 3. The small pump station watersheds will react to rainfall events much more quickly than the Grand River Watershed. Figure 20 shows the 1 percent annual chance, 24-hour duration, precipitation runoff hydrographs for the pump station watersheds in Grand Rapids developed using the NRCS WinTR-55 and HEC-HMS programs. Note that all the watershed hydrographs peak in less than 9 hours and the runoff completely diminishes to 0 within 25 hours of the start of the rainfall.

The 1 percent annual chance flood in the Grand River was developed from historic records for the top ten largest floods on the Grand River at Grand Rapids using data collected at the USGS stream station no. 04119000. To determine the shape of the 1 percent annual chance flood hydrograph, the hydrographs from the top ten discharge magnitude floods in Grand Rapids were aligned so that their peaks coincided as shown in Figure 21.

From these aligned hydrographs, the 1 percent annual chance flood hydrograph was estimated assuming a peak discharge of 50,000 cubic feet per second (cfs), which is the peak discharge used in the effective HEC-RAS hydraulic model of the Grand River. The final 1 percent annual chance flood hydrograph is shown in Figure 22. Note that the time to peak for the Figure 22 hydrograph is 625 hours, which is much greater than the time to peak for the interior pump station watersheds.

Because the relative size of the interior (inside the GRFPS) and exterior (Grand River) drainage areas are drastically different, the probability of interior and exterior events was assumed be independent. This is consistent with assumptions used in the coincident frequency methods published in USACE Engineering and Design Manual *EM 1110-2-1413 Hydrologic Analysis of Interior Areas*. These methods are applicable where interior and exterior events are independent and occurring where small interior drainage areas are near large rivers.

High Water Operations and Duration

When the Grand River floods in Grand Rapids, water levels will reach elevations where the flap gates or interior weir elevations (Market Avenue Pump Station) at each pump station will close and the pump stations will be activated. Table 5 shows the closing elevation for each pump station's bypass conduit flap gates (or overflow weir) assuming the flap gates close when the Grand River elevation reaches the top of flap gate elevation, the river discharge necessary to reach the top of flap gate elevation, and the duration that the pump station will be activated based on the 1 percent annual chance flood hydrograph for the Grand River (Figure 22). The duration of pump station operation was determined by overlaying the flap gate closure (Market Avenue Pump Station weir crest) discharges on the 1 percent annual chance flood hydrograph as shown in Figure 23. The discharges necessary to close the flap gates or overtop the Market Avenue Pump Station weir elevation were obtained through multiple runs of the HEC-RAS model of the Grand River with different flood discharges.

Table 5
1 Percent Annual Chance Flood
Pump Station Bypass Conduit Flap Gate Operation

Pump Station	Grand River Discharge When Flap Gate Closes (cfs)	Pump Station Bypass Conduit Flap Gate Closure and Opening Elevation Feet, NAVD88*	Duration (Hours)
Wealthy Street	7,900	593.34 (594.34)	903
Market Avenue**	11,730	596.00 (597.02)	619
Front/Scribner	17,450	601.27 (599.99)	303
Caledonia Street	17,220	609.36 (599.88)	307
Palmer Street	11,530	608.28 (596.90)	631
Indian Mill Creek	17,000	609.67 (599.78)	310

*Elevations in parentheses are the corresponding flood elevations at USGS station no. 04119000.
**River water level exceeds height of diversion weir causing slide gate internal to pump station to close and water to flow into wet well. There are no outlet flap gates.

Joint Probability Analysis

Average daily river discharges for the years 1901 through 2012 were obtained for USGS station no. 04119000 Grand River at Grand Rapids, Michigan from the USGS Michigan Water Science Center internet web site. Additionally, a stage versus discharge rating curve was obtained for the gage from the USGS. The USGS gage rating curve had a maximum river stage of 20 feet at a discharge of 30,200 cfs. The gage depth was then converted to a river stage by adding the gage datum of 585.7 feet NGVD29 resulting in an elevation vs. discharge rating curve. For river discharges above 30,200 cfs, computed river elevations at the USGS gage location were obtained from the HEC-RAS (USACE, 2010) water surface profile model of the Grand River approved by FEMA in 2015 for a planned update to the current effective Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) of Grand Rapids (FEMA, 1982). The resulting elevation vs. discharge rating curve spanned the entire range of Grand River discharges.

The Grand River gage discharge data was ordered from the highest recorded average daily discharge in March 1904 (53,300 cfs) to the lowest recorded average daily discharge in August 1936 (381 cfs). The frequency of occurrence for each discharge value was calculated, which is shown in Figure 24. The discharges were then related back to the elevation vs. discharge rating curve and the frequency of occurrence for each river elevation was then established. Figure 25 shows the resulting Grand River elevation versus percent time exceeded at the USGS gage in Grand Rapids.

Probability is defined as the likelihood that a given event will occur, and it is expressed as a decimal number less than or equal to 1.0. The data used to generate Figure 7 was divided into discharge ranges, and the exterior (Grand River) percent exceedances and probabilities for each range summarized in Table 6. The sum of all probabilities is equal to 1.0 (100 percent), which covers all observed discharges for the period of record evaluated. The probabilities in Table 6 were used to evaluate the chance of exterior conditions meeting a range of discharges and river elevations.

Table 6
Average Annual Exterior Percent Exceedance and Probability
Grand River at Grand Rapids, Michigan

Discharge Range (cfs)	No. of Occurrences	Average Annual Exceedance (Percent)	Average Annual Probability
0 – 1,000	1,262	98.55	3.99E-02
1,001 – 2,000	9,730	80.33	3.08E-01
2,001 – 3,000	6,548	53.70	2.07E-01
3,001 – 4,000	3,938	37.79	1.25E-01
4,001 – 5,000	2,798	27.34	8.86E-02
5,001 – 6,000	2,006	19.79	6.35E-02
6,001 – 7,500	1,897	13.52	6.00E-02
7,500 – 9,000	1,103	8.96	3.49E-02
9,001 – 11,000	912	6.32	2.89E-02
11,001 – 13,000	486	3.58	1.54E-02
13,001 – 15,000	315	2.31	9.97E-03
15,001 – 17,000	219	1.49	6.93E-03
17,001 – 20,000	177	0.88	5.60E-03
20,001 – 25,000	129	0.42	4.08E-03
25,001 – 35,000	56	0.13	1.77E-03
35,001 – 45,000	10	0.04	3.17E-04
45,001 – 50,000	5	0.0119	1.58E-04
50,001 – 53,300	2	0.0016	6.33E-05
Total	31,593	---	1.00

Data for the interior discharges were not available for any of the pump station outlets or storm sewer outfalls. Therefore, probabilities were assigned directly from recurrence intervals of interior precipitation as discussed in EM 1110-2-1413.

For the GRFPS, the joint probability analysis was based on two independent events occurring separately. This means that the probability of event A (interior rainfall runoff) is not dependent on the occurrence of event B (pump station operation). For Grand Rapids, a small drainage area (interior) is located adjacent to a large river drainage basin (exterior). If the following definitions are used:

P (A) = Probability of event A

P (B) = Probability of event B

P (A | B) = Probability of event A given event B

P (B | A) = Probability of event B given event A

P (A ∩ B) = Probability of the intersection of event A and event B

Then two events are independent if:

$$P (A \mid B) = P (A)$$

or

$$P (B \mid A) = P (B)$$

Applying the probability of the intersection of two events and substituting for independent events, the resultant is:

$$P (A \cap B) = P (A) \bullet P (B \mid A) = P (A) \bullet P (B)$$

$$P (B \cap A) = P (B) \bullet P (A \mid B) = P (B) \bullet P (A)$$

Therefore, the joint probability of independent events for interior and exterior flood events is:

$$P (\text{Interior} \cap \text{Exterior}) = P (\text{Interior}) \bullet P (\text{Exterior})$$

Tables 7 through 13 provide the tabular computations of the joint probability of interior rainfall runoff and exterior flood events sufficient to start pump station operations for each of the six storm water pump stations in Grand Rapids. The highlighted water surface elevation ranges in each table correspond to the flap gate closure (initiation of pump station operation) elevations listed in Table 5 and the joint probability of that river elevation with the probability of a 1 percent annual frequency of occurrence rain event.

Table 7
Joint Probability of Interior and Exterior Events for the Wealthy Street Pump Station Above Operation Elevation

	Interior P (A)						
Recurrence Interval (Year)	1	2	5	10	25	50	100
Probability	0.9999	0.5	0.2	0.1	0.04	0.02	0.01

Elevation (Feet, NAVD88)	Exterior P (B)	Probability of Interior Rainfall Runoff Event Given Exterior Flooding Sufficient to Initiate Pump Station Operations P (A ∩ B) = P (A) • P (B) Pump Station Begins Operation above Elev. 593.34						
579.10 – 584.51	3.99E-02	3.99E-02	2.00E-02	7.98E-03	3.99E-03	1.60E-03	7.98E-04	3.99E-04
584.52 – 586.54	3.08E-01	3.08E-01	1.54E-01	6.16E-02	3.08E-02	1.23E-02	6.16E-03	3.08E-03
586.55 – 588.14	2.07E-01	2.07E-01	1.04E-01	4.14E-02	2.07E-02	8.28E-03	4.14E-03	2.07E-03
588.15 – 589.50	1.25E-01	1.25E-01	6.25E-02	2.50E-02	1.25E-02	5.00E-03	2.50E-03	1.25E-03
589.51 – 590.68	8.86E-02	8.86E-02	4.43E-02	1.77E-02	8.86E-03	3.54E-03	1.77E-03	8.86E-04
590.69 – 591.70	6.35E-02	6.35E-02	3.18E-02	1.27E-02	6.35E-03	2.54E-03	1.27E-03	6.35E-04
591.71 – 593.03	6.00E-02	6.00E-02	3.00E-02	1.20E-02	6.00E-03	2.40E-03	1.20E-03	6.00E-04
593.04 – 594.17	3.49E-02	3.49E-02	1.75E-02	6.98E-03	3.49E-03	1.40E-03	6.98E-04	**3.49E-04**
594.18 – 595.49	2.89E-02	2.89E-02	1.45E-02	5.78E-03	2.89E-03	1.16E-03	5.78E-04	2.89E-04
595.50 – 596.57	1.54E-02	1.54E-02	7.70E-03	3.08E-03	1.54E-03	6.16E-04	3.08E-04	1.54E-04
596.58 – 597.60	9.97E-03	9.97E-03	4.99E-03	1.99E-03	9.97E-04	3.99E-04	1.99E-04	9.97E-05
597.61 – 598.51	6.93E-03	6.93E-03	3.47E-03	1.39E-03	6.93E-04	2.77E-04	1.39E-04	6.93E-05
598.52 – 599.71	5.60E-03	5.60E-03	2.80E-03	1.12E-03	5.60E-04	2.24E-04	1.12E-04	5.60E-05
599.72 – 601.53	4.08E-03	4.08E-03	2.04E-03	8.16E-04	4.08E-04	1.63E-04	8.16E-05	4.08E-05
601.54 – 604.58	1.77E-03	1.77E-03	8.85E-04	3.54E-04	1.77E-04	7.08E-05	3.54E-05	1.77E-05
604.59 – 607.15	3.17E-04	3.17E-04	1.59E-04	6.34E-05	3.17E-05	1.27E-05	6.34E-06	3.17E-06
607.16 – 608.34	1.58E-04	1.58E-04	7.90E-05	3.16E-05	1.58E-05	6.32E-06	3.16E-06	1.58E-06
608.35 – 609.08	6.33E-05	6.33E-05	3.17E-05	1.27E-05	6.33E-06	2.53E-06	1.27E-06	6.33E-07

Table 8
Joint Probability of Interior and Exterior Events for the Market Avenue Pump Station Above Operation Elevation

	Interior P (A)						
Recurrence Interval (Year)	1	2	5	10	25	50	100
Probability	0.9999	0.5	0.2	0.1	0.04	0.02	0.01

Elevation (Feet, NAVD88)	Exterior P (B)	Probability of Interior Rainfall Runoff Event Given Exterior Flooding Sufficient to Initiate Pump Station Operations P (A ∩ B) = P (A) • P (B) Pump Station Begins Operation above Elev. 596.00						
578.81 – 584.57	3.99E-02	3.99E-02	2.00E-02	7.98E-03	3.99E-03	1.60E-03	7.98E-04	3.99E-04
584.58 – 586.59	3.08E-01	3.08E-01	1.54E-01	6.16E-02	3.08E-02	1.23E-02	6.16E-03	3.08E-03
586.60 – 588.19	2.07E-01	2.07E-01	1.04E-01	4.14E-02	2.07E-02	8.28E-03	4.14E-03	2.07E-03
588.20 – 589.55	1.25E-01	1.25E-01	6.25E-02	2.50E-02	1.25E-02	5.00E-03	2.50E-03	1.25E-03
589.56 – 590.73	8.86E-02	8.86E-02	4.43E-02	1.77E-02	8.86E-03	3.54E-03	1.77E-03	8.86E-04
590.74 – 591.76	6.35E-02	6.35E-02	3.18E-02	1.27E-02	6.35E-03	2.54E-03	1.27E-03	6.35E-04
591.77 – 593.09	6.00E-02	6.00E-02	3.00E-02	1.20E-02	6.00E-03	2.40E-03	1.20E-03	6.00E-04
593.10 – 594.23	3.49E-02	3.49E-02	1.75E-02	6.98E-03	3.49E-03	1.40E-03	6.98E-04	3.49E-04
594.24 – 595.56	2.89E-02	2.89E-02	1.45E-02	5.78E-03	2.89E-03	1.16E-03	5.78E-04	2.89E-04
595.57 – 596.65	1.54E-02	1.54E-02	7.70E-03	3.08E-03	1.54E-03	6.16E-04	3.08E-04	1.54E-04
596.66 – 597.68	9.97E-03	9.97E-03	4.99E-03	1.99E-03	9.97E-04	3.99E-04	1.99E-04	9.97E-05
597.69 – 598.61	6.93E-03	6.93E-03	3.47E-03	1.39E-03	6.93E-04	2.77E-04	1.39E-04	6.93E-05
598.62 – 599.81	5.60E-03	5.60E-03	2.80E-03	1.12E-03	5.60E-04	2.24E-04	1.12E-04	5.60E-05
599.82 – 601.65	4.08E-03	4.08E-03	2.04E-03	8.16E-04	4.08E-04	1.63E-04	8.16E-05	4.08E-05
601.66 – 604.74	1.77E-03	1.77E-03	8.85E-04	3.54E-04	1.77E-04	7.08E-05	3.54E-05	1.77E-05
604.75 – 607.34	3.17E-04	3.17E-04	1.59E-04	6.34E-05	3.17E-05	1.27E-05	6.34E-06	3.17E-06
607.35 – 608.54	1.58E-04	1.58E-04	7.90E-05	3.16E-05	1.58E-05	6.32E-06	3.16E-06	1.58E-06
608.55 – 609.29	6.33E-05	6.33E-05	3.17E-05	1.27E-05	6.33E-06	2.53E-06	1.27E-06	6.33E-07

Table 9
Joint Probability of Interior and Exterior Events for the Front/Scribner Pump Station Above Operation Elevation

	Interior P (A)						
Recurrence Interval (Year)	1	2	5	10	25	50	100
Probability	0.9999	0.5	0.2	0.1	0.04	0.02	0.01

Elevation (Feet, NAVD88)	Exterior P (B)	Probability of Interior Rainfall Runoff Event Given Exterior Flooding Sufficient to Initiate Pump Station Operations P (A ∩ B) = P (A) • P (B) Pump Station Begins Operation above Elev. 601.27						
589.10 – 595.66	3.99E-02	3.99E-02	2.00E-02	7.98E-03	3.99E-03	1.60E-03	7.98E-04	3.99E-04
595.67 – 596.17	3.08E-01	3.08E-01	1.54E-01	6.16E-02	3.08E-02	1.23E-02	6.16E-03	3.08E-03
596.18 – 596.60	2.07E-01	2.07E-01	1.04E-01	4.14E-02	2.07E-02	8.28E-03	4.14E-03	2.07E-03
596.61 – 596.97	1.25E-01	1.25E-01	6.25E-02	2.50E-02	1.25E-02	5.00E-03	2.50E-03	1.25E-03
596.98 – 597.31	8.86E-02	8.86E-02	4.43E-02	1.77E-02	8.86E-03	3.54E-03	1.77E-03	8.86E-04
597.32 – 597.63	6.35E-02	6.35E-02	3.18E-02	1.27E-02	6.35E-03	2.54E-03	1.27E-03	6.35E-04
597.64 – 598.12	6.00E-02	6.00E-02	3.00E-02	1.20E-02	6.00E-03	2.40E-03	1.20E-03	6.00E-04
598.13 – 598.46	3.49E-02	3.49E-02	1.75E-02	6.98E-03	3.49E-03	1.40E-03	6.98E-04	3.49E-04
598.47 – 598.95	2.89E-02	2.89E-02	1.45E-02	5.78E-03	2.89E-03	1.16E-03	5.78E-04	2.89E-04
598.96 – 599.47	1.54E-02	1.54E-02	7.70E-03	3.08E-03	1.54E-03	6.16E-04	3.08E-04	1.54E-04
599.48 – 600.25	9.97E-03	9.97E-03	4.99E-03	1.99E-03	9.97E-04	3.99E-04	1.99E-04	9.97E-05
600.26 – 601.11	6.93E-03	6.93E-03	3.47E-03	1.39E-03	6.93E-04	2.77E-04	1.39E-04	6.93E-05
601.12 – 601.92	5.60E-03	5.60E-03	2.80E-03	1.12E-03	5.60E-04	2.24E-04	1.12E-04	5.60E-05
601.93 – 603.71	4.08E-03	4.08E-03	2.04E-03	8.16E-04	4.08E-04	1.63E-04	8.16E-05	4.08E-05
603.72 – 607.02	1.77E-03	1.77E-03	8.85E-04	3.54E-04	1.77E-04	7.08E-05	3.54E-05	1.77E-05
607.03 – 610.40	3.17E-04	3.17E-04	1.59E-04	6.34E-05	3.17E-05	1.27E-05	6.34E-06	3.17E-06
610.41 – 612.77	1.58E-04	1.58E-04	7.90E-05	3.16E-05	1.58E-05	6.32E-06	3.16E-06	1.58E-06
612.78 – 614.00	6.33E-05	6.33E-05	3.17E-05	1.27E-05	6.33E-06	2.53E-06	1.27E-06	6.33E-07

Table 10
Joint Probability of Interior and Exterior Events for Caledonia Street Pump Station Above Operating Elevation

	Interior P (A)						
Recurrence Interval (Year)	1	2	5	10	25	50	100
Probability	0.9999	0.5	0.2	0.1	0.04	0.02	0.01

Elevation (Feet, NAVD88)	Exterior P (B)	Probability of Interior Rainfall Runoff Event Given Exterior Flooding Sufficient to Initiate Pump Station Operations P (A ∩ B) = P (A) • P (B) Pump Station Begins Operation above Elev. 609.36						
595.52 – 604.26	3.99E-02	3.99E-02	2.00E-02	7.98E-03	3.99E-03	1.60E-03	7.98E-04	3.99E-04
604.27 – 604.79	3.08E-01	3.08E-01	1.54E-01	6.16E-02	3.08E-02	1.23E-02	6.16E-03	3.08E-03
604.80 – 605.25	2.07E-01	2.07E-01	1.04E-01	4.14E-02	2.07E-02	8.28E-03	4.14E-03	2.07E-03
605.26 – 605.66	1.25E-01	1.25E-01	6.25E-02	2.50E-02	1.25E-02	5.00E-03	2.50E-03	1.25E-03
605.67 – 606.04	8.86E-02	8.86E-02	4.43E-02	1.77E-02	8.86E-03	3.54E-03	1.77E-03	8.86E-04
606.05 – 606.40	6.35E-02	6.35E-02	3.18E-02	1.27E-02	6.35E-03	2.54E-03	1.27E-03	6.35E-04
606.41 – 606.90	6.00E-02	6.00E-02	3.00E-02	1.20E-02	6.00E-03	2.40E-03	1.20E-03	6.00E-04
606.91 – 607.36	3.49E-02	3.49E-02	1.75E-02	6.98E-03	3.49E-03	1.40E-03	6.98E-04	3.49E-04
607.37 – 607.94	2.89E-02	2.89E-02	1.45E-02	5.78E-03	2.89E-03	1.16E-03	5.78E-04	2.89E-04
607.95 – 608.32	1.54E-02	1.54E-02	7.70E-03	3.08E-03	1.54E-03	6.16E-04	3.08E-04	1.54E-04
608.33 – 608.83	9.97E-03	9.97E-03	4.99E-03	1.99E-03	9.97E-04	3.99E-04	1.99E-04	9.97E-05
608.84 – 609.31	6.93E-03	6.93E-03	3.47E-03	1.39E-03	6.93E-04	2.77E-04	1.39E-04	6.93E-05
609.32 – 609.99	5.60E-03	5.60E-03	2.80E-03	1.12E-03	5.60E-04	2.24E-04	1.12E-04	5.60E-05
610.00 – 611.04	4.08E-03	4.08E-03	2.04E-03	8.16E-04	4.08E-04	1.63E-04	8.16E-05	4.08E-05
611.05 – 612.88	1.77E-03	1.77E-03	8.85E-04	3.54E-04	1.77E-04	7.08E-05	3.54E-05	1.77E-05
612.89 – 614.50	3.17E-04	3.17E-04	1.59E-04	6.34E-05	3.17E-05	1.27E-05	6.34E-06	3.17E-06
614.51 – 615.45	1.58E-04	1.58E-04	7.90E-05	3.16E-05	1.58E-05	6.32E-06	3.16E-06	1.58E-06
615.46 – 616.07	6.33E-05	6.33E-05	3.17E-05	1.27E-05	6.33E-06	2.53E-06	1.27E-06	6.33E-07

Table 11
Joint Probability of Interior and Exterior Events for the Palmer Street Pump Station Above Operation Elevation

	Interior P (A)						
Recurrence Interval (Year)	1	2	5	10	25	50	100
Probability	0.9999	0.5	0.2	0.1	0.04	0.02	0.01

Elevation (Feet, NAVD88)	Exterior P (B)	Probability of Interior Rainfall Runoff Event Given Exterior Flooding Sufficient to Initiate Pump Station Operations P (A ∩ B) = P (A) • P (B) Pump Station Begins Operation above Elev. 608.28						
596.64 - 604.27	3.99E-02	3.99E-02	2.00E-02	7.98E-03	3.99E-03	1.60E-03	7.98E-04	3.99E-04
604.28 - 604.83	3.08E-01	3.08E-01	1.54E-01	6.16E-02	3.08E-02	1.23E-02	6.16E-03	3.08E-03
604.84 - 605.31	2.07E-01	2.07E-01	1.04E-01	4.14E-02	2.07E-02	8.28E-03	4.14E-03	2.07E-03
605.32 - 605.75	1.25E-01	1.25E-01	6.25E-02	2.50E-02	1.25E-02	5.00E-03	2.50E-03	1.25E-03
605.76 - 606.16	8.86E-02	8.86E-02	4.43E-02	1.77E-02	8.86E-03	3.54E-03	1.77E-03	8.86E-04
606.17 - 606.54	6.35E-02	6.35E-02	3.18E-02	1.27E-02	6.35E-03	2.54E-03	1.27E-03	6.35E-04
606.55 - 607.08	6.00E-02	6.00E-02	3.00E-02	1.20E-02	6.00E-03	2.40E-03	1.20E-03	6.00E-04
607.09 - 607.58	3.49E-02	3.49E-02	1.75E-02	6.98E-03	3.49E-03	1.40E-03	6.98E-04	3.49E-04
607.59 - 608.20	2.89E-02	2.89E-02	1.45E-02	5.78E-03	2.89E-03	1.16E-03	5.78E-04	2.89E-04
608.21 - 608.64	1.54E-02	1.54E-02	7.70E-03	3.08E-03	1.54E-03	6.16E-04	3.08E-04	1.54E-04
608.65 - 609.18	9.97E-03	9.97E-03	4.99E-03	1.99E-03	9.97E-04	3.99E-04	1.99E-04	9.97E-05
609.19 - 609.70	6.93E-03	6.93E-03	3.47E-03	1.39E-03	6.93E-04	2.77E-04	1.39E-04	6.93E-05
609.71 - 610.43	5.60E-03	5.60E-03	2.80E-03	1.12E-03	5.60E-04	2.24E-04	1.12E-04	5.60E-05
610.44 - 611.56	4.08E-03	4.08E-03	2.04E-03	8.16E-04	4.08E-04	1.63E-04	8.16E-05	4.08E-05
611.57 - 613.53	1.77E-03	1.77E-03	8.85E-04	3.54E-04	1.77E-04	7.08E-05	3.54E-05	1.77E-05
613.54 - 615.26	3.17E-04	3.17E-04	1.59E-04	6.34E-05	3.17E-05	1.27E-05	6.34E-06	3.17E-06
615.27 - 616.24	1.58E-04	1.58E-04	7.90E-05	3.16E-05	1.58E-05	6.32E-06	3.16E-06	1.58E-06
616.25 - 616.91	6.33E-05	6.33E-05	3.17E-05	1.27E-05	6.33E-06	2.53E-06	1.27E-06	6.33E-07

Table 12
Joint Probability of Interior and Exterior Events for Indian Mill Creek Pump Station Above Operating Elevation

	Interior P (A)						
Recurrence Interval (Year)	1	2	5	10	25	50	100
Probability	0.9999	0.5	0.2	0.1	0.04	0.02	0.01

Elevation (Feet, NAVD88)	Exterior P (B)	Probability of Interior Rainfall Runoff Event Given Exterior Flooding Sufficient to Initiate Pump Station Operations P (A ∩ B) = P (A) • P (B) Pump Station Begins Operation above Elev. 609.67						
596.99 - 604.27	3.99E-02	3.99E-02	2.00E-02	7.98E-03	3.99E-03	1.60E-03	7.98E-04	3.99E-04
604.28 - 604.82	3.08E-01	3.08E-01	1.54E-01	6.16E-02	3.08E-02	1.23E-02	6.16E-03	3.08E-03
604.83 - 605.30	2.07E-01	2.07E-01	1.04E-01	4.14E-02	2.07E-02	8.28E-03	4.14E-03	2.07E-03
605.31 -605.74	1.25E-01	1.25E-01	6.25E-02	2.50E-02	1.25E-02	5.00E-03	2.50E-03	1.25E-03
605.75 - 606.15	8.86E-02	8.86E-02	4.43E-02	1.77E-02	8.86E-03	3.54E-03	1.77E-03	8.86E-04
606.16 - 606.53	6.35E-02	6.35E-02	3.18E-02	1.27E-02	6.35E-03	2.54E-03	1.27E-03	6.35E-04
606.54 - 607.06	6.00E-02	6.00E-02	3.00E-02	1.20E-02	6.00E-03	2.40E-03	1.20E-03	6.00E-04
607.07 - 607.56	3.49E-02	3.49E-02	1.75E-02	6.98E-03	3.49E-03	1.40E-03	6.98E-04	3.49E-04
607.57 - 608.18	2.89E-02	2.89E-02	1.45E-02	5.78E-03	2.89E-03	1.16E-03	5.78E-04	2.89E-04
608.19 - 608.61	1.54E-02	1.54E-02	7.70E-03	3.08E-03	1.54E-03	6.16E-04	3.08E-04	1.54E-04
608.62 - 609.15	9.97E-03	9.97E-03	4.99E-03	1.99E-03	9.97E-04	3.99E-04	1.99E-04	9.97E-05
609.16 - 609.67	6.93E-03	6.93E-03	3.47E-03	1.39E-03	6.93E-04	2.77E-04	1.39E-04	6.93E-05
609.68 - 610.40	5.60E-03	5.60E-03	2.80E-03	1.12E-03	5.60E-04	2.24E-04	1.12E-04	5.60E-05
610.41 - 611.52	4.08E-03	4.08E-03	2.04E-03	8.16E-04	4.08E-04	1.63E-04	8.16E-05	4.08E-05
611.53 - 613.49	1.77E-03	1.77E-03	8.85E-04	3.54E-04	1.77E-04	7.08E-05	3.54E-05	1.77E-05
613.50 - 615.22	3.17E-04	3.17E-04	1.59E-04	6.34E-05	3.17E-05	1.27E-05	6.34E-06	3.17E-06
615.23 - 616.20	1.58E-04	1.58E-04	7.90E-05	3.16E-05	1.58E-05	6.32E-06	3.16E-06	1.58E-06
616.21 - 616.88	6.33E-05	6.33E-05	3.17E-05	1.27E-05	6.33E-06	2.53E-06	1.27E-06	6.33E-07

Interior Flooding

The City of Grand Rapids Code of Ordinances, Title II – Utilities and Services, Chapter 32 – Stormwater Drainage System, Article 4 – Stormwater Management Standards, Section 2.245 – Stormwater Drainage System Design Criteria specifies that during normal river elevations storm drain pipes in collector systems are to be designed to handle a 10-year design storm while trunk systems are to handle the 25 to 100-year storm.

The City of Walker relies on the Kent County, Michigan *Development Drainage Rules*, for its storm water drainage system, which specify:

- Culverts are to be designed for a minimum 10-year storm in the developed watershed.
- Storm sewers are to be designed to have a 10-year storm flow capacity if a floodway is available.
- Storm sewers are to be designed to have a 100-year flow capacity if no floodway channel is available.

The floodway in this case is an overland conveyance to serve all trapped yard basins and low areas in the road to prevent flooding should the storm sewer fail or be inadequate to handle runoff from a severe storm.

High intensity rain events in watersheds tributary to the GRFPS in the City and in the City of Walker have caused minor street flooding as the amount of water exceeds the inlet and pipe capacity of the storm drainage system. However, because of the moderately steep topography of the Cities of Grand Rapids and Walker, which slopes toward the floodplain along the Grand River, the depth of street flooding does not exceed 1-foot as the excess storm water flows on the streets downhill to the next catch basin inlets that can handle the flow. The City of Grand Rapids has not recorded any persistent flooding problems in the areas outside of the floodplain along the Grand River. The City of Walker recently acted to resolve flooding problems along Turner Avenue (see Reach W1 below). Both the City of Walker and the City of Grand Rapids have evaluated the potential for storm water ponding and have confirmed that all low areas within the protected areas have positive drainage through storm sewers either directly to the river or to the storm water pump stations. If storm water outfalls at the Grand River were blocked due to high water, low area flooding would spill over into areas with storm sewers that lead to the storm water pump stations without resulting in flooding more than an average depth of 1-foot. The topography of the area behind the flood protection project does not support interior flooding to an average depth greater than 1 foot as confirmed by the topographic mapping provided with these levee certification documents. Areas of shallow flooding for each reach are identified as follows:

Reach E1 Both the Palmer Street Pump Station and the Caledonia Street Pump Station in Reach E1 were designed to handle the discharge from a 10-year, 24-hour duration storm. A small area of the watershed draining Reach E1 does not flow to the pump stations when the Grand River is at the BFE. However, water will continue to discharge through partially open flap gates with as little as 6-inches of hydraulic head. Therefore, there has been little flooding in the areas adjacent to the GRFPS in Reach E1.

Reach E2 There are no storm water pump stations in Reach E2; therefore, all storm water drainage is directed directly to the Grand River. Street flooding in the floodplain areas adjacent to the GRFPS in Reach E2 is not usually a problem, rainfall from a 1-year event in conjunction with Grand River levels sufficient to close the backflow prevention devices on the storm drainage outfalls could result in shallow (<1 foot) street flooding at the following location:

- Monroe Avenue from I-196 to Mason Street and 6th Street from Monroe to Bond Avenues.

Reach E3 In Reach E3 there is no pump station to handle discharge to the Grand River in the event flood levels cause closure of backflow prevention flap gates. There has been little flooding in the areas adjacent to and interior to the GRFPS in Reach E3; rainfall from a 1-year event in conjunction with Grand River levels sufficient to close the backflow prevention devices on the storm drainage outfalls could result in shallow (<1 foot) street flooding at the following locations:

- Intersection of Market Avenue and Fulton Street.
- Portions of Monroe/Market Avenues north and south of Fulton Street.
- Campau Avenue between the walkway leading to the Blue Pedestrian Bridge and Pearl Street.

Reach E4 The Market Avenue Storm Water Pump Station is in Reach E4, and it was designed to handle the discharge from a 10-year, 24-hour duration storm. The storm water drainage in the watershed that drains to Reach E4 is handled by the pump station with no interior ponding areas caused by excessive rainfall events.

Reach E5 Reach E5 includes the area encircled by the ring levee around the WRRF. Under long-duration intense rainfall events in conjunction with flood events on the Grand River when the flap gates and sluice gate on the storm water outfalls are closed, the screw pumps used to discharge treated wastewater at the head of outfall 3B can be used to discharge storm water that ponds inside the ring levee. In addition, water will pond at the northeast corner of the WRRF where it will be pumped over the levee into Plaster Creek using portable pumps. Interior ponding is kept below an average of 1-foot depth using the WRRF portable pumps and screw pumps.

Reach W1 The Indian Mill Creek Storm Water Pump Station is located along Indian Mill Creek in Reach W1. This pump station receives storm water drainage from both the City and the City of Walker. In Walker excess storm water that is blocked from flowing to the Grand River due to flap gate closure on the culverts beneath Turner Avenue is conveyed through a relief storm sewer to the Indian Mill Creek Storm Water Pump Station in Grand Rapids to handle discharge to the Grand River. However, water will continue to discharge through partially open flap gates with as little as 6-inches of hydraulic head. There has been little flooding in the areas adjacent to and interior to the GRFPS in Reach W1; however, the 1-year rainfall event could result in street and adjacent area flooding to a depth of less than 1 foot at the following location:

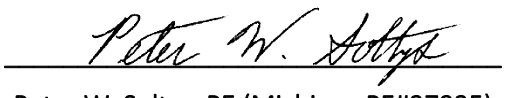
- Portions of Turner Avenue north of US-131 ramps to the PADNOS Leitelt, Inc. facility at 2301 Turner Ave. NW.

Reach W2 The Front-Scribner Storm Water Pump Station is located along the Grand River in Reach W2. There has been little flooding in the areas adjacent to and interior to the GRFPS in Reach W2 and no ponding areas due to excessive rainfall have been identified.

Reach W3 are no storm water pump stations in Reach W3 although the Wealthy Street Storm Water Pump Station in Reach W4 also handles storm water from this reach. No ponding areas due to excessive rainfall have been identified in this reach.

Reach W4 The Wealthy Street Storm Water Pump Station is set back from the Grand River in Reach W4. During rainfall from a 1-year event in conjunction with the Grand River at flood stage, an area that would be subject to interior flooding is in the immediate area of the pump station. The pump station has been flood-proofed in anticipation of this occurrence. No other ponding areas due to excessive rainfall have been identified in this reach.

Fishbeck attests that the modeling data, documentation, and the findings of no ponding areas with the average depth greater than one foot meet the requirements of this section of 44 CFR 65.10.



Peter W. Soltys, PE (Michigan PE#37935)

Historic High Water

Grand Rapids has experienced only one flood that exceeded the 1 percent annual chance flood discharge of 50,000 cfs at the USGS gage. This flood occurred in March 1904 before the current flood protection system was constructed. The most recent flood since the completion of the existing GRFPS occurred in April 2013 and had a peak discharge of 35,100 cfs. This flood had an annual chance of occurrence of between 4 percent and 10 percent. Interior area flooding during the April 2013 flood was largely located in low lying areas along the left (east) river bank in Riverside Park at the north end of the City.

Summary and Conclusions

The GRFPS protects approximately 1,420 acres on the right (west) bank and 195 acres on the left (east) bank of residential, commercial, institutional, and industrial properties within the City boundaries from a Base Flood (1 percent annual chance of occurrence) event. During a flood event, the bypass conduit flap gates may close at the Wealthy Street, Front/Scribner, Caledonia Street, Palmer Street, and Indian Mill Creek Pump Stations may close and the bypass weir at the Market Avenue Pump Station may overtop causing the pump stations to begin pumping, but the time to peak of the river (exterior) is much longer than the time to peak for the interior rainfall runoff event. Therefore, the interior area will drain prior to the arrival of the Grand River flood peak.

The joint probability analysis for a 1 percent annual chance event on both the interior and exterior was estimated to be a rare occurrence. The pump station backflow prevention devices (flap gates on the bypass conduits and a sluice gate in the Market Ave. Pump Station) would be closed at different exterior river elevations while an additional precipitation event occurs at a 100-year annual return interval (0.1 probability). The joint probability of interior and exterior flooding is summarized in Table 13.

Table 13
Joint Probability of 1 Percent Annual Frequency of Occurrence Interior Rainfall Event and Exterior Flooding Sufficient to Initiate Pump Station Operations

Pump Station	Joint Probability of Interior and Exterior Events*	Recurrence (Years)
Wealthy Street	3.49E-04	2,865
Market Avenue	1.54E-04	6,494
Front/Scribner	5.60E-05	17,857
Caledonia	5.60E-05	17,857
Palmer	1.54E-04	6,494
Indian Mill Creek	6.93E-05	14,300

*Pump station operation was assumed to occur at the flap gate closure/weir overtopping elevations given in Table 5. These elevations were used in Tables 7 through 12 to obtain the joint probabilities.

As shown in Table 13, the existing GRFPS project provides a very low probability of interior flooding during flooding in the Grand River in the drainage areas served by the stormwater pump stations. All depressions where storm water accumulates have direct storm sewer connections to the river or to the storm sewers served by the storm water pump stations. The potential for interior flooding while the Grand River is at flood stage was evaluated, and it was determined that water will not pond to an average depth greater than 1-foot in the areas protected by the GRFPS. In areas not served directly by the pump stations, the water that collects in depressions and on streets in the areas protected by the GRFPS will either overflow into adjacent drainage areas served by a stormwater pump station or directly into the Grand River before the average depth of ponding exceeds 1 foot.

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Figures

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\InteriorDrain_Flood Protection Project.mxd Date: 8/31/2017 9:15:08 AM User: MCL

Legend

- E1 - Knapp to Leonard
- E2 - Leonard to I-196
- E3 - Pedestrian (Gillett) Bridge to US 131
- E4 - US 131 to 50% distance to WRRF
- E5 - WRRF Boundary
- W1 - North of Indian Mill Creek
- W2 - Indian Mill Creek to I-196
- W3 - I-196 to Fulton
- W4 - Fulton to Butterworth Landfill
- PS — Storm Water Pump Station

W1

CITY LIMIT

INDIAN MILL CREEK PUMP STATION

PALMER STREET PUMP STATION

E1

CALEDONIA STREET PUMP STATION

W2

E2

FRONT & SCRIBNER PUMP STATION

W3

E3

W4

WEALTHY STREET PUMP STATION

E4

MARKET AVENUE PUMP STATION

E5 GR WRRF

Sources: Esri, H... China (Hong Ko... Community

NORTH 0 1,000 2,000 FEET

City of Grand Rapids

Kent County, Michigan

Interior Drainage Analysis

PROJECT NO. G120330LMP

FIGURE NO. 1

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Interior Drainage Anal sis

PROJECT NO.
G12 33

FIGURE NO.
2

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EXISTI G O TFA S
REACH E2

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Interior Drainage Anal sis

PROJECT NO.
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3

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EXISTING OUTFALLS
REACH E3

NORTH

SCALE: 1" = 600'

0 300 600

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Interior Drainage Analysis

PROJECT NO.
G120330

FIGURE NO.
4

PLOT INFO: Z:\2012\120330LMP\CAD\REF\INTERIOR DRAINAGE ANALYSIS.DWG LAYOUT: REACH E3 DATE: 8/28/2017 TIME: 11:17:38 AM USER: JNK

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REACH E4

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SCALE: 1" = 900'

0 450 900

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Interior Drainage Anal□sis

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REACH E5

SCALE: 1" = 600'

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Interior Drainage Anal□sis

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FIGURE NO.
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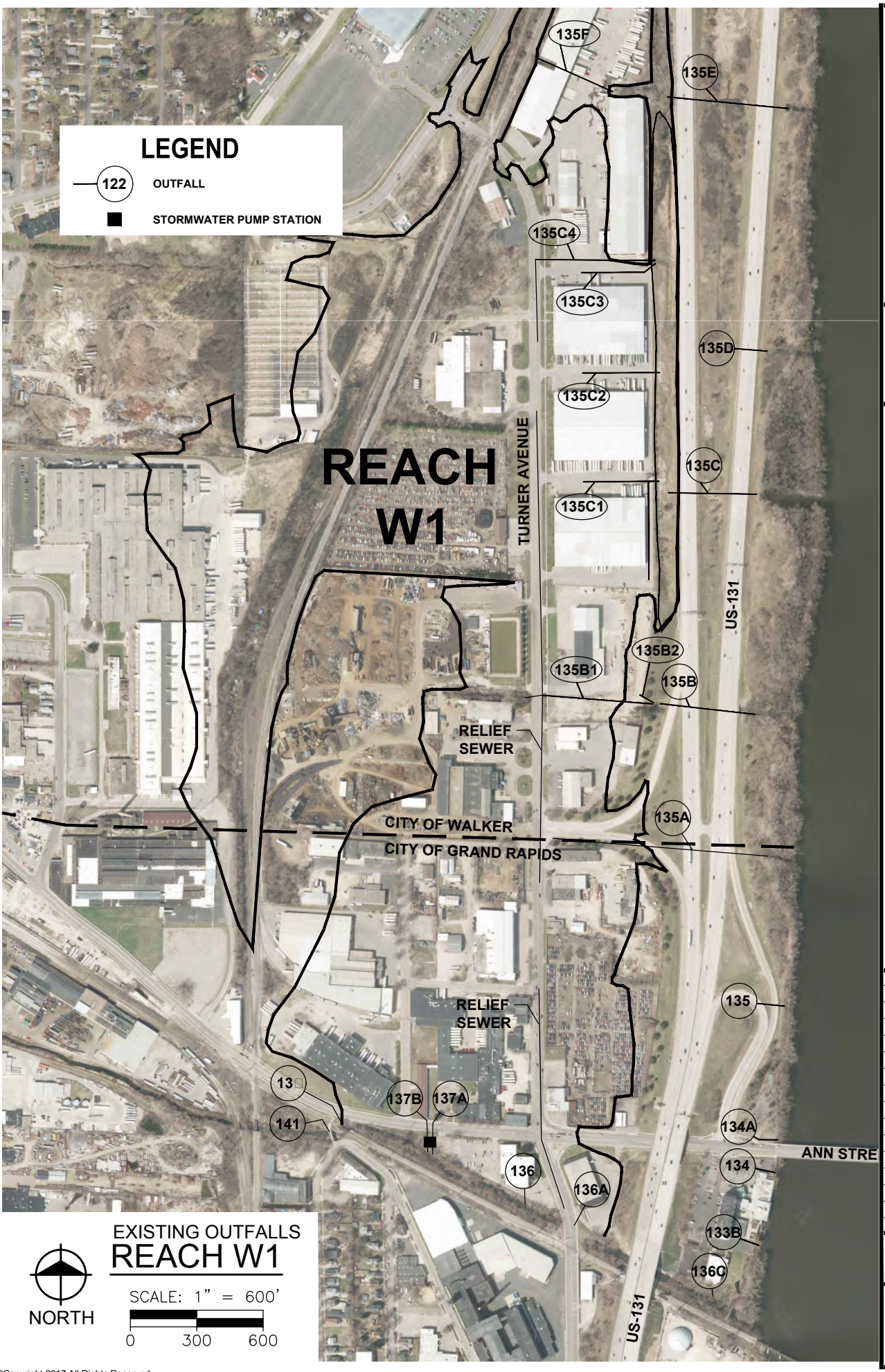

EXISTING OUTFALLS
REACH W1

SCALE: 1" = 600'

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FIGURE NO.
7

PLOT INFO: Z:\2012\120330LMP\CAD\REF\INTERIOR DRAINAGE ANALYSIS.DWG LAYOUT: REACH W1 DATE: 8/28/2017 TIME: 11:18:07 AM USER: JNK

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EXISTI G O TFA S

REACH 2

SCALE: 1" = 900'

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PROJECT NO.
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NORTH

EXISTING OUTFALLS
REACH W3

SCALE: 1" = 600'

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REACH □ 4

SCALE: 1" = 800'

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Interior Drainage Anal□sis

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Legend

- Storm Water Pump Station
- E1 - Knapp to Leonard
- Pump Station Service Area
- Reach Drainage Area

PALMER STREET PUMP STATION

CALEDONIA STREET PUMP STATION

E1

Comstock Park

Grand Rapids

East Grand Rapids

REACH E1
DRAINAGE BASIN MAP

Sources: Esri, H
China (Hong Ko
Commun ty

NORTH

0 1,500 3,000 FEET

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

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FIGURE NO. 11

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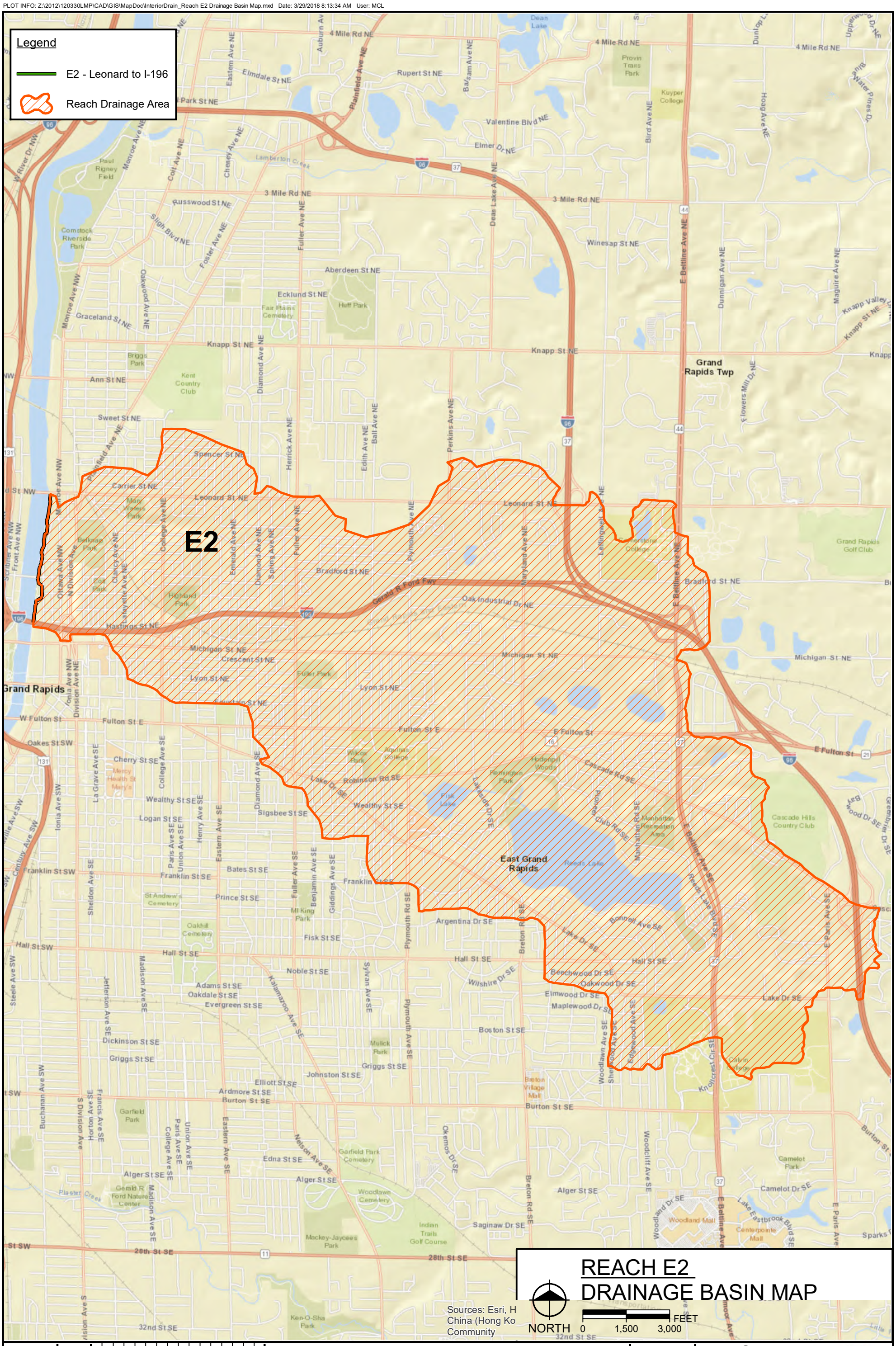

REACH E2
DRAINAGE BASIN MAP

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

FIGURE NO. 12

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Legend

E3 - Pedestrian (Gillett) Bridge to US 131

Reach Drainage Area

E3

REACH E3 DRAINAGE BASIN MAP

NORTH

0 1,500 3,000 FEET

Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

City of Grand Rapids
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Interior Drainage Analysis

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FIGURE NO. 13

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Legend

- Storm Water Pump Station
- E4 - US 131 to 50% distance to WRRF
- Pump Station Service Area
- Reach Drainage Area

MARKET AVENUE PUMP STATION

E4

REACH E4
DRAINAGE BASIN MAP

NORTH

0 1,500 3,000 FEET

Sources: Esri, H China (Hong Ko Commun ty

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

PROJECT NO.
G120330LMP

FIGURE NO.
14

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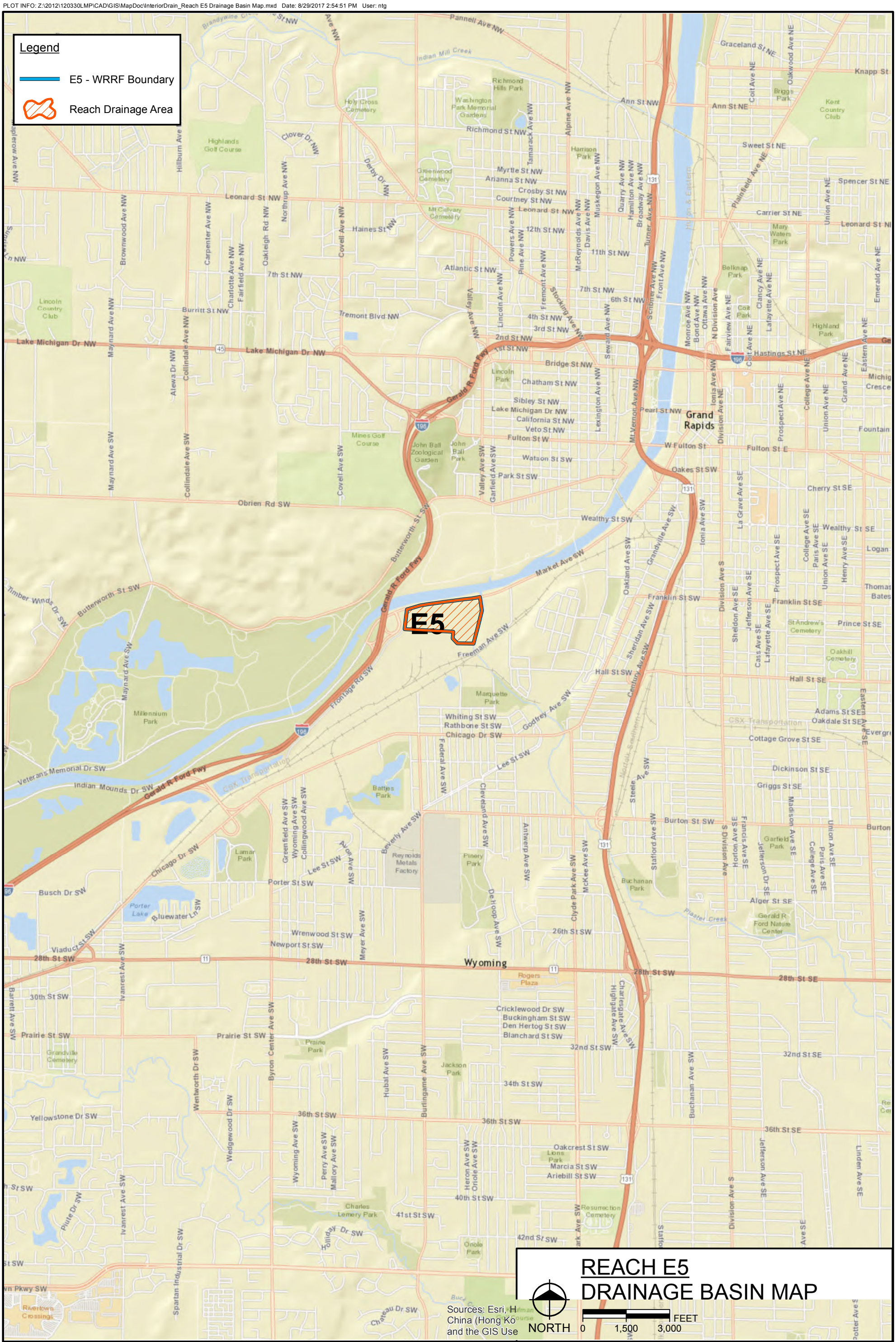
PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\InteriorDrain_Reach E5 Drainage Basin Map.mxd Date: 8/29/2017 2:54:51 PM User: ntg



REACH E5
DRAINAGE BASIN MAP

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

PROJECT NO. G120330LMP

FIGURE NO. 15

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PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\InteriorDrain_Reach W1 Drainage Basin Map.mxd Date: 3/29/2018 8:18:40 AM User: MCL

Legend

- Storm Water Pump Station
- W1 - North of Indian Mill Creek
- Pump Station Service Area
- Reach Drainage Area

W1

INDIAN MILL CREEK PUMP STATION

REACH W1
DRAINAGE BASIN MAP

NORTH 0 1,500 3,000 FEET

Sources: Esri, H China (Hong Ko Community

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

PROJECT NO. G120330LMP

FIGURE NO. 16

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PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\InteriorDrain_Reach W2 Drainage Basin Map.mxd Date: 3/29/2018 8:20:12 AM User: MCL

Legend

- Storm Water Pump Station
- W2 - Indian Mill Creek to I-196
- Pump Station Service Area
- Reach Drainage Area

W2

FRONT & SCRIBNER PUMP STATION

REACH W2
DRAINAGE BASIN MAP

NORTH

0 1,500 3,000 FEET

Sources: Esri, H China (Hong Ko Community

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

PROJECT NO. G120330LMP

FIGURE NO. 17

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PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\InteriorDrain_Reach W3 Drainage Basin Map.mxd Date: 8/29/2017 3:20:11 PM User: ntg


Legend
W3 - I-196 to Fulton
Reach Drainage Area
W3
Grand Rapids
Wyoming
4 Mile Rd NW
3 Mile Rd NW
Ferris St NW
Waldorf St NW
Pannell Ave NW
Indian Mill Creek
Richmond St NW
Ann St NW
Ann St NE
Graceland St NE
Knapp St NE
3 Mile Rd NE
Russwood St NE
Ellsmere St NE
Oaklawn St NE
Aberdeen St NE
N Park St NE
Elmdale St NE
Rupert St NE
Lamberton Creek
Bridge St NW
Chatham St NW
Sibley St NW
Lake Michigan Dr NW
California St NW
Veto St NW
Fulton St W
W Fulton St
Fulton St E
Watson St SW
Oakes St SW
Park St SW
Wealthy St SW
Market Ave SW
Franklin St SW
Franklin St SE
Hall St SW
Hall St SE
Whiting St SW
Rathbone St SW
Chicago Dr SW
Lee St SW
Burton St SW
Burton St SE
Elliott St SE
Griggs St SE
Dickinson St SE
Cottage Grove St SE
Boston St SE
Edna St SE
Alger St SE
Fountain St NE
Lyon St NE
Michigan St NE
Crescent St NE
Hastings St NE
Bradford St NE
Sweet St NE
Spencer St NE
Carrier St NE
Leonard St NE
Leonard
Tremont Blvd NW
Atlantic St NW
Haines St NW
Leonard St NW
Crosby St NW
Courtney St NW
Arianna St NW
Myrtle St NW
Cheney Ave NE
Plainfield Ave NE
Dorais Dr NE
Plaza Dr NE
Oak Industrial Dr NE
Gerald R Ford Fwy
Frontage Rd SW
Butterworth St SW
Freeman Ave SW
Godfrey Ave SW
Cricklewood Dr SW
Buckingham St SW
Den Hertog St SW
Blanchard St SW
26th St SW
28th St SW
Saginaw Dr SE
Cherry St SE
Robinson Rd SE
Lake Dr SE
Wealthy St SE
Logan St SE
Sigsbee St SE
Sherman St SE
Thomas St SE
Bates St SE
Franklin St SE
Prince St SE
Alexander St SE
Argentina Dr SE
Fisk St SE
Hall St SE
Adams St SE
Oakdale St SE
Evergreen St SE
Wilshire Dr SE
Cottage Grove St SE
Dickinson St SE
Griggs St SE
Elliott St SE
Burton St SE
Edna St SE
Alger St SE
Saginaw Dr SE
Michigan
Fulton St E
Lake Michigan
Grand River
Indian Mill Creek
Plaster Creek
Fisk Lake
Reeds Lake
Holy Cross Cemetery
Mt Calvary Cemetery
Greenwood Cemetery
Fair Plains Cemetery
Oakhill Cemetery
St Andrew's Cemetery
Garfield Park Cemetery
Woodlawn Cemetery
Mackey-Jaycees
Kent Country Club
English Hills Country Club
Alpine Estates Park
Comstock Riverside Park
Paul Rigney Field
Richmond Hills Park
Washington Park Memorial Gardens
Harrison Park
Mary Waters Park
Belknap Park
Coit Park
Highland Park
Fuller Park
Aquinas College
Wilcox Park
Remington Park
Huff Park
Briggs Park
Mulick Park
Garfield Park
Pinery Park
Buchanan Park
Gerald R Ford Nature Center
Marquette Park
Battles Park
Prairie Park
Rogers Plaza
Reynolds Metals Factory
Lincoln Park
Alpine Park
John Ball Park
John Ball Zoological Garden
Mines Golf Course
Harrison Park
Greenwood Cemetery
Mt Calvary Cemetery
Holy Cross Cemetery
Oakhill Cemetery
Woodlawn Cemetery
Fair Plains Cemetery
Garfield Park Cemetery
Mackey-Jaycees
Indian Trails Golf
Aquinas College
Wilcox Park
Remington Park
Huff Park
Fisk Lake
Reeds Lake

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\InteriorDrain_Reach W4 Drainage Basin Map.mxd Date: 3/29/2018 8:21:52 AM User: MCL

Legend

- Storm Water Pump Station
- W4 - Fulton to Butterworth Landfill
- Reach Drainage Area
- Pump Station Service Area

W4

WEALTHY STREET PUMP STATION

Grand Rapids

Wyoming

REACH W4
DRAINAGE BASIN MAP

NORTH

0 1,500 3,000 FEET

Sources: Esri, H China (Hong Ko Commun ty

City of Grand Rapids
Kent County, Michigan

Interior Drainage Analysis

PROJECT NO. G120330LMP

FIGURE NO. 19

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Figure 20: Interior Areas 1 Percent Annual Chance Precipitation Runoff Hydrographs

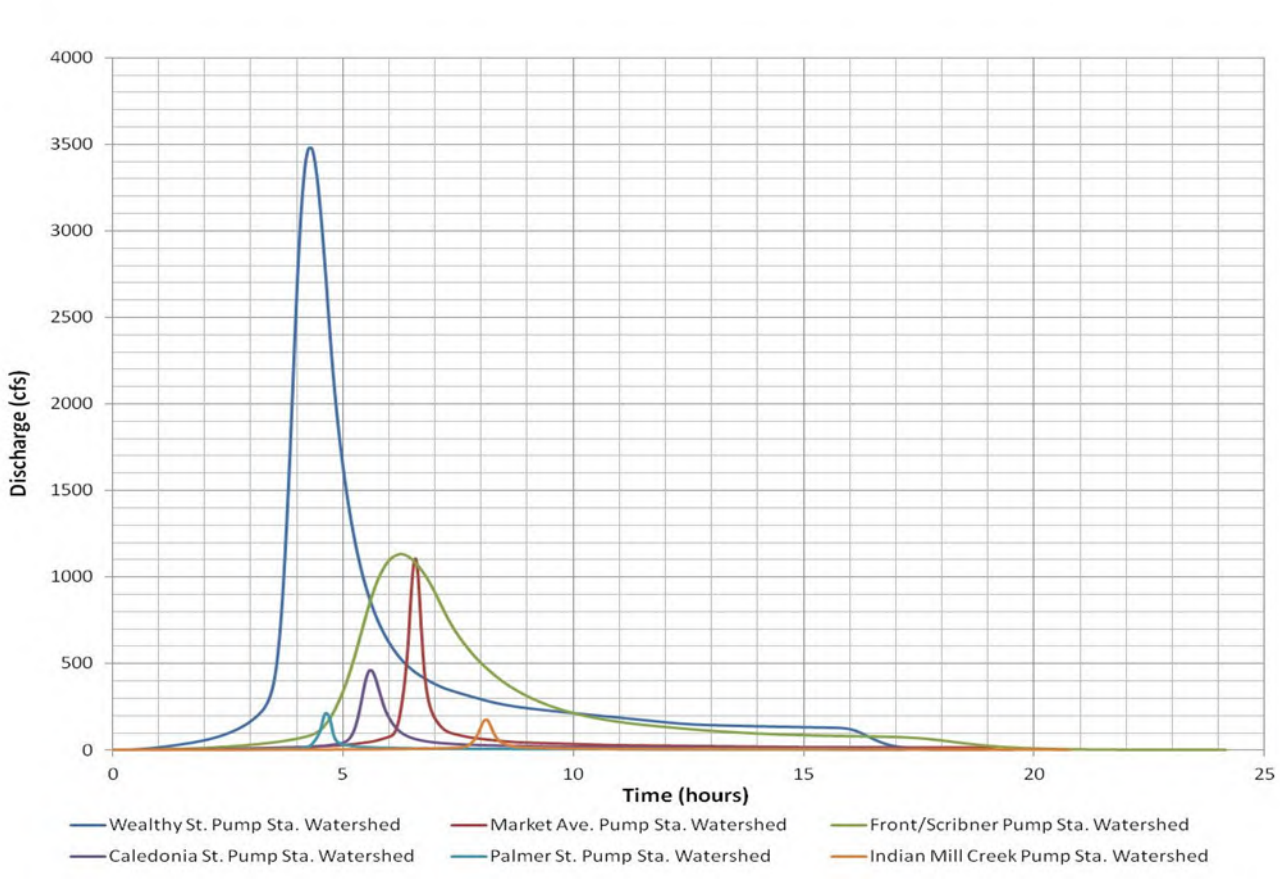


Figure 21: Grand River Top Ten Discharge Flood Hydrographs and Estimated 1 Percent Annual Chance Flood Hydrograph

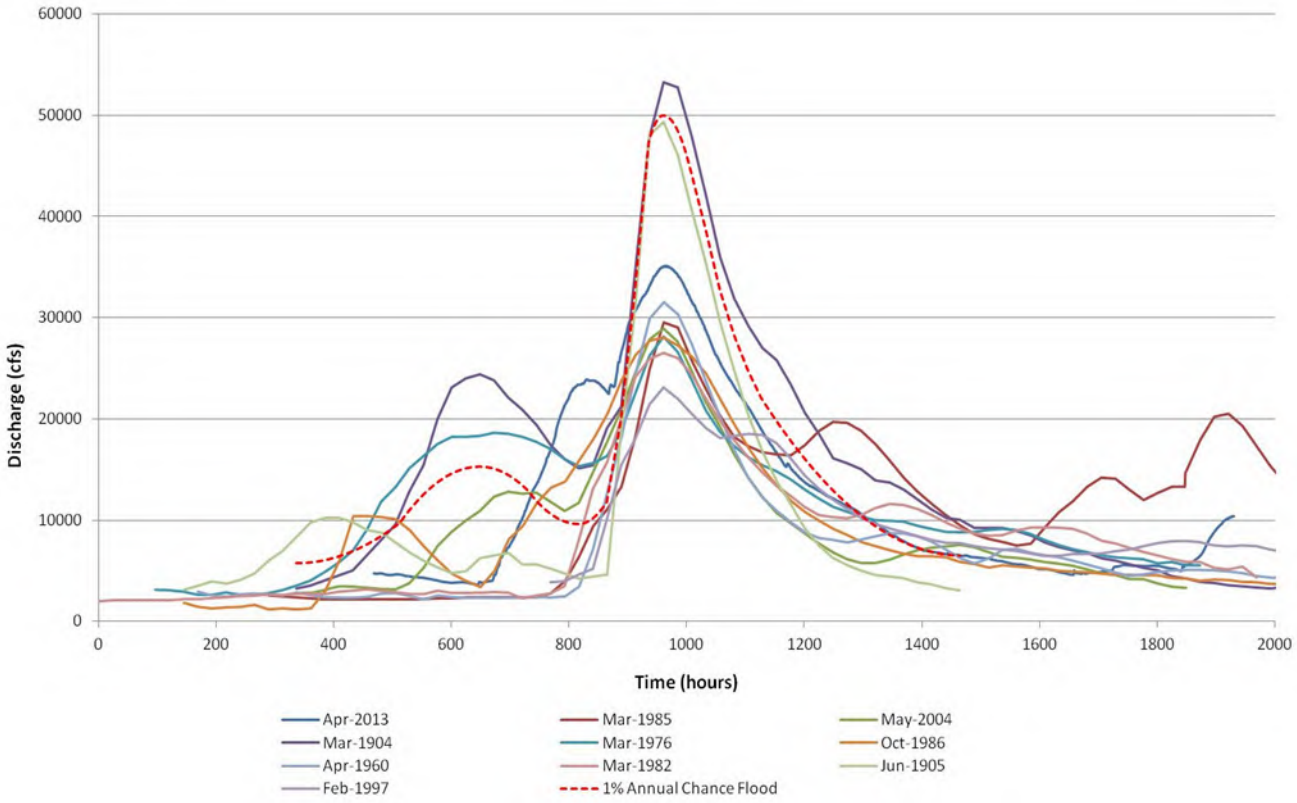


Figure 22: Grand River at Grand Rapids 1 Percent Annual Chance Flood Hydrograph

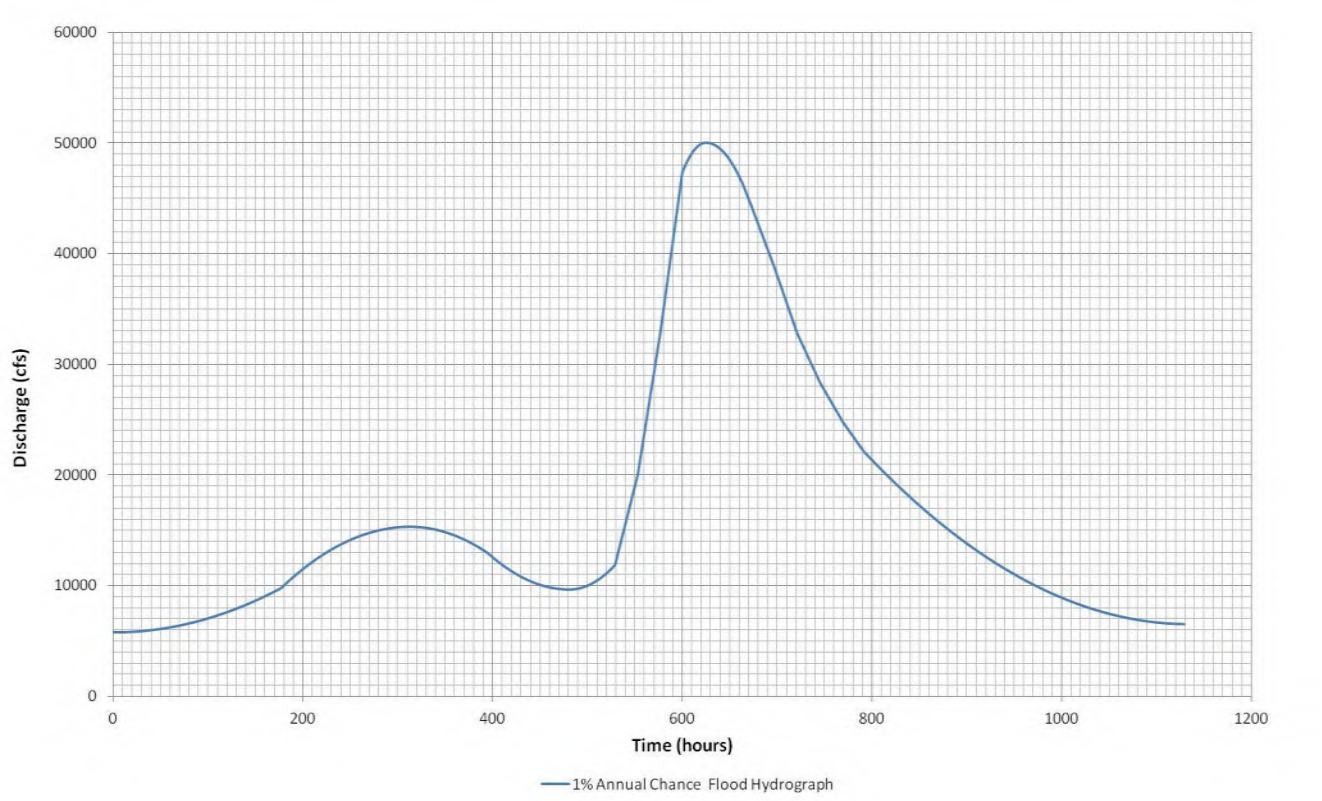


Figure 23: Grand River 1 Percent Annual Chance Flood Hydrograph and Pump Station Operation Levels

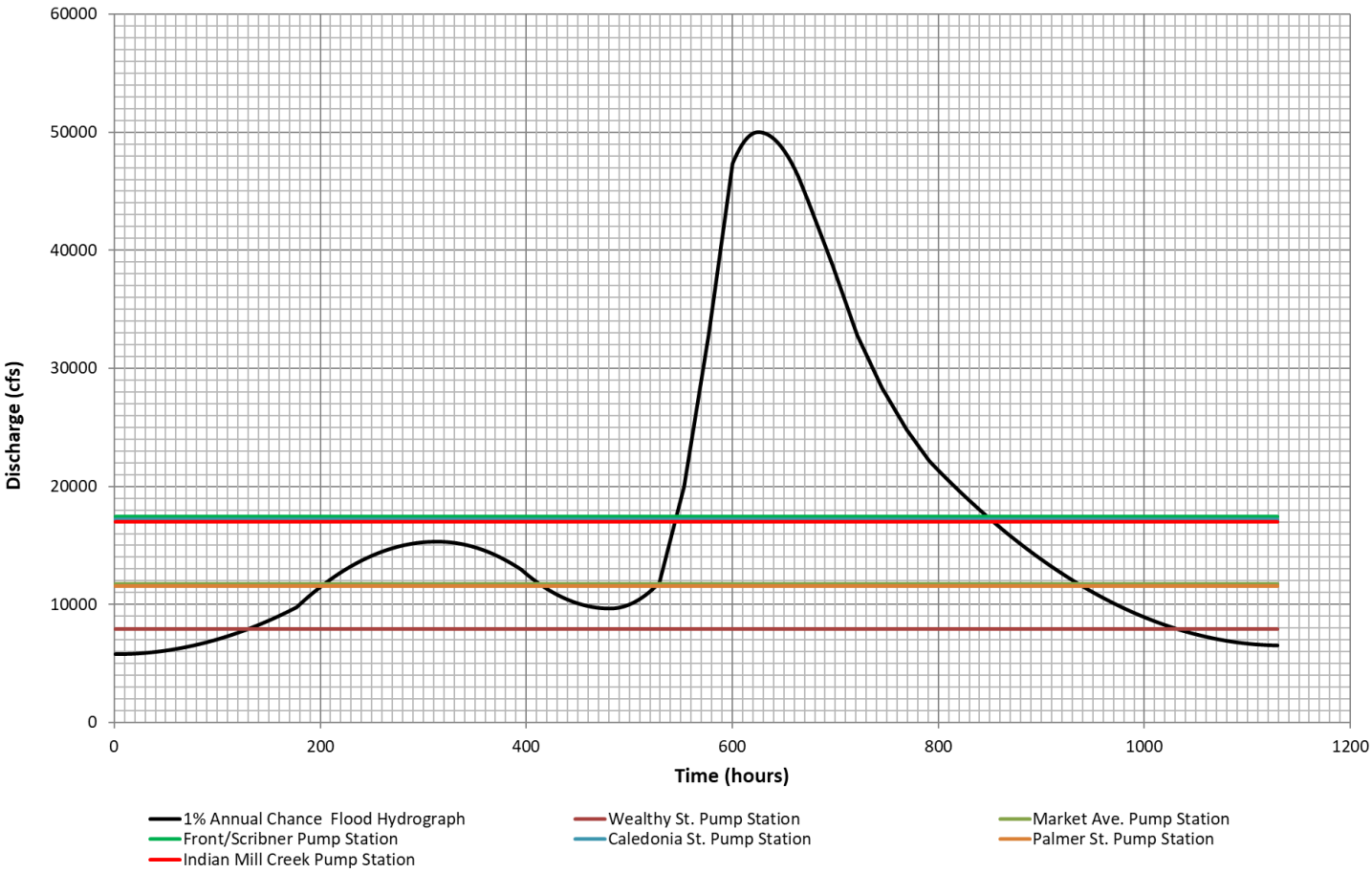


Figure 24: Discharge versus Percent Time Exceeded Curve for the Grand River at Grand Rapids, Michigan

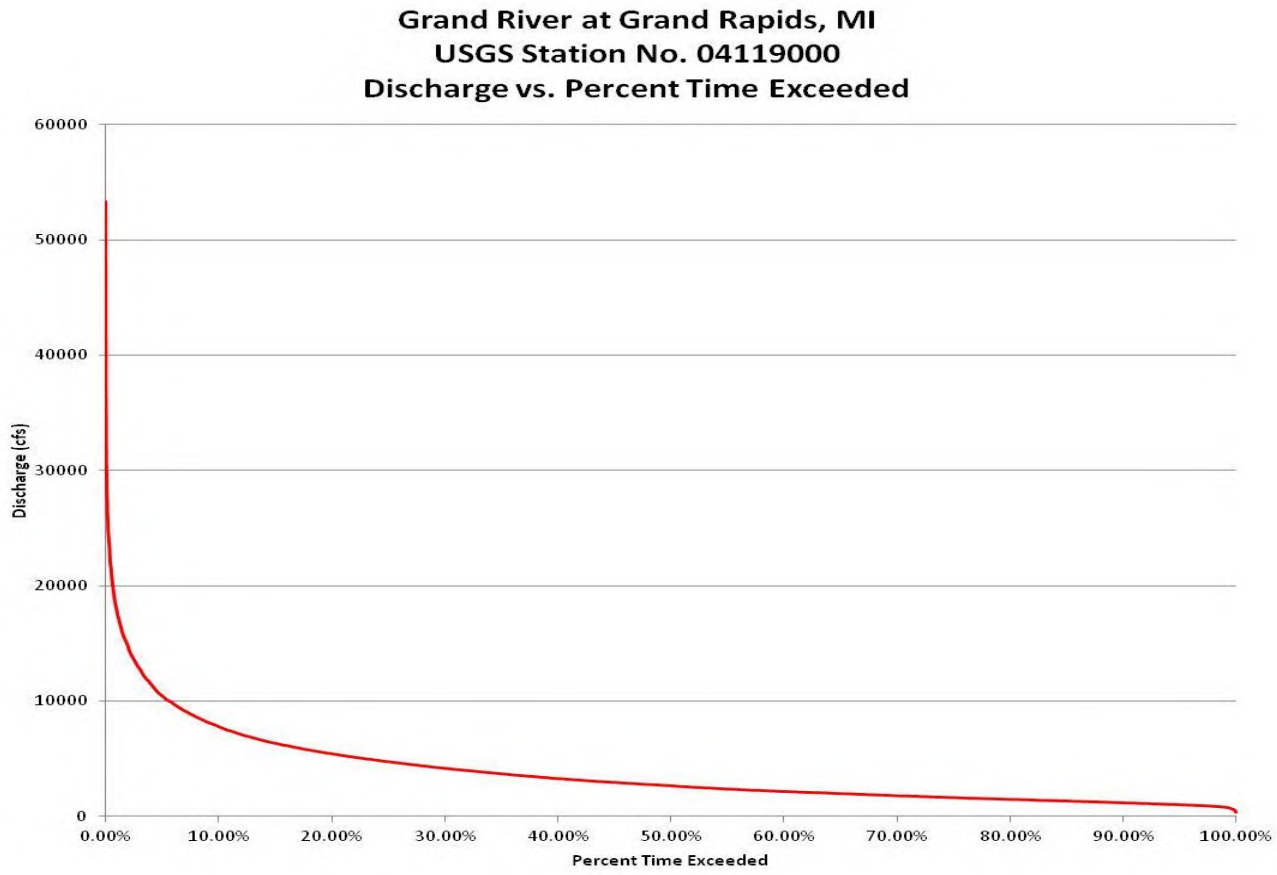
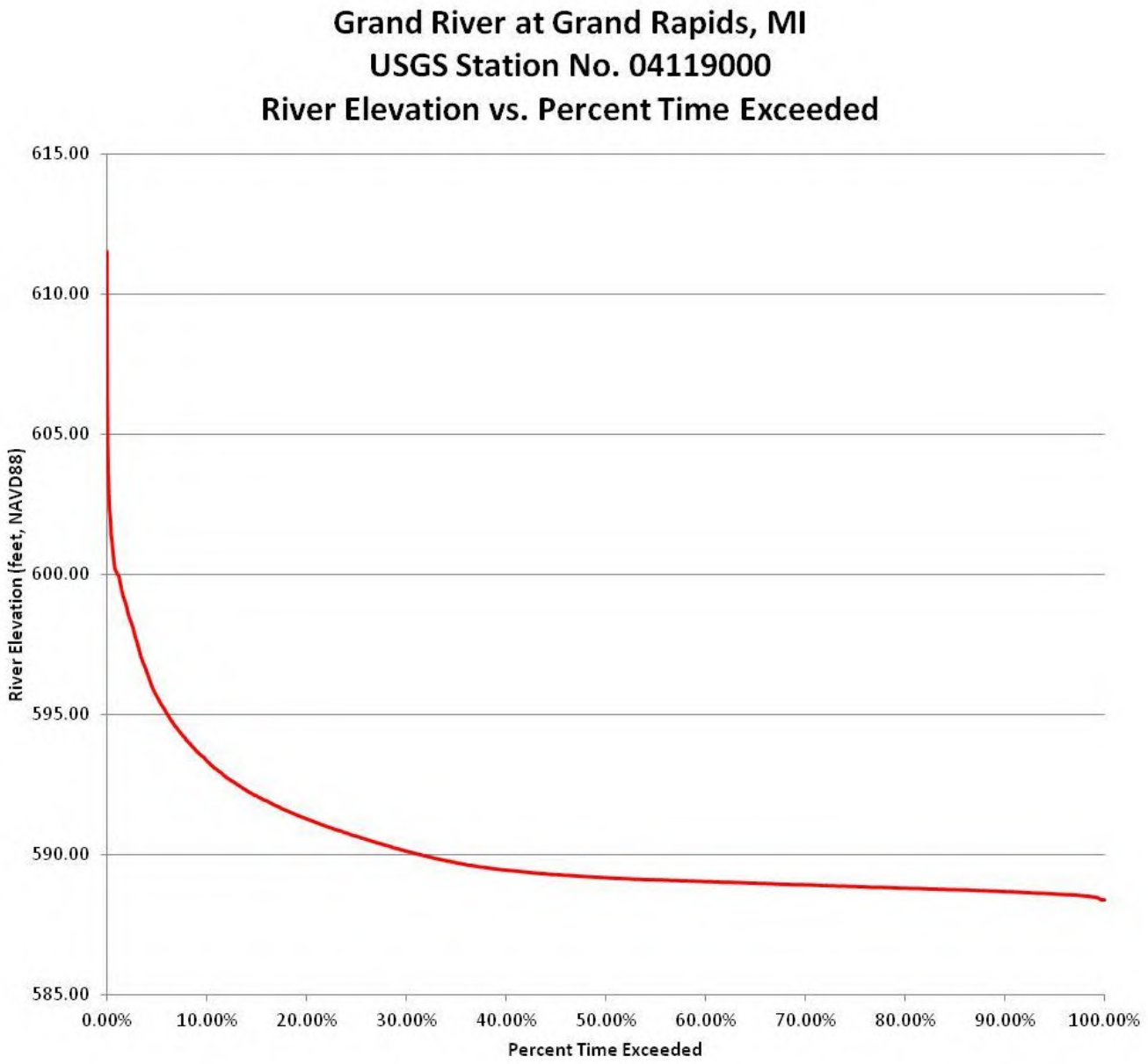


Figure 25: Elevation versus Percent Time Exceeded curve for the Grand River at Grand Rapids, Michigan



Appendix 1

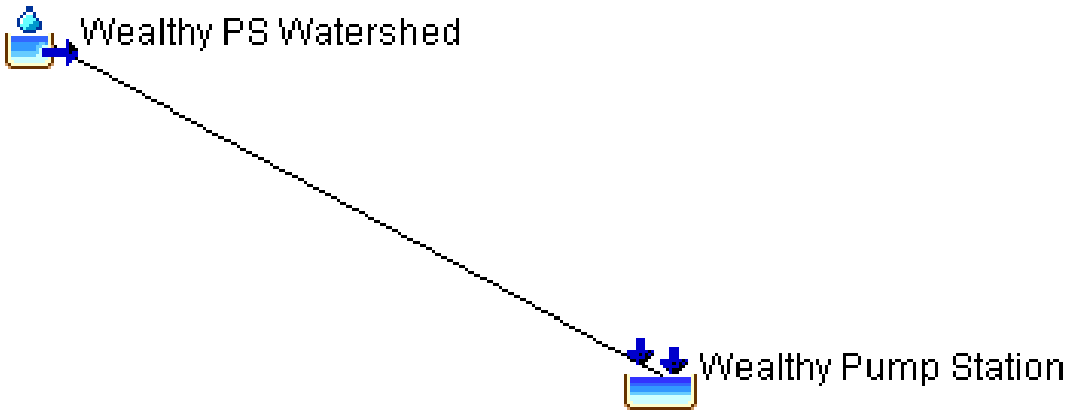
Hydrologic Analysis

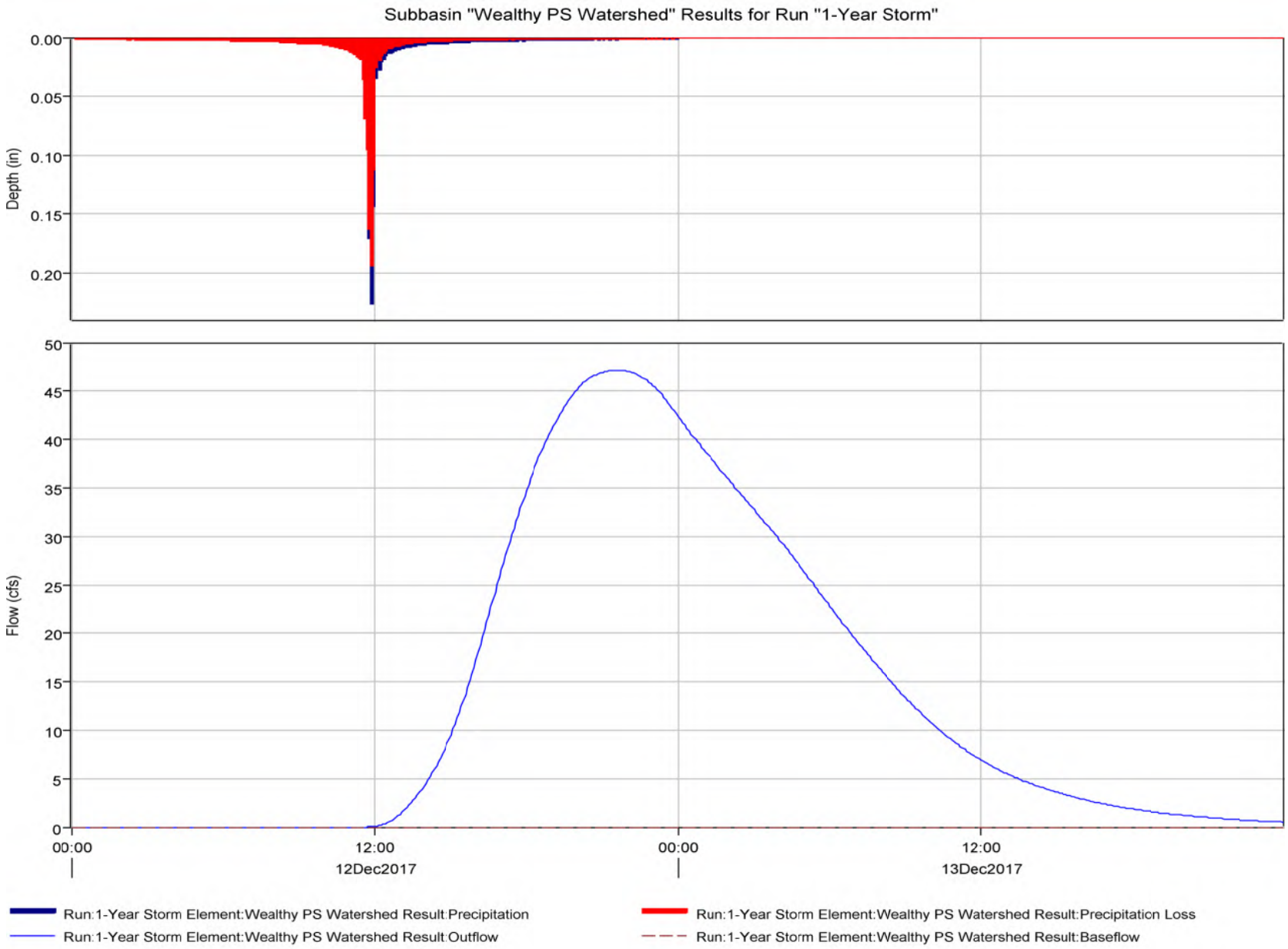
WinTR-55

Wealthy Street Pump Station Watershed

Wealthy Street Pump Station

HEC-HMS Basin Model




Subbasin "Wealthy PS Watershed" Results for Run "1-Year Storm"
Depth (in)
0.00
0.05
0.10
0.15
0.20
Flow (cfs)
50
45
40
35
30
25
20
15
10
5
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:1-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:1-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:1-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:1-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 1-Year Storm

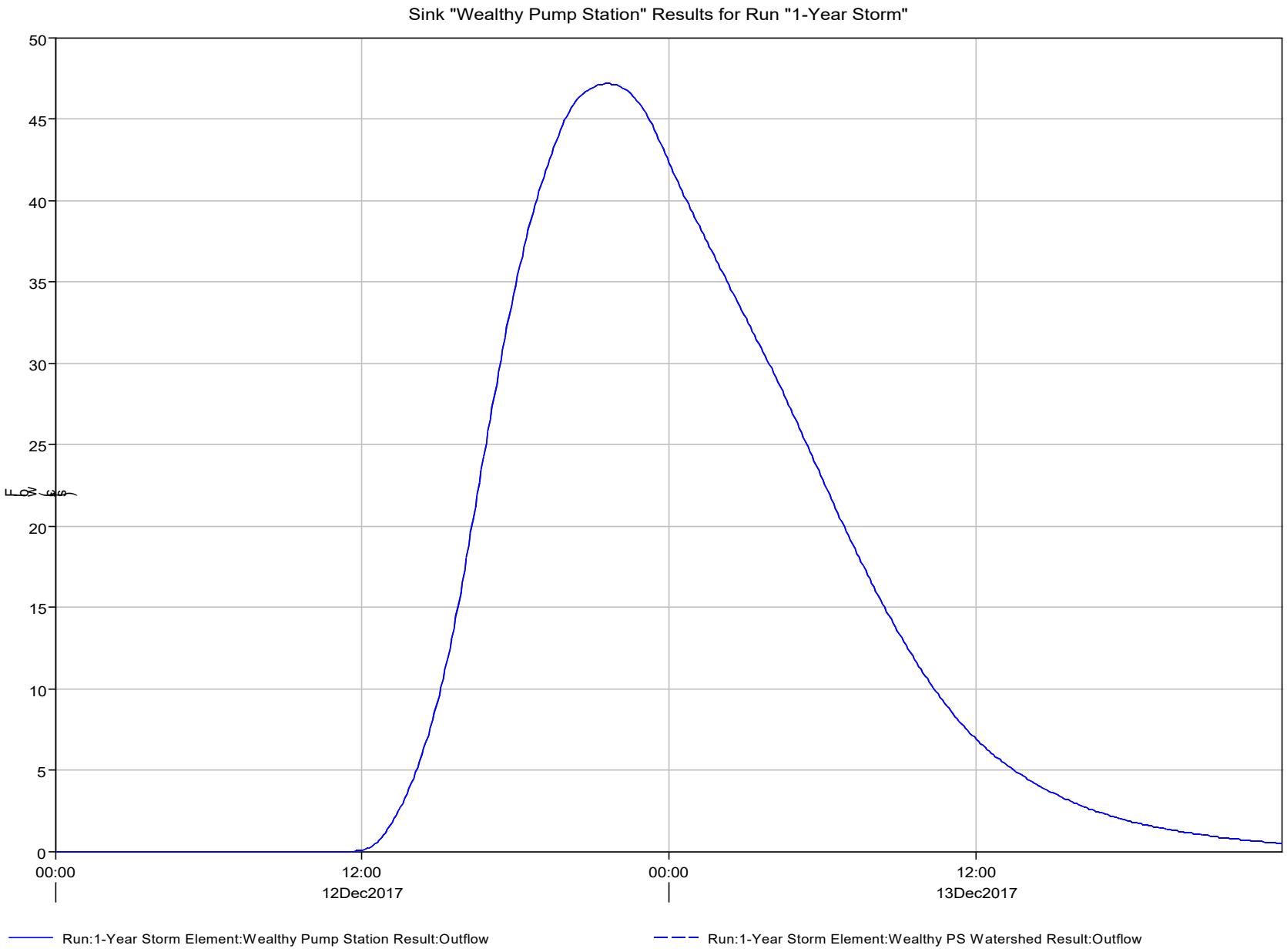
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	1-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:04	Control Specifications:	1-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	47.2 (CFS)	Date/Time of Peak Discharge	12Dec2017, 21:35
Precipitation Volume	1.95 (IN)	Direct Runoff Volume:	0.30 (IN)
Loss Volume:	1.65 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	0.30 (IN)	Discharge Volume:	0.30 (IN)


Sink "Wealthy Pump Station" Results for Run "1-Year Storm"
50
45
40
35
30
25
20
15
10
5
0
Flow (cfs)
00:00
12Dec2017
12:00
00:00
13Dec2017
12:00
Run:1-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:1-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 1-Year Storm

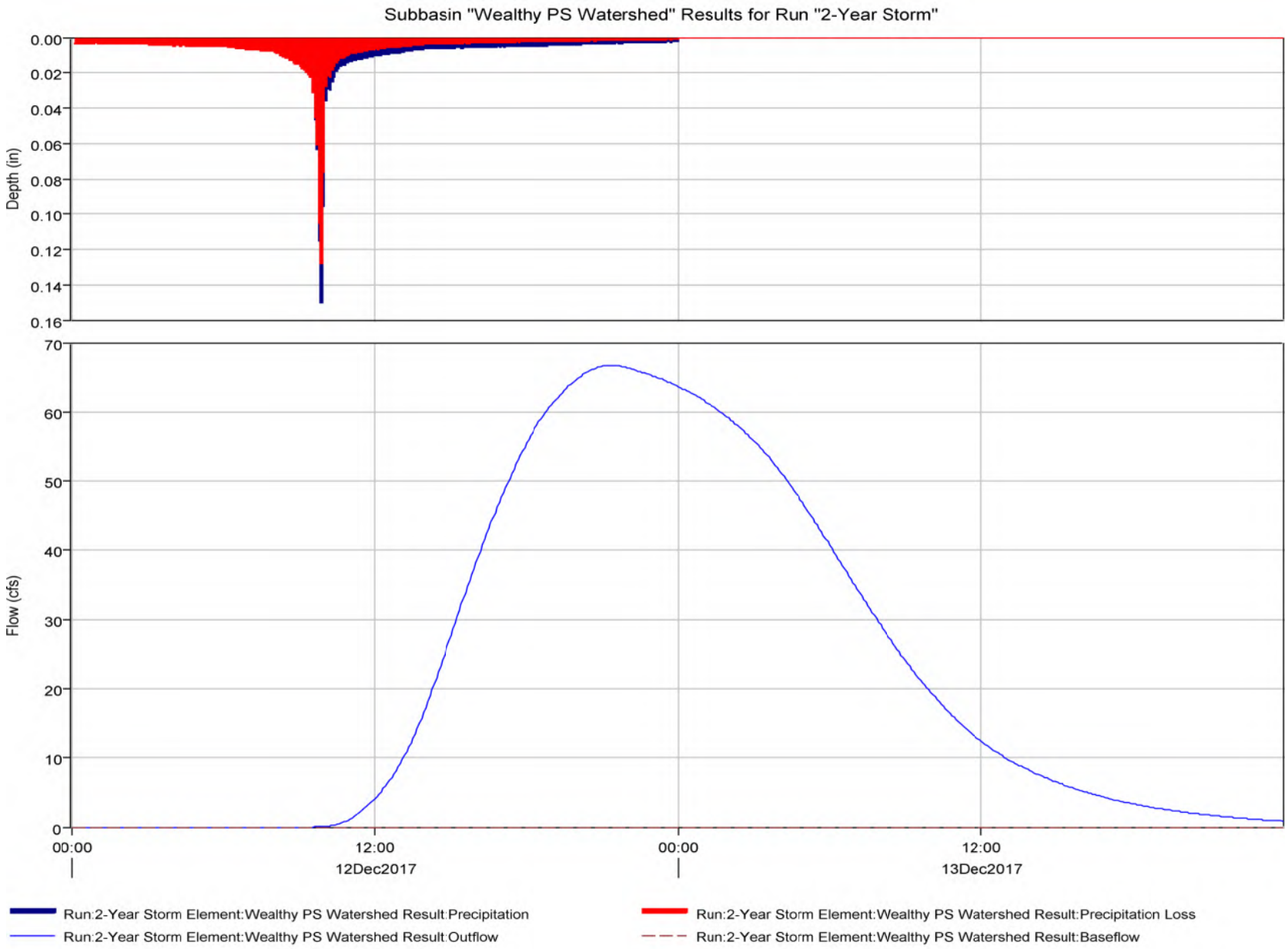
Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	1-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:04	Control Specifications:	1-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	47.2 (CFS)	Date/Time of Peak Discharge	12Dec2017, 21:35
Volume:	0.30 (IN)		


Subbasin "Wealthy PS Watershed" Results for Run "2-Year Storm"
Depth (in)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
Flow (cfs)
70
60
50
40
30
20
10
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:2-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:2-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:2-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:2-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 2-Year Storm

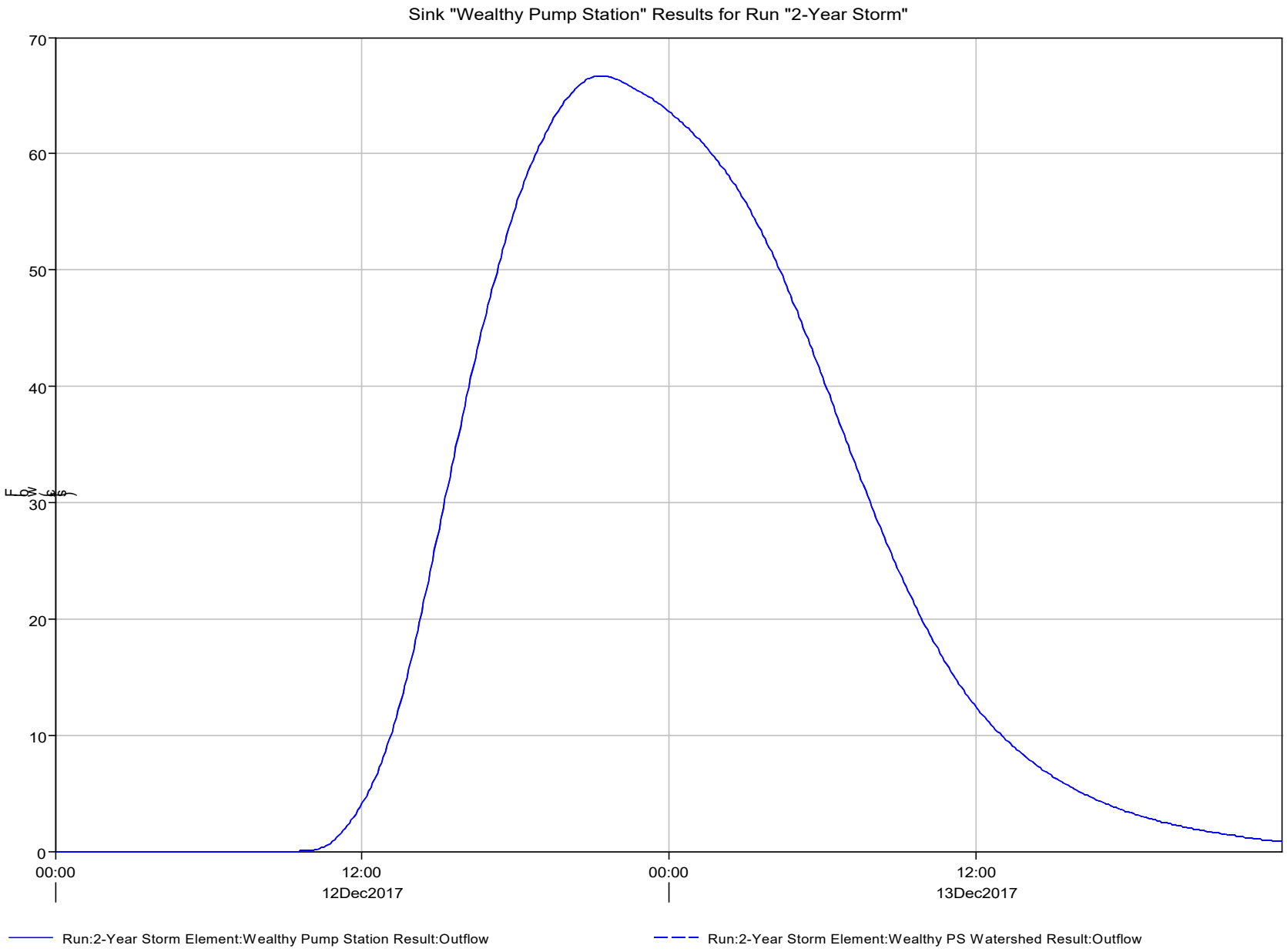
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	2-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:08	Control Specifications:	2-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	66.7 (CFS)	Date/Time of Peak Discharge	12Dec2017, 21:20
Precipitation Volume	2.37 (IN)	Direct Runoff Volume:	0.50 (IN)
Loss Volume:	1.87 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	0.50 (IN)	Discharge Volume:	0.50 (IN)


Sink "Wealthy Pump Station" Results for Run "2-Year Storm"
70
60
50
40
30
20
10
0
Flow (cfs)
00:00
12Dec2017
12:00
00:00
13Dec2017
12:00
Run:2-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:2-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 2-Year Storm

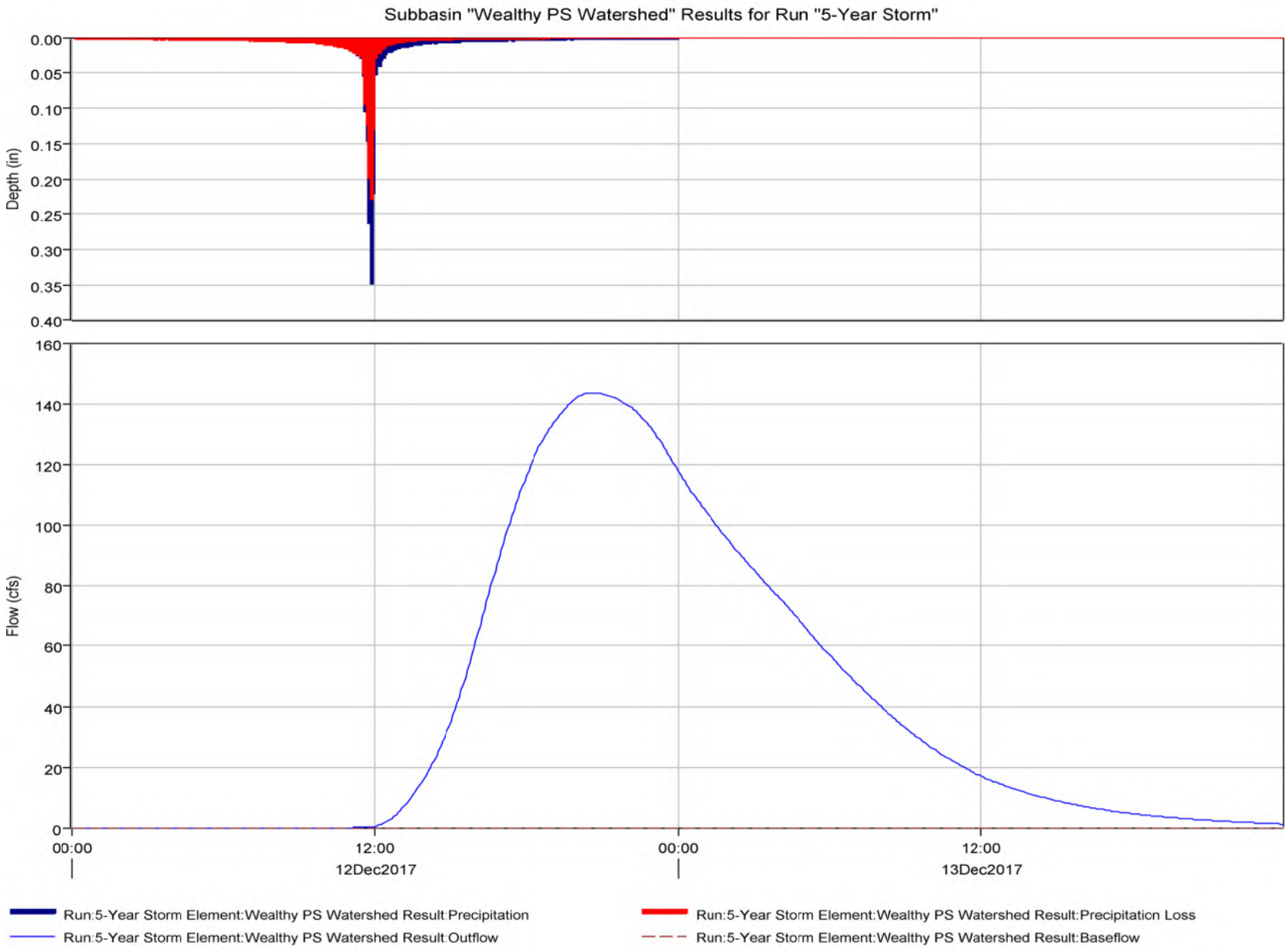
Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	2-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:08	Control Specifications:	2-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	66.7 (CFS)	Date/Time of Peak Discharge	12Dec2017, 21:20
Volume:	0.50 (IN)		


Subbasin "Wealthy PS Watershed" Results for Run "5-Year Storm"
Depth (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Flow (cfs)
160
140
120
100
80
60
40
20
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:5-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:5-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:5-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:5-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 5-Year Storm

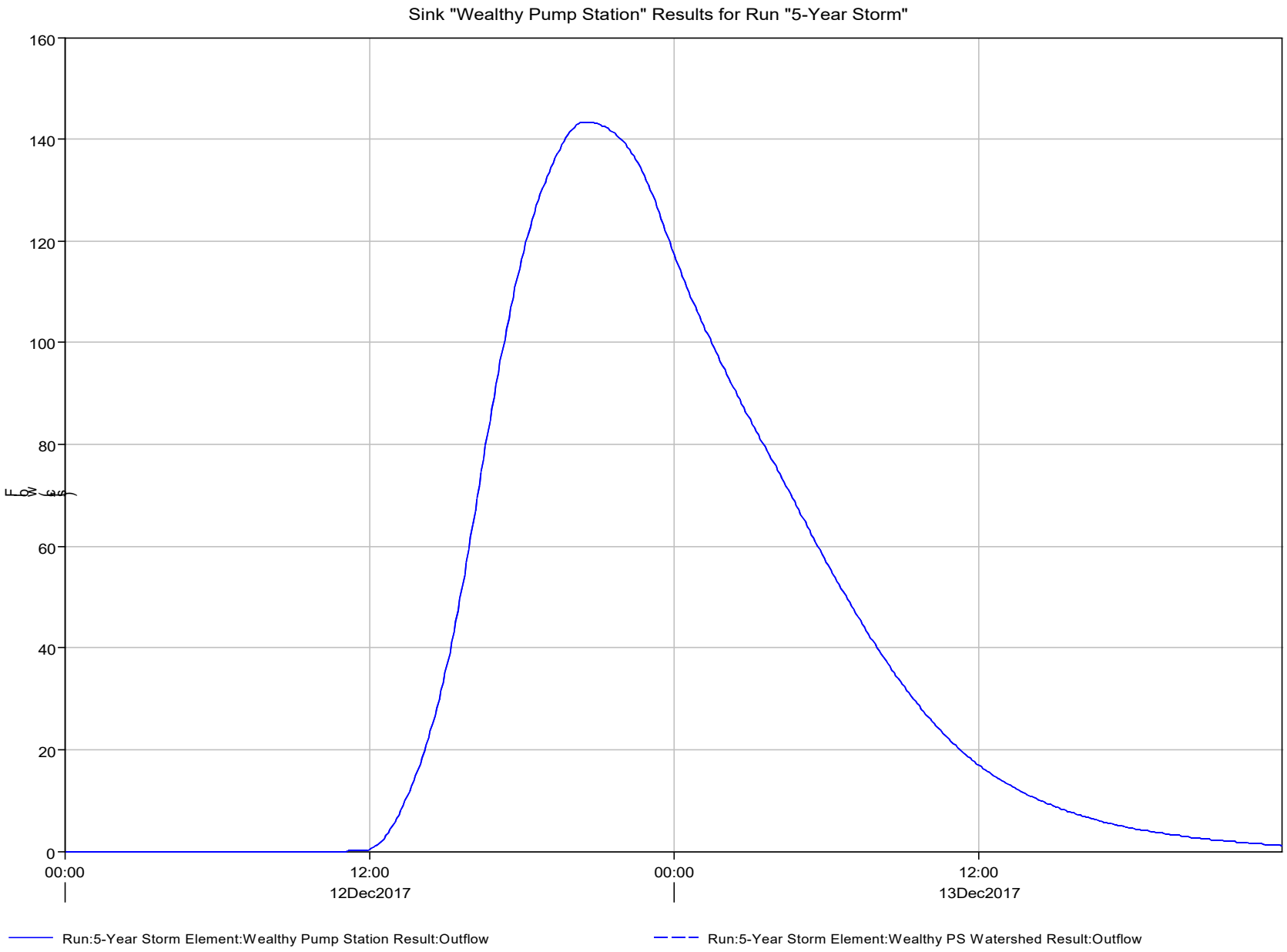
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	5-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:11	Control Specifications:	5-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	143.4 (CFS)	Date/Time of Peak Discharge:	12Dec2017, 20:35
Precipitation Volume:	3.00 (IN)	Direct Runoff Volume:	0.86 (IN)
Loss Volume:	2.14 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	0.86 (IN)	Discharge Volume:	0.86 (IN)


Sink "Wealthy Pump Station" Results for Run "5-Year Storm"
160
140
120
100
80
60
40
20
0
Flow (cfs)
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:5-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:5-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 5-Year Storm

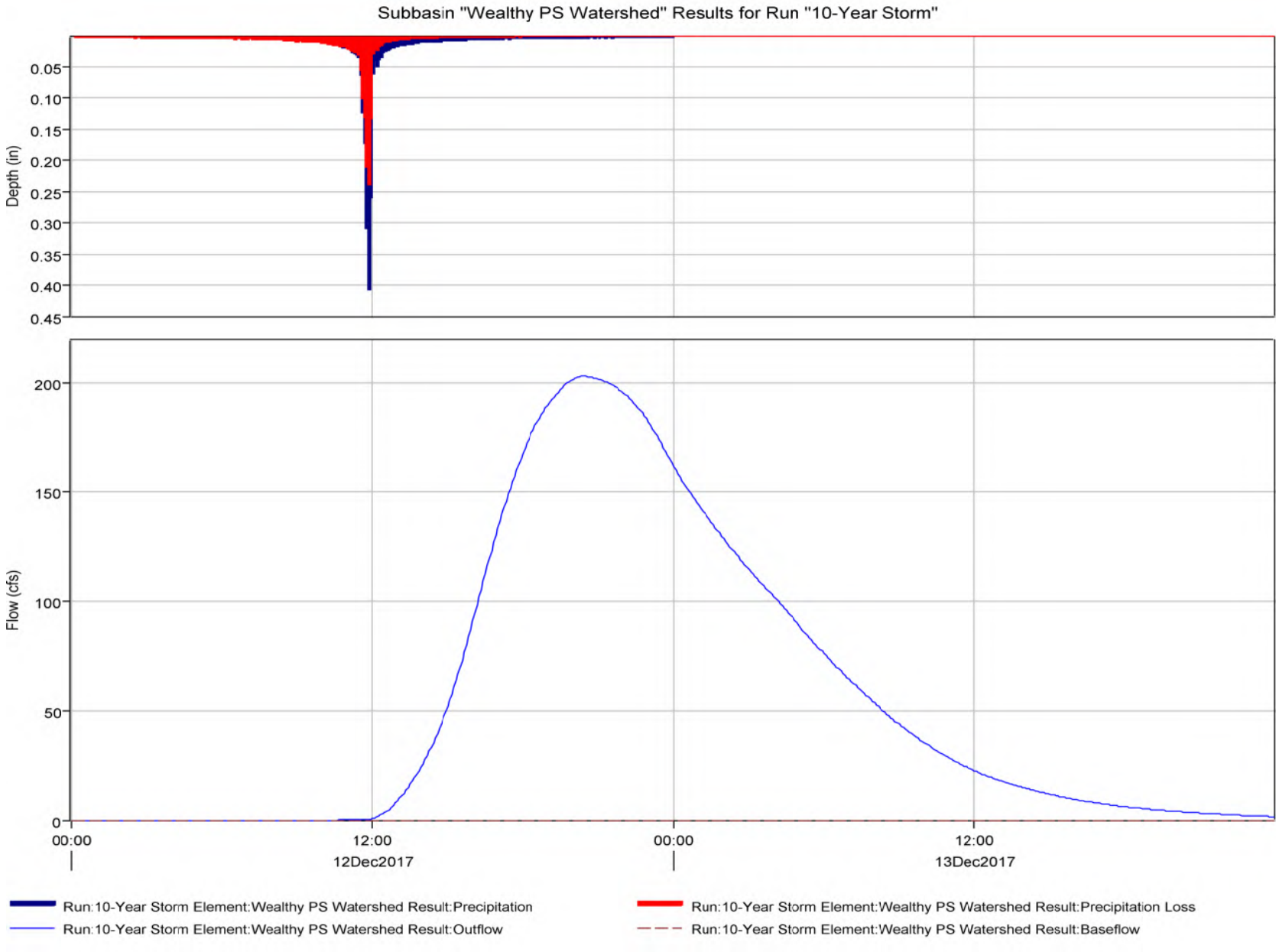
Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	5-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:11	Control Specifications:	5-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	143.4 (CFS)	Date/Time of Peak Discharge	12Dec2017, 20:35
Volume:	0.86 (IN)		


Subbasin "Wealthy PS Watershed" Results for Run "10-Year Storm"
Depth (in)
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Flow (cfs)
200
150
100
50
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:10-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:10-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:10-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:10-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 10-Year Storm

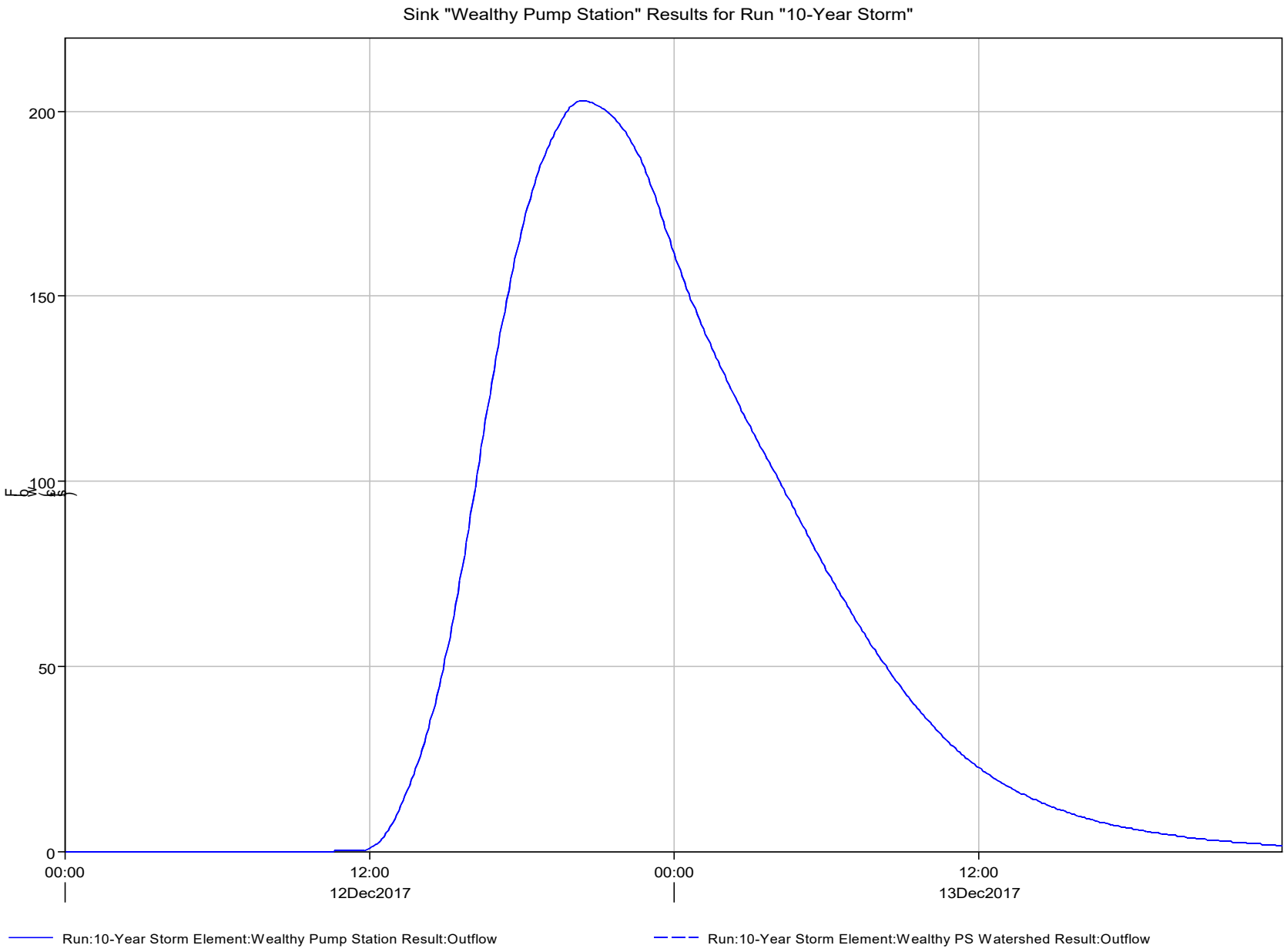
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	10-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:05	Control Specifications:	10-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	202.9 (CFS)	Date/Time of Peak Discharge:	12Dec2017, 20:25
Precipitation Volume:	3.52 (IN)	Direct Runoff Volume:	1.19 (IN)
Loss Volume:	2.33 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	1.19 (IN)	Discharge Volume:	1.19 (IN)


Sink "Wealthy Pump Station" Results for Run "10-Year Storm"
200
150
100
50
0
Flow (cfs)
00:00
12Dec2017
12:00
00:00
13Dec2017
12:00
Run:10-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:10-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 10-Year Storm

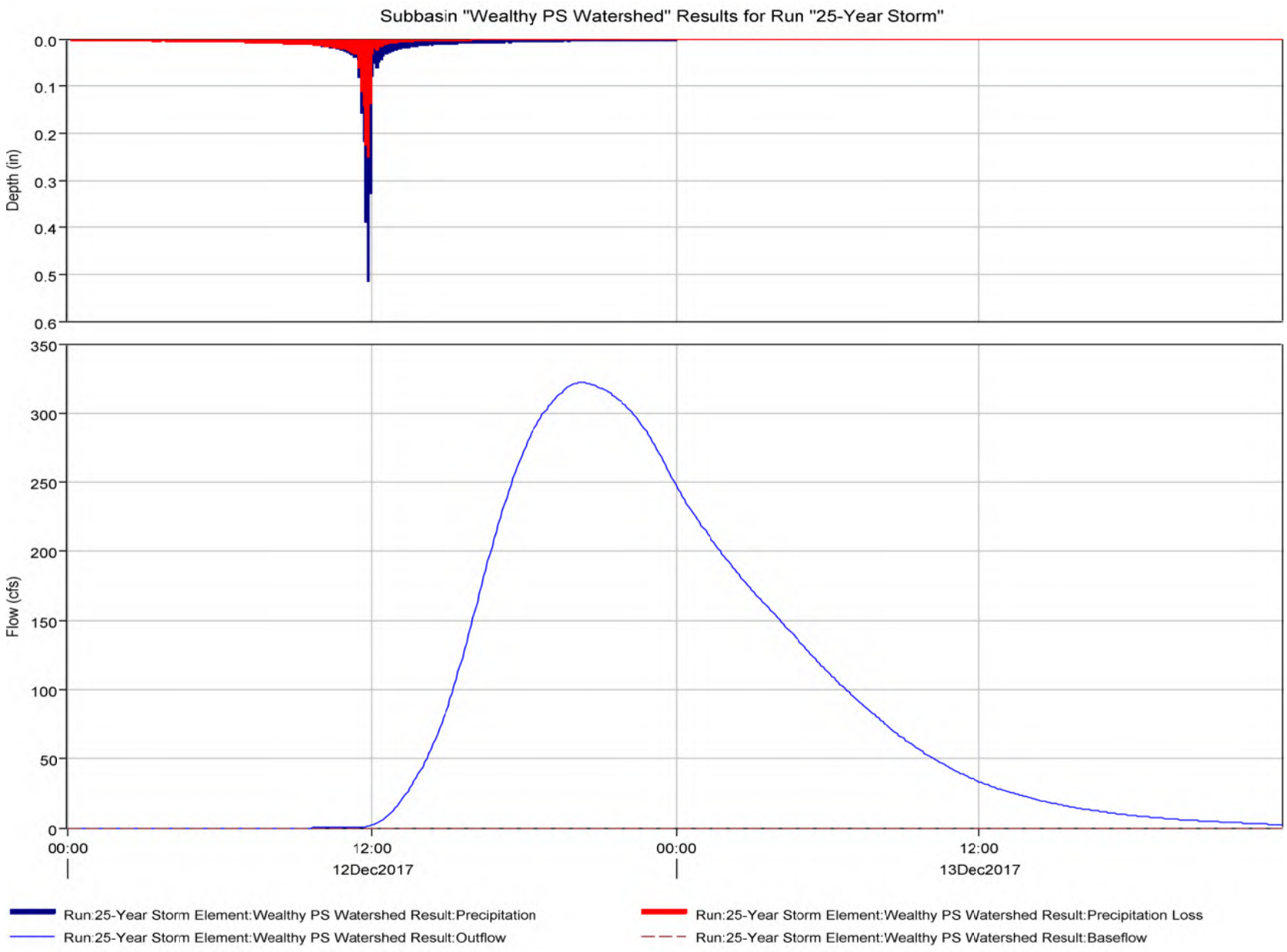
Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	10-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:05	Control Specifications:	10-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	202.9 (CFS)	Date/Time of Peak Discharge	12Dec2017, 20:25
Volume:	1.19 (IN)		


Subbasin "Wealthy PS Watershed" Results for Run "25-Year Storm"
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Flow (cfs)
350
300
250
200
150
100
50
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:25-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:25-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:25-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:25-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 25-Year Storm

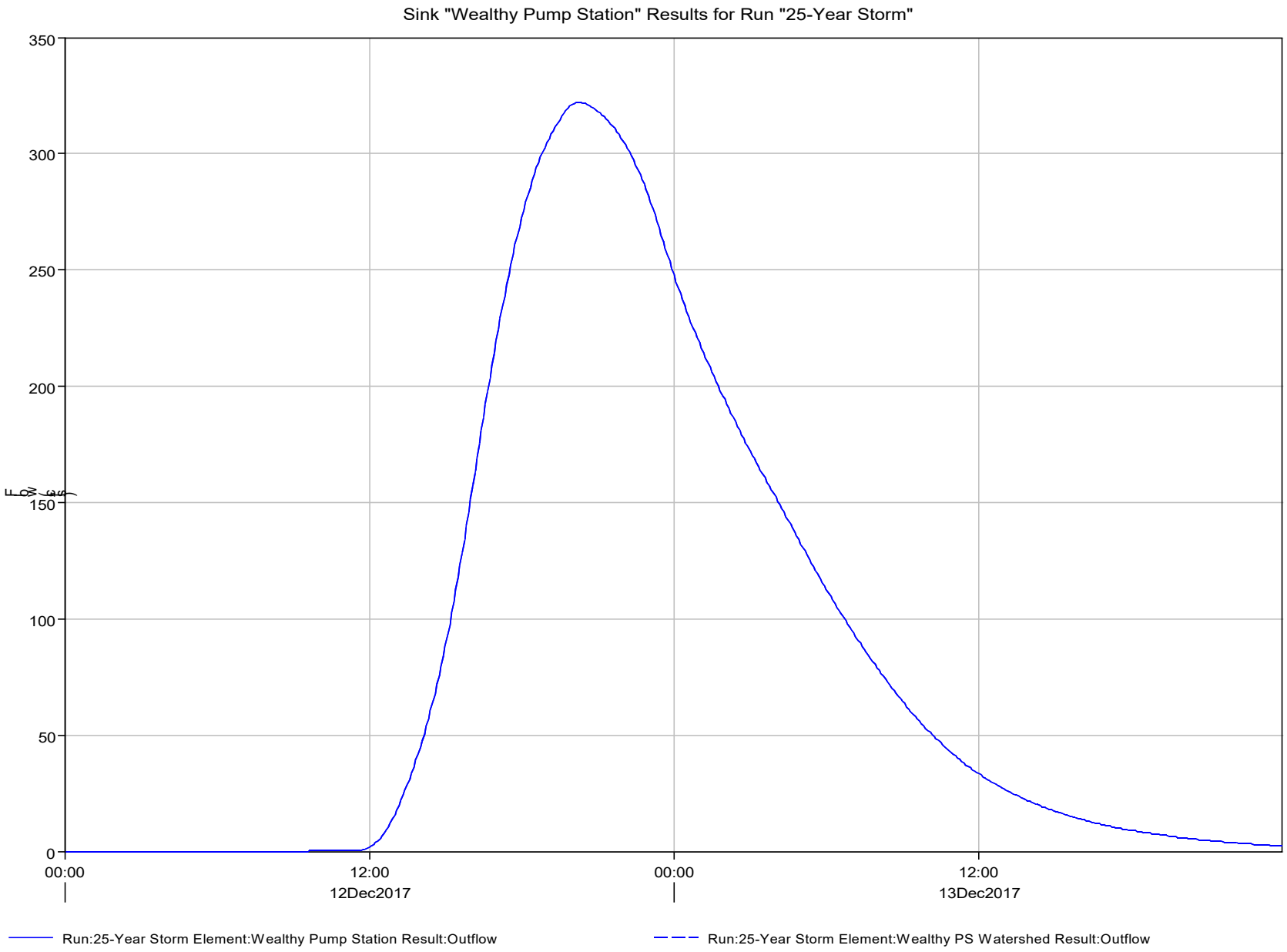
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	25-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:09	Control Specifications:	25-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	322.1 (CFS)	Date/Time of Peak Discharge:	12Dec2017, 20:15
Precipitation Volume:	4.45 (IN)	Direct Runoff Volume:	1.86 (IN)
Loss Volume:	2.59 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	1.86 (IN)	Discharge Volume:	1.86 (IN)


Sink "Wealthy Pump Station" Results for Run "25-Year Storm"
350
300
250
200
150
100
50
0
Flow (cfs)
00:00
12Dec2017
12:00
00:00
13Dec2017
12:00
Run:25-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:25-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 25-Year Storm

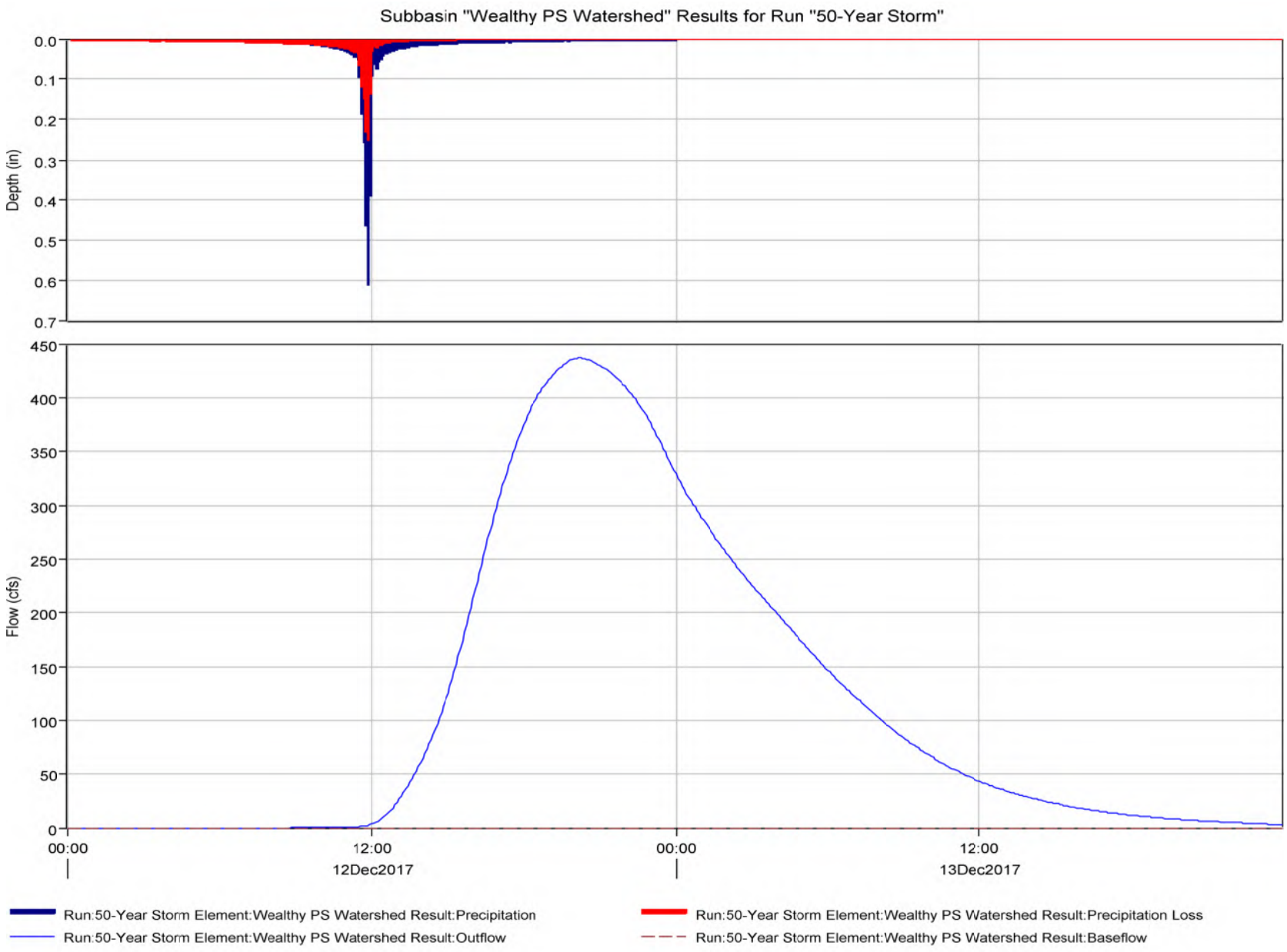
Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	25-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:09	Control Specifications:	25-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	322.1 (CFS)	Date/Time of Peak Discharge	12Dec2017, 20:15
Volume:	1.86 (IN)		


Subbasin "Wealthy PS Watershed" Results for Run "50-Year Storm"
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Flow (cfs)
450
400
350
300
250
200
150
100
50
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:50-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:50-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:50-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:50-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 50-Year Storm

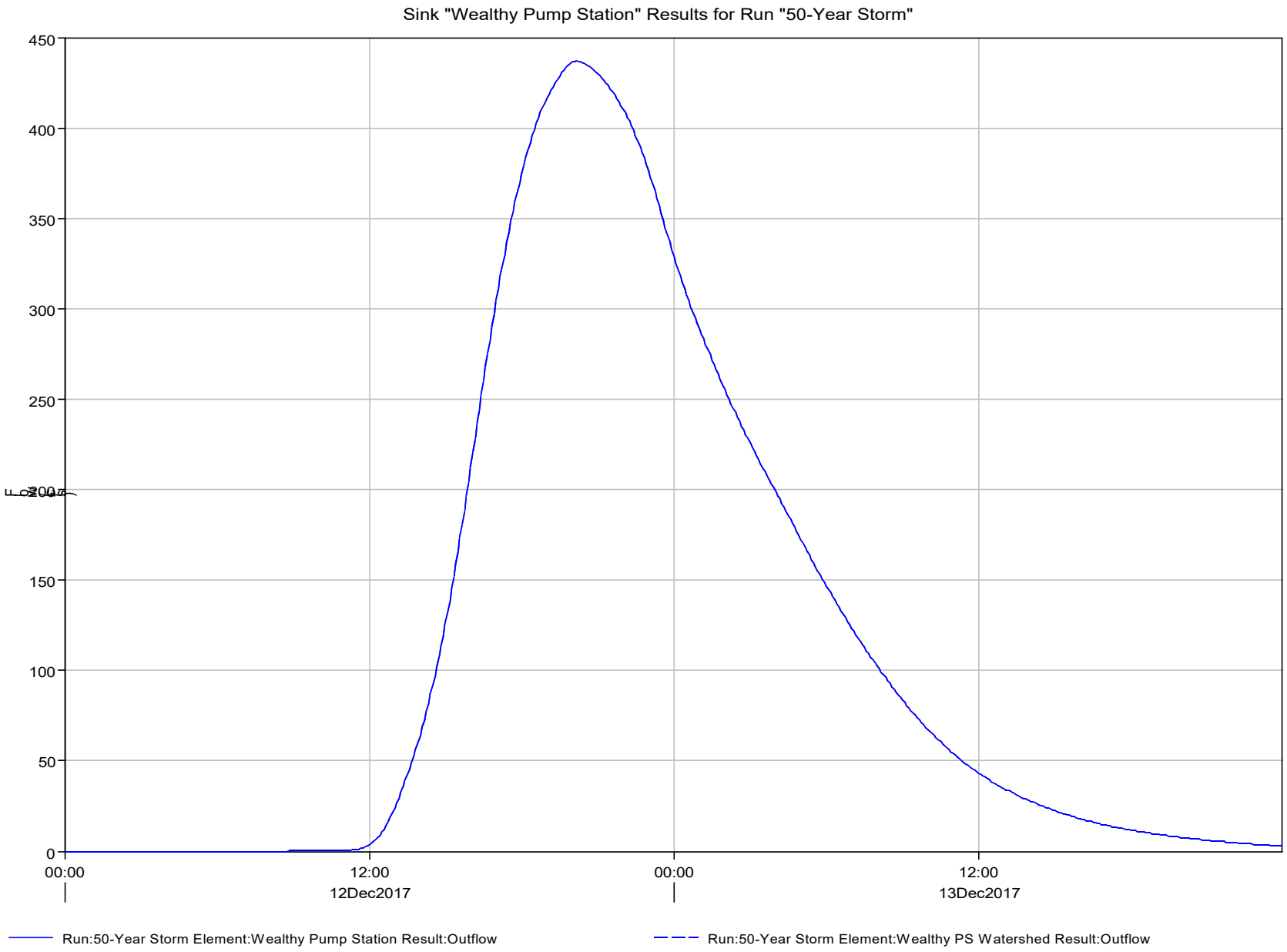
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	50-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:12	Control Specifications:	50-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	436.9 (CFS)	Date/Time of Peak Discharge:	12Dec2017, 20:10
Precipitation Volume:	5.27 (IN)	Direct Runoff Volume:	2.49 (IN)
Loss Volume:	2.78 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	2.49 (IN)	Discharge Volume:	2.49 (IN)


Sink "Wealthy Pump Station" Results for Run "50-Year Storm"
450
400
350
300
250
200
150
100
50
0
00:00
12Dec2017
12:00
00:00
13Dec2017
12:00
Run:50-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:50-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 50-Year Storm

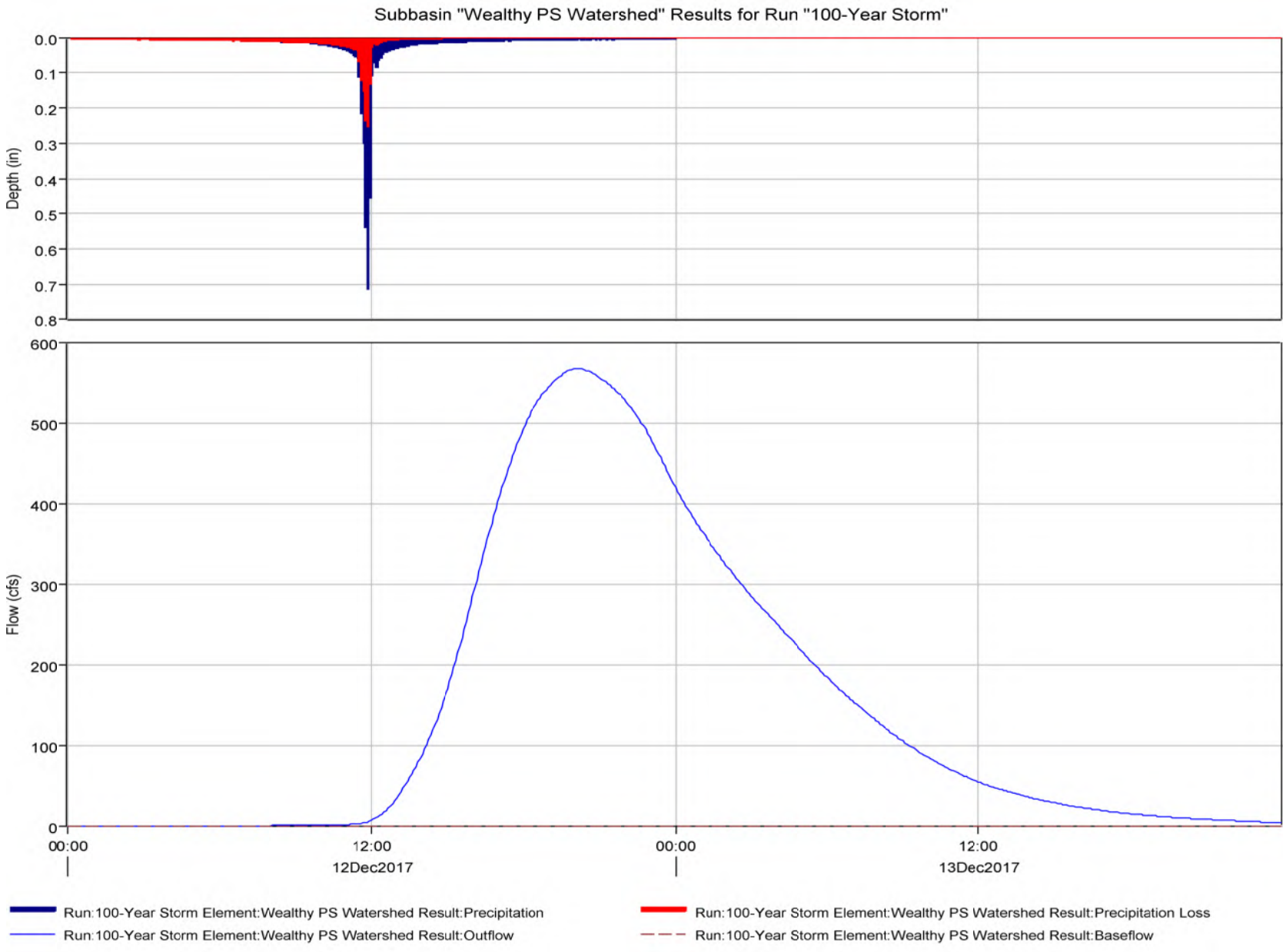
Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	50-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:12	Control Specifications:	50-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	436.9 (CFS)	Date/Time of Peak Discharge	12Dec2017, 20:10
Volume:	2.49 (IN)		


Subbasin "Wealthy PS Watershed" Results for Run "100-Year Storm"
Depth (in)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Flow (cfs)
600
500
400
300
200
100
0
00:00
12:00
12Dec2017
00:00
12:00
13Dec2017
Run:100-Year Storm Element:Wealthy PS Watershed Result:Precipitation
Run:100-Year Storm Element:Wealthy PS Watershed Result:Precipitation Loss
Run:100-Year Storm Element:Wealthy PS Watershed Result:Outflow
Run:100-Year Storm Element:Wealthy PS Watershed Result:Baseflow

Project: Wealthy PS Simulation Run: 100-Year Storm

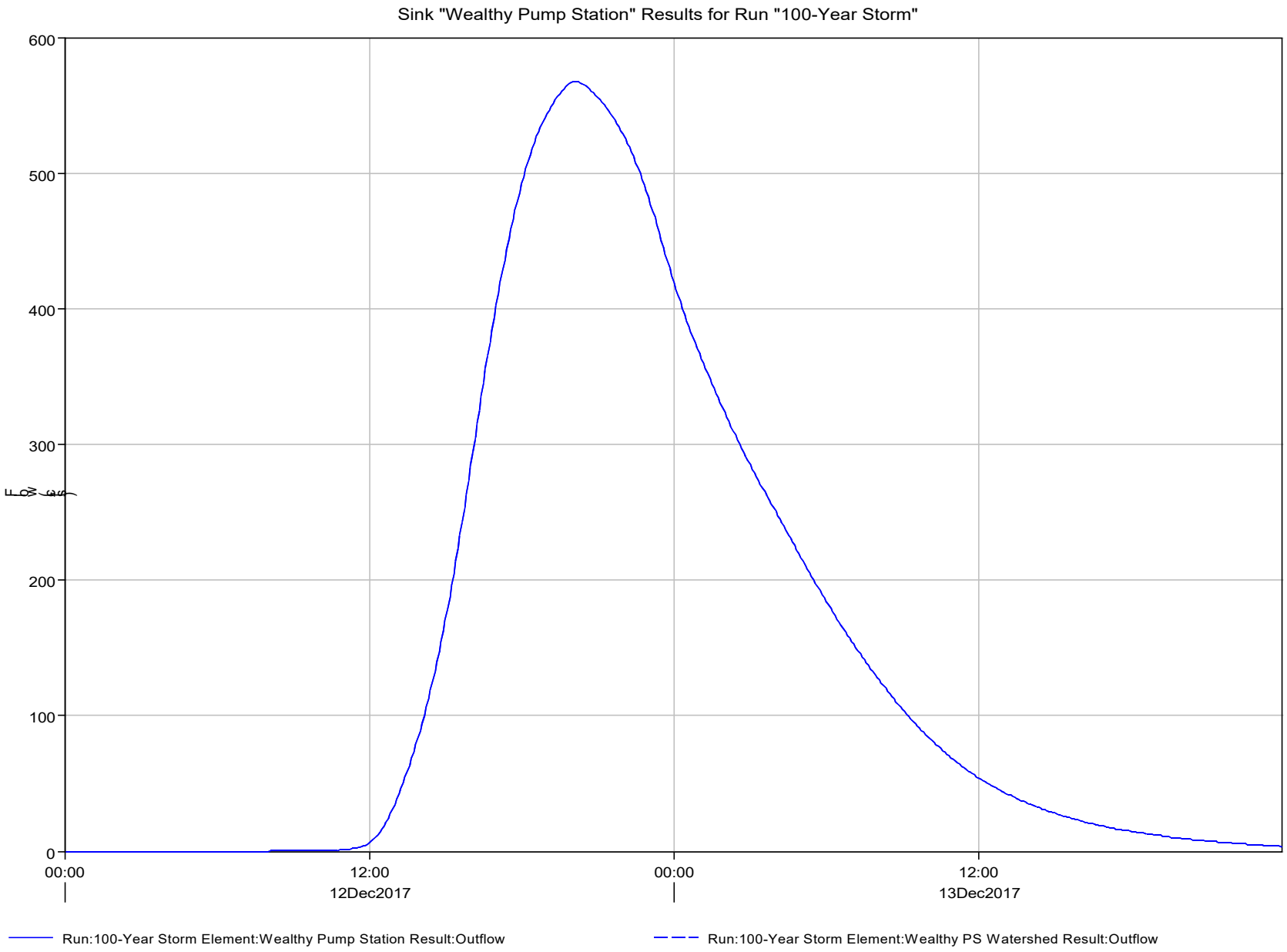
Subbasin: Wealthy PS Watershed

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	100-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:07	Control Specifications:	100-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	567.1 (CFS)	Date/Time of Peak Discharge:	12Dec2017, 20:10
Precipitation Volume:	6.15 (IN)	Direct Runoff Volume:	3.21 (IN)
Loss Volume:	2.94 (IN)	Baseflow Volume:	0.00 (IN)
Excess Volume:	3.21 (IN)	Discharge Volume:	3.21 (IN)


Sink "Wealthy Pump Station" Results for Run "100-Year Storm"
600
500
400
300
200
100
0
Flow (cfs)
00:00
12Dec2017
12:00
00:00
13Dec2017
12:00
Run:100-Year Storm Element:Wealthy Pump Station Result:Outflow
Run:100-Year Storm Element:Wealthy PS Watershed Result:Outflow

Project: Wealthy PS Simulation Run: 100-Year Storm

Sink: Wealthy Pump Station

Start of Run:	12Dec2017, 00:00	Basin Model:	Wealthy PS
End of Run:	13Dec2017, 23:55	Meteorologic Model:	100-Year, 24-Hour
Compute Time:	24Jan2020, 08:29:07	Control Specifications:	100-Year storm

Volume Units: IN

Computed Results

Peak Discharge:	567.1 (CFS)	Date/Time of Peak Discharge	12Dec2017, 20:10
Volume:	3.21 (IN)		

Market Avenue Pump Station Watershed

Grand River Interior Drainage
Project No. 120330
Kent County, Michigan

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	5-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	25-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)	1-Yr (cfs)	(hr)
SUBAREAS														
Market PS	40.93	14.07	64.28	14.00	85.13	14.06	123.86	14.09	159.31	13.92	197.77	13.87	26.77	14.20
REACHES														
OUTLET	40.93		64.28		85.13		123.86		159.31		197.77		26.77	

WinTR-20 Printed Page File Beginning of Input Data List
TR20.inp

WinTR-20: Version 1.10 0 0 0.05
Grand River Interior Drainage
Project No. 120330

SUB-AREA:
  Market PS Outlet .33313 82. 3.31

STREAM REACH:

STORM ANALYSIS:
  2-Yr 2.37 Type II 2
  5-Yr 3.0 Type II 2
  10-Yr 3.52 Type II 2
  25-Yr 4.45 Type II 2
  50-Yr 5.27 Type II 2
  100-Yr 6.15 Type II 2
  1-Yr 1.95 Type II 2

STRUCTURE RATING:

GLOBAL OUTPUT:
  2 0.05 YYYYN YYYYNN

WinTR-20 Printed Page File End of Input Data List

Grand River Interior Drainage
Project No. 120330

Name of printed page file:
TR20.out

STORM 2-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		0.903		14.07	40.93	122.87

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
11.148	0.08	0.16	0.31	0.71	1.99	4.39	7.69
12.611	12.10	17.75	24.17	30.08	34.81	38.13	40.06
14.075	40.93	40.44	39.24	37.38	34.76	31.56	28.61
15.538	26.17	24.01	22.11	20.47	18.98	17.57	16.32
17.002	15.23	14.24	13.34	12.54	11.82	11.15	10.58
18.465	10.05	9.58	9.16	8.78	8.43	8.10	7.79
19.928	7.51	7.25	6.99	6.76	6.53	6.32	6.11
21.392	5.91	5.72	5.54	5.38	5.23	5.11	5.01
22.855	4.92	4.83	4.76	4.69	4.63	4.57	4.52
24.318	4.45	4.35	4.23	4.07	3.86	3.60	3.31
25.782	2.99	2.66	2.34	2.03	1.74	1.48	1.25
27.245	1.05	0.89	0.76	0.64	0.55	0.46	0.39
28.708	0.33	0.28	0.24	0.20	0.17	0.14	0.12
30.172	0.10	0.09	0.07	0.06	0.05		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.333		0.903		14.07	40.93	122.87

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 2-Yr

SUB-AREA:

Market PS Outlet	.33313	82.	3.31

STREAM REACH:

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
11.148	0.08	0.16	0.31	0.71	1.99	4.39	7.69
12.611	12.10	17.75	24.17	30.08	34.81	38.13	40.06
14.075	40.93	40.44	39.24	37.38	34.76	31.56	28.61
15.538	26.17	24.01	22.11	20.47	18.98	17.57	16.32
17.002	15.23	14.24	13.34	12.54	11.82	11.15	10.58
18.465	10.05	9.58	9.16	8.78	8.43	8.10	7.79
19.928	7.51	7.25	6.99	6.76	6.53	6.32	6.11
21.392	5.91	5.72	5.54	5.38	5.23	5.11	5.01
22.855	4.92	4.83	4.76	4.69	4.63	4.57	4.52
24.318	4.45	4.35	4.23	4.07	3.86	3.60	3.31
25.782	2.99	2.66	2.34	2.03	1.74	1.48	1.25
27.245	1.05	0.89	0.76	0.64	0.55	0.46	0.39
28.708	0.33	0.28	0.24	0.20	0.17	0.14	0.12
30.172	0.10	0.09	0.07	0.06	0.05		

STORM 5-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		1.379		14.00	64.28	192.96

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
10.233	0.09	0.16	0.27	0.42	0.64	0.94	1.35
11.697	2.02	3.74	7.13	12.00	18.42	26.66	36.37
13.160	45.85	53.68	59.33	62.71	64.28	63.84	61.96
14.624	59.12	55.16	50.18	45.21	41.02	37.42	34.25
16.087	31.52	29.10	26.83	24.79	23.01	21.42	19.99
17.550	18.70	17.55	16.50	15.57	14.75	14.01	13.35
19.014	12.76	12.21	11.71	11.24	10.81	10.41	10.02
20.477	9.67	9.34	9.02	8.71	8.42	8.14	7.87
21.940	7.62	7.40	7.21	7.06	6.92	6.80	6.69
23.404	6.59	6.50	6.41	6.33	6.24	6.12	5.97
24.867	5.77	5.50	5.16	4.77	4.33	3.87	3.42
26.330	2.98	2.57	2.19	1.85	1.56	1.32	1.12
27.794	0.95	0.81	0.68	0.58	0.49	0.42	0.35
29.257	0.30	0.25	0.21	0.18	0.15	0.13	0.11
30.721	0.09	0.08	0.06	0.05			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.333		1.379		14.00	64.28	192.96

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 5-Yr

SUB-AREA:
Market PS Outlet .33313 82. 3.31

STREAM REACH:
Line
Start Time ---------- Flow Values @ time increment of 0.209 hr ----------
(hr) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs)

10.233	0.09	0.16	0.27	0.42	0.64	0.94	1.35
11.697	2.02	3.74	7.13	12.00	18.42	26.66	36.37
13.160	45.85	53.68	59.33	62.71	64.28	63.84	61.96
14.624	59.12	55.16	50.18	45.21	41.02	37.42	34.25
16.087	31.52	29.10	26.83	24.79	23.01	21.42	19.99
17.550	18.70	17.55	16.50	15.57	14.75	14.01	13.35
19.014	12.76	12.21	11.71	11.24	10.81	10.41	10.02
20.477	9.67	9.34	9.02	8.71	8.42	8.14	7.87
21.940	7.62	7.40	7.21	7.06	6.92	6.80	6.69
23.404	6.59	6.50	6.41	6.33	6.24	6.12	5.97
24.867	5.77	5.50	5.16	4.77	4.33	3.87	3.42
26.330	2.98	2.57	2.19	1.85	1.56	1.32	1.12
27.794	0.95	0.81	0.68	0.58	0.49	0.42	0.35
29.257	0.30	0.25	0.21	0.18	0.15	0.13	0.11
30.721	0.09	0.08	0.06	0.05			

STORM 10-Yr

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		1.799		14.06	85.13	255.54

Line
Start Time ---------- Flow Values @ time increment of 0.209 hr ----------
(hr) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs)

9.459	0.09	0.16	0.25	0.39	0.56	0.79	1.07
10.923	1.43	1.87	2.44	3.19	4.48	7.54	12.81
12.386	19.90	29.10	40.66	53.59	65.36	74.57	80.78
13.849	84.07	85.13	83.49	80.36	75.98	70.12	63.21
15.313	56.85	51.60	46.99	42.98	39.52	36.40	33.49
16.776	30.91	28.68	26.65	24.84	23.21	21.77	20.45
18.240	19.30	18.27	17.34	16.52	15.77	15.08	14.46
19.703	13.87	13.34	12.83	12.34	11.91	11.49	11.09
21.166	10.71	10.34	9.99	9.66	9.36	9.08	8.87
22.630	8.68	8.51	8.36	8.23	8.11	8.00	7.89
24.093	7.79	7.67	7.51	7.30	7.03	6.67	6.23
25.556	5.72	5.18	4.61	4.06	3.53	3.03	2.58
27.020	2.18	1.83	1.55	1.32	1.12	0.95	0.81
28.483	0.68	0.58	0.49	0.41	0.35	0.30	0.25
29.946	0.21	0.18	0.15	0.13	0.11	0.09	0.07
31.410	0.06	0.05					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.333		1.799		14.06	85.13	255.54

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Market PS Outlet .33313 82. 3.31

STREAM REACH:

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
9.459	0.09	0.16	0.25	0.39	0.56	0.79	1.07
10.923	1.43	1.87	2.44	3.19	4.48	7.54	12.81
12.386	19.90	29.10	40.66	53.59	65.36	74.57	80.78
13.849	84.07	85.13	83.49	80.36	75.98	70.12	63.21
15.313	56.85	51.60	46.99	42.98	39.52	36.40	33.49
16.776	30.91	28.68	26.65	24.84	23.21	21.77	20.45
18.240	19.30	18.27	17.34	16.52	15.77	15.08	14.46
19.703	13.87	13.34	12.83	12.34	11.91	11.49	11.09
21.166	10.71	10.34	9.99	9.66	9.36	9.08	8.87
22.630	8.68	8.51	8.36	8.23	8.11	8.00	7.89
24.093	7.79	7.67	7.51	7.30	7.03	6.67	6.23
25.556	5.72	5.18	4.61	4.06	3.53	3.03	2.58
27.020	2.18	1.83	1.55	1.32	1.12	0.95	0.81
28.483	0.68	0.58	0.49	0.41	0.35	0.30	0.25
29.946	0.21	0.18	0.15	0.13	0.11	0.09	0.07
31.410	0.06	0.05					

STORM 25-Yr

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		2.592		14.09	123.86	371.80

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
8.237	0.08	0.14	0.22	0.33	0.49	0.68	0.91
9.700	1.20	1.54	1.93	2.38	2.90	3.50	4.20
11.164	5.05	6.08	7.42	9.73	14.88	23.23	34.07
12.627	48.02	65.22	83.84	100.02	112.15	119.86	123.43
14.091	123.86	120.41	115.15	108.10	98.97	88.63	79.51
15.554	72.08	65.49	59.78	54.87	50.40	46.23	42.60
17.017	39.45	36.58	34.03	31.75	29.73	27.87	26.27
18.481	24.83	23.54	22.40	21.36	20.40	19.53	18.72
19.944	17.99	17.28	16.62	16.02	15.45	14.90	14.37
21.407	13.87	13.39	12.94	12.52	12.16	11.87	11.62
22.871	11.40	11.20	11.02	10.86	10.71	10.57	10.42
24.334	10.25	10.03	9.74	9.35	8.86	8.25	7.55
25.798	6.82	6.06	5.32	4.62	3.96	3.36	2.84
27.261	2.39	2.03	1.72	1.46	1.24	1.05	0.89
28.724	0.75	0.64	0.54	0.46	0.39	0.33	0.27
30.188	0.23	0.19	0.16	0.14	0.11	0.10	0.08
31.651	0.07	0.05					

Area or Reach	Drainage Area	Rain Gage ID or	Runoff Amount	Peak Flow Elevation	Peak Flow Time	Peak Flow Rate	Peak Flow Rate

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 25-Yr

SUB-AREA:

Market PS Outlet	.33313	82.	3.31

STREAM REACH:

Identifier	(sq mi)	Location	(in)	(ft)	(hr)	(cfs)	(csm)
OUTLET	0.333		2.592		14.09	123.86	371.80

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
8.237	0.08	0.14	0.22	0.33	0.49	0.68	0.91
9.700	1.20	1.54	1.93	2.38	2.90	3.50	4.20
11.164	5.05	6.08	7.42	9.73	14.88	23.23	34.07
12.627	48.02	65.22	83.84	100.02	112.15	119.86	123.43
14.091	123.86	120.41	115.15	108.10	98.97	88.63	79.51
15.554	72.08	65.49	59.78	54.87	50.40	46.23	42.60
17.017	39.45	36.58	34.03	31.75	29.73	27.87	26.27
18.481	24.83	23.54	22.40	21.36	20.40	19.53	18.72
19.944	17.99	17.28	16.62	16.02	15.45	14.90	14.37
21.407	13.87	13.39	12.94	12.52	12.16	11.87	11.62
22.871	11.40	11.20	11.02	10.86	10.71	10.57	10.42
24.334	10.25	10.03	9.74	9.35	8.86	8.25	7.55
25.798	6.82	6.06	5.32	4.62	3.96	3.36	2.84
27.261	2.39	2.03	1.72	1.46	1.24	1.05	0.89
28.724	0.75	0.64	0.54	0.46	0.39	0.33	0.27
30.188	0.23	0.19	0.16	0.14	0.11	0.10	0.08
31.651	0.07	0.05					

STORM 50-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		3.321		13.92	159.31	478.22

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
7.436	0.09	0.16	0.26	0.38	0.54	0.74	0.98
8.899	1.26	1.58	1.96	2.40	2.89	3.44	4.06
10.363	4.75	5.52	6.41	7.43	8.65	10.13	12.09
11.826	15.72	23.10	34.38	48.94	67.49	89.86	113.13
13.290	132.81	147.13	155.74	159.31	158.62	153.45	146.03
14.753	136.28	124.02	110.80	99.35	89.92	81.60	74.42
16.216	68.21	62.53	57.29	52.75	48.78	45.19	41.99
17.680	39.15	36.61	34.30	32.30	30.52	28.92	27.50
19.143	26.21	25.02	23.93	22.93	22.01	21.14	20.32
20.606	19.58	18.88	18.20	17.54	16.92	16.33	15.78
22.070	15.27	14.83	14.49	14.19	13.92	13.67	13.45
23.533	13.25	13.07	12.90	12.72	12.50	12.21	11.84
24.997	11.35	10.71	9.95	9.09	8.18	7.26	6.36
26.460	5.50	4.71	4.00	3.37	2.84	2.41	2.04
27.923	1.74	1.47	1.25	1.06	0.90	0.76	0.64
29.387	0.54	0.46	0.39	0.33	0.27	0.23	0.19

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 50-Yr

SUB-AREA:
Market PS Outlet .33313 82. 3.31

STREAM REACH:
30.850 0.16 0.14 0.11 0.09 0.08 0.06 0.05

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.333		3.321		13.92	159.31	478.22

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.436	0.09	0.16	0.26	0.38	0.54	0.74	0.98
8.899	1.26	1.58	1.96	2.40	2.89	3.44	4.06
10.363	4.75	5.52	6.41	7.43	8.65	10.13	12.09
11.826	15.72	23.10	34.38	48.94	67.49	89.86	113.13
13.290	132.81	147.13	155.74	159.31	158.62	153.45	146.03
14.753	136.28	124.02	110.80	99.35	89.92	81.60	74.42
16.216	68.21	62.53	57.29	52.75	48.78	45.19	41.99
17.680	39.15	36.61	34.30	32.30	30.52	28.92	27.50
19.143	26.21	25.02	23.93	22.93	22.01	21.14	20.32
20.606	19.58	18.88	18.20	17.54	16.92	16.33	15.78
22.070	15.27	14.83	14.49	14.19	13.92	13.67	13.45
23.533	13.25	13.07	12.90	12.72	12.50	12.21	11.84
24.997	11.35	10.71	9.95	9.09	8.18	7.26	6.36
26.460	5.50	4.71	4.00	3.37	2.84	2.41	2.04
27.923	1.74	1.47	1.25	1.06	0.90	0.76	0.64

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
29.387	0.54	0.46	0.39	0.33	0.27	0.23	0.19
30.850	0.16	0.14	0.11	0.09	0.08	0.06	0.05

STORM 100-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		4.125		13.87	197.77	593.68

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
6.553	0.06	0.11	0.19	0.30	0.45	0.64	0.87
8.017	1.13	1.44	1.80	2.19	2.63	3.12	3.66
9.480	4.27	4.94	5.69	6.52	7.43	8.45	9.59
10.943	10.90	12.44	14.30	16.65	20.55	28.81	42.07
12.407	59.25	81.19	108.10	137.13	162.34	181.08	192.72
13.870	197.77	197.77	191.75	182.80	171.10	156.23	139.53
15.333	124.73	112.65	102.02	92.82	84.93	77.77	71.13

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 100-Yr

SUB-AREA:
Market PS Outlet .33313 82. 3.31

STREAM REACH:

16.797	65.34	60.32	55.79	51.76	48.15	44.97	42.05
18.260	39.54	37.29	35.29	33.50	31.90	30.41	29.07
19.724	27.82	26.69	25.61	24.59	23.69	22.83	21.99
21.187	21.19	20.43	19.71	19.03	18.40	17.84	17.41
22.650	17.04	16.71	16.41	16.14	15.89	15.67	15.46
24.114	15.25	14.99	14.67	14.25	13.70	12.98	12.09
25.577	11.09	10.01	8.91	7.83	6.79	5.83	4.96
27.040	4.18	3.53	2.98	2.53	2.15	1.83	1.55
28.504	1.31	1.11	0.94	0.80	0.67	0.57	0.48
29.967	0.40	0.34	0.29	0.24	0.20	0.17	0.14
31.430	0.12	0.10	0.08	0.06	0.05		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.333		4.125		13.87	197.77	593.68

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
6.553	0.06	0.11	0.19	0.30	0.45	0.64	0.87
8.017	1.13	1.44	1.80	2.19	2.63	3.12	3.66
9.480	4.27	4.94	5.69	6.52	7.43	8.45	9.59
10.943	10.90	12.44	14.30	16.65	20.55	28.81	42.07
12.407	59.25	81.19	108.10	137.13	162.34	181.08	192.72
13.870	197.77	197.77	191.75	182.80	171.10	156.23	139.53
15.333	124.73	112.65	102.02	92.82	84.93	77.77	71.13

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
16.797	65.34	60.32	55.79	51.76	48.15	44.97	42.05
18.260	39.54	37.29	35.29	33.50	31.90	30.41	29.07
19.724	27.82	26.69	25.61	24.59	23.69	22.83	21.99
21.187	21.19	20.43	19.71	19.03	18.40	17.84	17.41
22.650	17.04	16.71	16.41	16.14	15.89	15.67	15.46
24.114	15.25	14.99	14.67	14.25	13.70	12.98	12.09
25.577	11.09	10.01	8.91	7.83	6.79	5.83	4.96
27.040	4.18	3.53	2.98	2.53	2.15	1.83	1.55
28.504	1.31	1.11	0.94	0.80	0.67	0.57	0.48
29.967	0.40	0.34	0.29	0.24	0.20	0.17	0.14
31.430	0.12	0.10	0.08	0.06	0.05		

STORM 1-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Market PS	0.333		0.616		14.20	26.77	80.36

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River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:

Market PS Outlet	.33313	82.	3.31

STREAM REACH:

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
11.693	0.10	0.55	1.70	3.48	5.94	9.24	13.28
13.156	17.40	20.97	23.70	25.50	26.55	26.77	26.32
14.620	25.44	24.06	22.18	20.20	18.50	17.04	15.73
16.083	14.60	13.59	12.64	11.77	11.01	10.32	9.70
17.546	9.13	8.63	8.16	7.75	7.38	7.04	6.74
19.010	6.47	6.21	5.98	5.76	5.56	5.37	5.19
20.473	5.01	4.85	4.70	4.55	4.41	4.27	4.14
21.936	4.02	3.91	3.81	3.73	3.67	3.60	3.55
23.400	3.50	3.45	3.41	3.37	3.32	3.26	3.18
24.863	3.08	2.94	2.76	2.55	2.32	2.07	1.83
26.327	1.60	1.38	1.17	0.99	0.84	0.71	0.60
27.790	0.51	0.43	0.37	0.31	0.26	0.22	0.19
29.253	0.16	0.13	0.11	0.10	0.08	0.07	0.06

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.333		0.616		14.20	26.77	80.36

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
11.693	0.10	0.55	1.70	3.48	5.94	9.24	13.28
13.156	17.40	20.97	23.70	25.50	26.55	26.77	26.32
14.620	25.44	24.06	22.18	20.20	18.50	17.04	15.73

Line Start Time (hr)	Flow Values @ time increment of 0.209 hr (cfs)						
16.083	14.60	13.59	12.64	11.77	11.01	10.32	9.70
17.546	9.13	8.63	8.16	7.75	7.38	7.04	6.74
19.010	6.47	6.21	5.98	5.76	5.56	5.37	5.19
20.473	5.01	4.85	4.70	4.55	4.41	4.27	4.14
21.936	4.02	3.91	3.81	3.73	3.67	3.60	3.55
23.400	3.50	3.45	3.41	3.37	3.32	3.26	3.18
24.863	3.08	2.94	2.76	2.55	2.32	2.07	1.83
26.327	1.60	1.38	1.17	0.99	0.84	0.71	0.60
27.790	0.51	0.43	0.37	0.31	0.26	0.22	0.19
29.253	0.16	0.13	0.11	0.10	0.08	0.07	0.06

WinTR-20: Version 1.10 0 0 0.05
 River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
 Market PS Outlet .33313 82. 3.31

STREAM REACH:

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	50-Yr (cfs)
Market PS	0.333		40.93	64.28	85.13	123.86	159.31
OUTLET	0.333		40.93	64.28	85.13	123.86	159.31

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 100-Yr (cfs)	1-Yr (cfs)	(cfs)	(cfs)	(cfs)
Market PS	0.333		197.77	26.77			
OUTLET	0.333		197.77	26.77			

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 River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Market PS Outlet .33313 82. 3.31

STREAM REACH:

Front/Scribner Pump Station Watershed

Grand River Interior Drainage
Project No. 120330
Kent County, Michigan

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	5-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	25-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)	1-Yr (cfs)	(hr)
SUBAREAS														
Scrib PS	203.44	13.56	342.89	13.47	472.32	13.50	718.52	13.48	946.72	13.53	1198.34	13.39	122.72	13.57
REACHES														
OUTLET	203.44		342.89		472.32		718.52		946.72		1198.34		122.72	

WinTR-20 Printed Page File Beginning of Input Data List
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WinTR-20: Version 1.10 0 0 0.05
Grand River Interior Drainage
Project No. 120330

SUB-AREA:
  Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

STORM ANALYSIS:
  2-Yr 2.37 Type II 2
  5-Yr 3.0 Type II 2
  10-Yr 3.52 Type II 2
  25-Yr 4.45 Type II 2
  50-Yr 5.27 Type II 2
  100-Yr 6.15 Type II 2
  1-Yr 1.95 Type II 2

STRUCTURE RATING:

GLOBAL OUTPUT:
  2 0.05 YYYYN YYYYNN

WinTR-20 Printed Page File End of Input Data List

Grand River Interior Drainage
Project No. 120330

Name of printed page file:
TR20.out

STORM 2-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Scrib PS	1.803		0.705		13.56	203.44	112.82

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
11.511	0.15	0.58	2.53	8.89	20.65	37.13	59.40
12.612	87.81	119.56	148.70	172.12	188.79	198.82	203.44
13.713	201.70	196.35	187.55	174.89	159.76	145.82	134.10
14.814	123.60	114.34	106.28	98.89	91.99	85.90	80.57
15.914	75.73	71.37	67.42	63.86	60.54	57.60	54.89
17.015	52.42	50.18	48.14	46.26	44.55	42.99	41.60
18.116	40.31	39.12	38.08	37.10	36.16	35.25	34.37
19.217	33.51	32.66	31.82	31.04	30.34	29.67	29.01
20.318	28.37	27.74	27.12	26.52	25.95	25.41	24.90
21.419	24.43	24.01	23.62	23.26	22.95	22.66	22.40
22.520	22.17	21.95	21.75	21.57	21.40	21.23	21.08
23.620	20.93	20.78	20.65	20.49	20.26	19.91	19.42
24.721	18.72	17.78	16.60	15.23	13.77	12.27	10.78
25.822	9.35	8.03	6.82	5.76	4.85	4.11	3.49
26.923	2.97	2.52	2.14	1.81	1.53	1.30	1.10
28.024	0.93	0.79	0.66	0.56	0.47	0.40	0.33
29.125	0.28	0.23	0.20	0.16	0.13	0.11	0.09
30.225	0.07	0.06					

Area or Reach	Drainage Area	Rain Gage ID or	Runoff Amount	Peak Flow Elevation	Peak Flow Time	Peak Flow Rate	Peak Flow Rate

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 2-Yr

SUB-AREA:

Scrib PS	Outlet	1.80313	78.	2.49	

STREAM REACH:

Identifier	(sq mi)	Location	(in)	(ft)	(hr)	(cfs)	(csm)
OUTLET	1.803		0.705		13.56	203.44	112.82

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
11.511	0.15	0.58	2.53	8.89	20.65	37.13	59.40
12.612	87.81	119.56	148.70	172.12	188.79	198.82	203.44
13.713	201.70	196.35	187.55	174.89	159.76	145.82	134.10
14.814	123.60	114.34	106.28	98.89	91.99	85.90	80.57
15.914	75.73	71.37	67.42	63.86	60.54	57.60	54.89
17.015	52.42	50.18	48.14	46.26	44.55	42.99	41.60
18.116	40.31	39.12	38.08	37.10	36.16	35.25	34.37
19.217	33.51	32.66	31.82	31.04	30.34	29.67	29.01
20.318	28.37	27.74	27.12	26.52	25.95	25.41	24.90
21.419	24.43	24.01	23.62	23.26	22.95	22.66	22.40
22.520	22.17	21.95	21.75	21.57	21.40	21.23	21.08

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
23.620	20.93	20.78	20.65	20.49	20.26	19.91	19.42
24.721	18.72	17.78	16.60	15.23	13.77	12.27	10.78
25.822	9.35	8.03	6.82	5.76	4.85	4.11	3.49
26.923	2.97	2.52	2.14	1.81	1.53	1.30	1.10
28.024	0.93	0.79	0.66	0.56	0.47	0.40	0.33
29.125	0.28	0.23	0.20	0.16	0.13	0.11	0.09
30.225	0.07	0.06					

STORM 5-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Scrib PS	1.803		1.129		13.47	342.89	190.16

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
10.639	0.06	0.17	0.38	0.74	1.36	2.33	3.88
11.739	7.06	15.65	33.02	58.67	92.76	136.71	188.39
12.840	239.53	282.31	313.75	333.33	342.89	342.26	333.44
13.941	319.26	299.11	273.64	247.72	225.52	206.44	189.50
15.042	174.80	161.76	149.66	138.72	129.22	120.76	113.14
16.143	106.29	100.15	94.53	89.45	84.90	80.74	76.97
17.244	73.56	70.44	67.60	65.02	62.70	60.60	58.64
18.345	56.91	55.34	53.85	52.41	51.03	49.68	48.35
19.445	47.06	45.81	44.69	43.68	42.69	41.72	40.77
20.546	39.85	38.95	38.08	37.25	36.47	35.75	35.08

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 5-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

21.647	34.47	33.92	33.42	32.97	32.56	32.20	31.86
22.748	31.55	31.26	30.99	30.74	30.50	30.27	30.05
23.849	29.84	29.63	29.37	28.96	28.37	27.54	26.39
24.950	24.86	23.02	20.97	18.81	16.65	14.53	12.55
26.050	10.72	9.07	7.63	6.45	5.47	4.65	3.95
27.151	3.35	2.84	2.41	2.04	1.73	1.46	1.24
28.252	1.04	0.88	0.74	0.63	0.53	0.44	0.37
29.353	0.31	0.26	0.21	0.18	0.14	0.12	0.09
30.454	0.07	0.06					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	1.803		1.129		13.47	342.89	190.16

Grand River Interior Drainage
Project No. 120330

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
10.639	0.06	0.17	0.38	0.74	1.36	2.33	3.88
11.739	7.06	15.65	33.02	58.67	92.76	136.71	188.39
12.840	239.53	282.31	313.75	333.33	342.89	342.26	333.44
13.941	319.26	299.11	273.64	247.72	225.52	206.44	189.50
15.042	174.80	161.76	149.66	138.72	129.22	120.76	113.14
16.143	106.29	100.15	94.53	89.45	84.90	80.74	76.97
17.244	73.56	70.44	67.60	65.02	62.70	60.60	58.64
18.345	56.91	55.34	53.85	52.41	51.03	49.68	48.35
19.445	47.06	45.81	44.69	43.68	42.69	41.72	40.77
20.546	39.85	38.95	38.08	37.25	36.47	35.75	35.08
21.647	34.47	33.92	33.42	32.97	32.56	32.20	31.86
22.748	31.55	31.26	30.99	30.74	30.50	30.27	30.05
23.849	29.84	29.63	29.37	28.96	28.37	27.54	26.39
24.950	24.86	23.02	20.97	18.81	16.65	14.53	12.55
26.050	10.72	9.07	7.63	6.45	5.47	4.65	3.95
27.151	3.35	2.84	2.41	2.04	1.73	1.46	1.24
28.252	1.04	0.88	0.74	0.63	0.53	0.44	0.37
29.353	0.31	0.26	0.21	0.18	0.14	0.12	0.09
30.454	0.07	0.06					

STORM 10-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Scrib PS	1.803		1.513		13.50	472.32	261.95

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
10.043	0.11	0.24	0.47	0.84	1.40	2.20	3.29
11.144	4.75	6.68	9.21	12.79	19.39	34.72	62.14
12.245	100.34	150.28	213.11	284.19	351.10	404.87	442.53
13.346	464.02	472.32	466.52	451.05	428.41	397.75	361.09
14.447	325.81	296.08	270.27	247.56	227.91	210.32	194.03
15.548	179.52	166.93	155.67	145.57	136.51	128.41	120.97
16.648	114.33	108.36	102.92	98.01	93.58	89.51	85.83
17.749	82.49	79.50	76.77	74.24	72.03	69.99	68.06
18.850	66.20	64.39	62.64	60.92	59.24	57.64	56.25
19.951	54.95	53.69	52.46	51.25	50.08	48.94	47.84
21.052	46.79	45.82	44.91	44.07	43.31	42.62	41.99
22.153	41.43	40.92	40.46	40.04	39.64	39.28	38.94
23.253	38.62	38.31	38.02	37.74	37.47	37.19	36.81
24.354	36.24	35.44	34.30	32.75	30.74	28.37	25.76
25.455	23.05	20.34	17.71	15.26	13.01	11.00	9.26
26.556	7.83	6.65	5.65	4.80	4.07	3.45	2.92
27.657	2.48	2.10	1.78	1.50	1.27	1.07	0.90
28.758	0.76	0.64	0.54	0.45	0.37	0.31	0.26
29.858	0.21	0.17	0.14	0.11	0.09	0.07	0.05

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	1.803		1.513		13.50	472.32	261.95

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
10.043	0.11	0.24	0.47	0.84	1.40	2.20	3.29
11.144	4.75	6.68	9.21	12.79	19.39	34.72	62.14
12.245	100.34	150.28	213.11	284.19	351.10	404.87	442.53
13.346	464.02	472.32	466.52	451.05	428.41	397.75	361.09
14.447	325.81	296.08	270.27	247.56	227.91	210.32	194.03
15.548	179.52	166.93	155.67	145.57	136.51	128.41	120.97
16.648	114.33	108.36	102.92	98.01	93.58	89.51	85.83
17.749	82.49	79.50	76.77	74.24	72.03	69.99	68.06
18.850	66.20	64.39	62.64	60.92	59.24	57.64	56.25
19.951	54.95	53.69	52.46	51.25	50.08	48.94	47.84
21.052	46.79	45.82	44.91	44.07	43.31	42.62	41.99
22.153	41.43	40.92	40.46	40.04	39.64	39.28	38.94
23.253	38.62	38.31	38.02	37.74	37.47	37.19	36.81
24.354	36.24	35.44	34.30	32.75	30.74	28.37	25.76
25.455	23.05	20.34	17.71	15.26	13.01	11.00	9.26
26.556	7.83	6.65	5.65	4.80	4.07	3.45	2.92
27.657	2.48	2.10	1.78	1.50	1.27	1.07	0.90
28.758	0.76	0.64	0.54	0.45	0.37	0.31	0.26
29.858	0.21	0.17	0.14	0.11	0.09	0.07	0.05

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

STORM 25-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Scrib PS	1.803		2.252		13.48	718.52	398.49

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
8.917	0.11	0.24	0.46	0.79	1.28	1.93	2.77
10.018	3.82	5.08	6.58	8.35	10.43	12.88	15.78
11.119	19.21	23.33	28.33	34.79	45.36	68.15	108.84
12.220	165.77	239.62	332.44	438.06	538.63	619.53	675.82
13.321	707.43	718.52	708.76	683.62	647.97	600.66	544.12
14.422	488.91	442.26	402.19	366.95	336.51	309.48	284.54
15.522	262.25	242.97	225.83	210.47	196.75	184.51	173.34
16.623	163.34	154.42	146.31	139.01	132.43	126.41	120.97
17.724	116.03	111.62	107.61	103.91	100.65	97.70	94.89
18.825	92.20	89.59	87.06	84.59	82.17	79.88	77.87
19.926	76.05	74.28	72.55	70.86	69.21	67.61	66.07
21.027	64.60	63.22	61.94	60.76	59.68	58.70	57.81
22.128	57.01	56.28	55.63	55.02	54.47	53.95	53.47

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
23.228	53.01	52.58	52.16	51.77	51.38	51.00	50.51
24.329	49.78	48.73	47.26	45.23	42.57	39.37	35.83
25.430	32.13	28.41	24.78	21.38	18.26	15.44	12.99
26.531	10.98	9.32	7.92	6.73	5.71	4.84	4.10
27.632	3.47	2.94	2.49	2.11	1.78	1.50	1.26
28.733	1.07	0.90	0.75	0.63	0.53	0.44	0.36
29.833	0.30	0.24	0.20	0.16	0.13	0.10	0.07
30.934	0.05						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	1.803		2.252		13.48	718.52	398.49

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
8.917	0.11	0.24	0.46	0.79	1.28	1.93	2.77
10.018	3.82	5.08	6.58	8.35	10.43	12.88	15.78
11.119	19.21	23.33	28.33	34.79	45.36	68.15	108.84
12.220	165.77	239.62	332.44	438.06	538.63	619.53	675.82
13.321	707.43	718.52	708.76	683.62	647.97	600.66	544.12

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

14.422	488.91	442.26	402.19	366.95	336.51	309.48	284.54
15.522	262.25	242.97	225.83	210.47	196.75	184.51	173.34
16.623	163.34	154.42	146.31	139.01	132.43	126.41	120.97
17.724	116.03	111.62	107.61	103.91	100.65	97.70	94.89
18.825	92.20	89.59	87.06	84.59	82.17	79.88	77.87
19.926	76.05	74.28	72.55	70.86	69.21	67.61	66.07
21.027	64.60	63.22	61.94	60.76	59.68	58.70	57.81
22.128	57.01	56.28	55.63	55.02	54.47	53.95	53.47
23.228	53.01	52.58	52.16	51.77	51.38	51.00	50.51
24.329	49.78	48.73	47.26	45.23	42.57	39.37	35.83
25.430	32.13	28.41	24.78	21.38	18.26	15.44	12.99
26.531	10.98	9.32	7.92	6.73	5.71	4.84	4.10
27.632	3.47	2.94	2.49	2.11	1.78	1.50	1.26
28.733	1.07	0.90	0.75	0.63	0.53	0.44	0.36
29.833	0.30	0.24	0.20	0.16	0.13	0.10	0.07
30.934	0.05						

STORM 50-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Scrib PS	1.803		2.942		13.53	946.72	525.05

Grand River Interior Drainage
Project No. 120330

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
8.023	0.10	0.20	0.38	0.66	1.06	1.61	2.34
9.124	3.26	4.39	5.74	7.31	9.10	11.12	13.36
10.225	15.84	18.59	21.67	25.15	29.14	33.75	39.14
11.326	45.55	53.29	63.80	81.98	119.34	180.45	261.88
12.427	366.31	493.92	632.45	756.36	850.96	912.60	942.31
13.527	946.72	923.68	884.11	830.83	762.85	685.99	615.41
14.628	556.70	505.51	460.85	422.30	387.65	355.73	327.68
15.729	303.40	281.66	262.29	244.96	229.54	215.39	202.92
16.830	191.69	181.53	172.40	164.18	156.63	149.86	143.70
17.931	138.24	133.23	128.64	124.63	120.92	117.39	114.00
19.032	110.71	107.51	104.38	101.36	98.54	96.11	93.85
20.133	91.64	89.49	87.39	85.34	83.36	81.46	79.65
21.233	77.96	76.40	74.96	73.65	72.46	71.38	70.41
22.334	69.53	68.73	67.99	67.31	66.68	66.08	65.51
23.435	64.98	64.46	63.97	63.49	62.98	62.27	61.24
24.536	59.78	57.74	54.97	51.45	47.36	42.90	38.31
25.637	33.74	29.33	25.23	21.48	18.14	15.28	12.93
26.738	10.98	9.32	7.92	6.73	5.70	4.83	4.09
27.838	3.46	2.93	2.48	2.09	1.76	1.49	1.25
28.939	1.05	0.88	0.74	0.62	0.51	0.42	0.35
30.040	0.28	0.23	0.18	0.14	0.11	0.08	0.06

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 50-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	1.803		2.942		13.53	946.72	525.05

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
8.023	0.10	0.20	0.38	0.66	1.06	1.61	2.34
9.124	3.26	4.39	5.74	7.31	9.10	11.12	13.36
10.225	15.84	18.59	21.67	25.15	29.14	33.75	39.14
11.326	45.55	53.29	63.80	81.98	119.34	180.45	261.88
12.427	366.31	493.92	632.45	756.36	850.96	912.60	942.31
13.527	946.72	923.68	884.11	830.83	762.85	685.99	615.41
14.628	556.70	505.51	460.85	422.30	387.65	355.73	327.68
15.729	303.40	281.66	262.29	244.96	229.54	215.39	202.92
16.830	191.69	181.53	172.40	164.18	156.63	149.86	143.70
17.931	138.24	133.23	128.64	124.63	120.92	117.39	114.00
19.032	110.71	107.51	104.38	101.36	98.54	96.11	93.85
20.133	91.64	89.49	87.39	85.34	83.36	81.46	79.65
21.233	77.96	76.40	74.96	73.65	72.46	71.38	70.41
22.334	69.53	68.73	67.99	67.31	66.68	66.08	65.51
23.435	64.98	64.46	63.97	63.49	62.98	62.27	61.24
24.536	59.78	57.74	54.97	51.45	47.36	42.90	38.31
25.637	33.74	29.33	25.23	21.48	18.14	15.28	12.93
26.738	10.98	9.32	7.92	6.73	5.70	4.83	4.09
27.838	3.46	2.93	2.48	2.09	1.76	1.49	1.25

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
28.939	1.05	0.88	0.74	0.62	0.51	0.42	0.35
30.040	0.28	0.23	0.18	0.14	0.11	0.08	0.06

STORM 100-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Scrib PS	1.803		3.712		13.39	1198.34	664.59

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
7.258	0.11	0.23	0.44	0.75	1.19	1.78	2.52
8.359	3.42	4.50	5.76	7.21	8.88	10.78	12.91
9.460	15.29	17.91	20.78	23.88	27.24	30.88	34.85
10.561	39.24	44.16	49.75	56.18	63.68	72.57	83.30
11.662	98.17	124.98	177.92	260.27	367.88	504.95	669.44

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 100-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

12.762	842.17	991.19	1101.20	1169.36	1198.34	1195.62	1159.53
13.863	1104.73	1032.48	942.40	844.34	757.05	684.53	620.93
14.964	565.72	517.92	474.66	435.02	400.49	370.50	343.60
16.065	319.69	298.32	279.29	261.86	246.58	232.76	220.30
17.166	209.12	199.04	189.78	181.51	174.00	167.33	161.19
18.267	155.61	150.75	146.20	141.87	137.70	133.66	129.73
19.368	125.89	122.20	118.81	115.91	113.16	110.48	107.87
20.468	105.32	102.84	100.44	98.14	95.97	93.94	92.06
21.569	90.33	88.76	87.33	86.04	84.87	83.81	82.84
22.670	81.96	81.13	80.36	79.64	78.96	78.31	77.68
23.771	77.08	76.50	75.85	74.95	73.64	71.79	69.21
24.872	65.74	61.39	56.38	50.97	45.43	39.93	34.66
25.973	29.78	25.31	21.36	18.01	15.25	12.95	11.00
27.073	9.34	7.93	6.72	5.69	4.82	4.08	3.45
28.174	2.92	2.46	2.08	1.75	1.47	1.24	1.04
29.275	0.87	0.72	0.60	0.50	0.41	0.33	0.27
30.376	0.21	0.17	0.13	0.09	0.06		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	1.803		3.712		13.39	1198.34	664.59

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
7.258	0.11	0.23	0.44	0.75	1.19	1.78	2.52
8.359	3.42	4.50	5.76	7.21	8.88	10.78	12.91
9.460	15.29	17.91	20.78	23.88	27.24	30.88	34.85

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)						
10.561	39.24	44.16	49.75	56.18	63.68	72.57	83.30
11.662	98.17	124.98	177.92	260.27	367.88	504.95	669.44
12.762	842.17	991.19	1101.20	1169.36	1198.34	1195.62	1159.53
13.863	1104.73	1032.48	942.40	844.34	757.05	684.53	620.93
14.964	565.72	517.92	474.66	435.02	400.49	370.50	343.60
16.065	319.69	298.32	279.29	261.86	246.58	232.76	220.30
17.166	209.12	199.04	189.78	181.51	174.00	167.33	161.19
18.267	155.61	150.75	146.20	141.87	137.70	133.66	129.73
19.368	125.89	122.20	118.81	115.91	113.16	110.48	107.87
20.468	105.32	102.84	100.44	98.14	95.97	93.94	92.06
21.569	90.33	88.76	87.33	86.04	84.87	83.81	82.84
22.670	81.96	81.13	80.36	79.64	78.96	78.31	77.68
23.771	77.08	76.50	75.85	74.95	73.64	71.79	69.21
24.872	65.74	61.39	56.38	50.97	45.43	39.93	34.66
25.973	29.78	25.31	21.36	18.01	15.25	12.95	11.00
27.073	9.34	7.93	6.72	5.69	4.82	4.08	3.45
28.174	2.92	2.46	2.08	1.75	1.47	1.24	1.04
29.275	0.87	0.72	0.60	0.50	0.41	0.33	0.27

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 100-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:
30.376 0.21 0.17 0.13 0.09 0.06

STORM 1-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Scrib PS	1.803		0.457		13.57	122.72	68.06

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.684	0.07	0.93	4.48	11.18	20.60	33.60	50.55
12.784	69.73	87.42	101.87	112.42	119.14	122.72	122.40
13.885	120.04	115.53	108.49	99.82	91.87	85.16	79.02
14.986	73.59	68.84	64.44	60.29	56.63	53.41	50.45
16.087	47.78	45.35	43.14	41.06	39.21	37.50	35.93
17.188	34.50	33.19	31.98	30.88	29.87	28.97	28.12
18.289	27.34	26.66	26.01	25.39	24.79	24.21	23.63
19.390	23.07	22.51	21.98	21.50	21.04	20.59	20.14
20.490	19.70	19.28	18.86	18.46	18.09	17.74	17.41
21.591	17.12	16.85	16.60	16.39	16.19	16.01	15.85
22.692	15.71	15.57	15.44	15.33	15.21	15.11	15.01
23.793	14.91	14.82	14.70	14.53	14.28	13.92	13.40
24.894	12.71	11.85	10.86	9.80	8.72	7.65	6.63
25.995	5.69	4.83	4.07	3.44	2.91	2.47	2.10
27.095	1.78	1.51	1.28	1.09	0.92	0.78	0.66
28.196	0.56	0.47	0.40	0.33	0.28	0.24	0.20
29.297	0.17	0.14	0.11	0.09	0.08	0.06	0.05

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	1.803		0.457		13.57	122.72	68.06

Line Start Time (hr)	Flow Values @ time increment of 0.157 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.684	0.07	0.93	4.48	11.18	20.60	33.60	50.55
12.784	69.73	87.42	101.87	112.42	119.14	122.72	122.40
13.885	120.04	115.53	108.49	99.82	91.87	85.16	79.02
14.986	73.59	68.84	64.44	60.29	56.63	53.41	50.45
16.087	47.78	45.35	43.14	41.06	39.21	37.50	35.93
17.188	34.50	33.19	31.98	30.88	29.87	28.97	28.12
18.289	27.34	26.66	26.01	25.39	24.79	24.21	23.63
19.390	23.07	22.51	21.98	21.50	21.04	20.59	20.14
20.490	19.70	19.28	18.86	18.46	18.09	17.74	17.41
21.591	17.12	16.85	16.60	16.39	16.19	16.01	15.85

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

22.692	15.71	15.57	15.44	15.33	15.21	15.11	15.01
23.793	14.91	14.82	14.70	14.53	14.28	13.92	13.40
24.894	12.71	11.85	10.86	9.80	8.72	7.65	6.63
25.995	5.69	4.83	4.07	3.44	2.91	2.47	2.10
27.095	1.78	1.51	1.28	1.09	0.92	0.78	0.66
28.196	0.56	0.47	0.40	0.33	0.28	0.24	0.20
29.297	0.17	0.14	0.11	0.09	0.08	0.06	0.05

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	50-Yr (cfs)
Scrib PS	1.803		203.44	342.89	472.32	718.52	946.72
OUTLET	1.803		203.44	342.89	472.32	718.52	946.72

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 100-Yr (cfs)	1-Yr (cfs)	(cfs)	(cfs)	(cfs)
Scrib PS	1.803		1198.34	122.72			
OUTLET	1.803		1198.34	122.72			

WinTR-20 Printed Page File Beginning of Input Data List
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WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Scrib PS Outlet 1.80313 78. 2.49

STREAM REACH:

Caledonia Street Pump Station Watershed

Grand River Interior Drainage
Project No. 120330
Kent County, Michigan

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	5-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	25-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)	1-Yr (cfs)	(hr)
SUBAREAS														
Cal PS	16.29	15.60	26.31	15.25	35.55	15.47	52.84	15.27	68.86	15.41	86.53	15.36	10.43	15.56
REACHES														
OUTLET	16.29		26.31		35.55		52.84		68.86		86.53		10.43	

WinTR-20 Printed Page File Beginning of Input Data List
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WinTR-20: Version 1.10 0 0 0.05
Grand River Interior Drainage
Project No. 120330

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

STORM ANALYSIS:
2-Yr 2.37 Type II 2
5-Yr 3.0 Type II 2
10-Yr 3.52 Type II 2
25-Yr 4.45 Type II 2
50-Yr 5.27 Type II 2
100-Yr 6.15 Type II 2
1-Yr 1.95 Type II 2

STRUCTURE RATING:

GLOBAL OUTPUT:
2 0.05 YYYYN YYYYNN

WinTR-20 Printed Page File End of Input Data List

Grand River Interior Drainage
Project No. 120330

Name of printed page file:
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STORM 2-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Cal PS	0.220		0.800		15.60	16.29	74.08

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.953	0.33	1.06	2.16	3.68	5.73	8.26	10.77
14.274	12.90	14.52	15.57	16.21	16.29	16.01	15.47
16.595	14.61	13.44	12.25	11.25	10.37	9.58	8.89
18.917	8.28	7.70	7.17	6.71	6.29	5.90	5.55
21.238	5.24	4.94	4.67	4.42	4.20	4.01	3.83
23.559	3.67	3.53	3.40	3.27	3.14	3.00	2.84
25.880	2.66	2.46	2.24	2.01	1.77	1.54	1.33
28.201	1.13	0.95	0.80	0.68	0.57	0.48	0.41
30.522	0.35	0.30	0.25	0.21	0.18	0.15	0.13
32.843	0.11	0.09	0.08	0.06	0.05		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.220		0.800		15.60	16.29	74.08

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 2-Yr

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

11.953	0.33	1.06	2.16	3.68	5.73	8.26	10.77
14.274	12.90	14.52	15.57	16.21	16.29	16.01	15.47
16.595	14.61	13.44	12.25	11.25	10.37	9.58	8.89
18.917	8.28	7.70	7.17	6.71	6.29	5.90	5.55
21.238	5.24	4.94	4.67	4.42	4.20	4.01	3.83
23.559	3.67	3.53	3.40	3.27	3.14	3.00	2.84
25.880	2.66	2.46	2.24	2.01	1.77	1.54	1.33
28.201	1.13	0.95	0.80	0.68	0.57	0.48	0.41
30.522	0.35	0.30	0.25	0.21	0.18	0.15	0.13
32.843	0.11	0.09	0.08	0.06	0.05		

STORM 5-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Cal PS	0.220		1.249		15.25	26.31	119.68

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
11.269	0.09	0.20	0.74	2.01	3.89	6.43	9.79
13.590	13.88	17.92	21.32	23.85	25.43	26.31	26.30
15.911	25.70	24.68	23.18	21.20	19.19	17.51	16.04
18.232	14.74	13.61	12.61	11.67	10.82	10.08	9.40
20.553	8.79	8.23	7.74	7.27	6.85	6.47	6.13
22.874	5.83	5.56	5.31	5.09	4.89	4.70	4.51
25.195	4.30	4.08	3.82	3.53	3.21	2.88	2.54
27.517	2.22	1.91	1.62	1.37	1.15	0.97	0.82
29.838	0.69	0.59	0.50	0.42	0.36	0.30	0.26
32.159	0.22	0.18	0.15	0.13	0.11	0.09	0.08
34.480	0.06	0.05					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.220		1.249		15.25	26.31	119.68

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
11.269	0.09	0.20	0.74	2.01	3.89	6.43	9.79
13.590	13.88	17.92	21.32	23.85	25.43	26.31	26.30
15.911	25.70	24.68	23.18	21.20	19.19	17.51	16.04
18.232	14.74	13.61	12.61	11.67	10.82	10.08	9.40
20.553	8.79	8.23	7.74	7.27	6.85	6.47	6.13
22.874	5.83	5.56	5.31	5.09	4.89	4.70	4.51
25.195	4.30	4.08	3.82	3.53	3.21	2.88	2.54
27.517	2.22	1.91	1.62	1.37	1.15	0.97	0.82

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 5-Yr

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

29.838	0.69	0.59	0.50	0.42	0.36	0.30	0.26
32.159	0.22	0.18	0.15	0.13	0.11	0.09	0.08
34.480	0.06	0.05					

STORM 10-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Cal PS	0.220		1.652		15.47	35.55	161.72

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
10.499	0.06	0.13	0.24	0.43	0.96	2.36	4.70
12.820	7.84	11.97	17.14	22.72	27.63	31.39	33.87
15.141	35.21	35.55	34.82	33.52	31.67	29.15	26.29
17.462	23.78	21.70	19.85	18.24	16.84	15.55	14.35
19.783	13.30	12.38	11.54	10.78	10.09	9.46	8.88

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
22.104	8.37	7.91	7.50	7.13	6.80	6.50	6.24
24.425	5.99	5.75	5.49	5.21	4.90	4.54	4.15
26.746	3.73	3.31	2.90	2.50	2.13	1.80	1.52
29.067	1.28	1.08	0.91	0.77	0.66	0.56	0.47
31.388	0.40	0.34	0.28	0.24	0.20	0.17	0.14
33.709	0.12	0.10	0.08	0.07	0.06		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.220		1.652		15.47	35.55	161.72

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
10.499	0.06	0.13	0.24	0.43	0.96	2.36	4.70
12.820	7.84	11.97	17.14	22.72	27.63	31.39	33.87
15.141	35.21	35.55	34.82	33.52	31.67	29.15	26.29
17.462	23.78	21.70	19.85	18.24	16.84	15.55	14.35
19.783	13.30	12.38	11.54	10.78	10.09	9.46	8.88
22.104	8.37	7.91	7.50	7.13	6.80	6.50	6.24
24.425	5.99	5.75	5.49	5.21	4.90	4.54	4.15
26.746	3.73	3.31	2.90	2.50	2.13	1.80	1.52
29.067	1.28	1.08	0.91	0.77	0.66	0.56	0.47
31.388	0.40	0.34	0.28	0.24	0.20	0.17	0.14
33.709	0.12	0.10	0.08	0.07	0.06		

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

STORM 25-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Cal PS	0.220		2.419		15.27	52.84	240.33

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
9.305	0.05	0.11	0.19	0.32	0.50	0.76	1.12
11.626	1.68	3.24	6.25	10.40	15.83	22.80	30.98
13.947	38.69	44.90	49.28	51.72	52.84	52.14	50.42
16.268	47.94	44.53	40.26	36.17	32.82	29.88	27.29
18.589	25.07	23.10	21.24	19.58	18.15	16.85	15.67
20.910	14.61	13.67	12.78	12.01	11.31	10.68	10.11
23.231	9.62	9.16	8.77	8.40	8.06	7.71	7.33
25.552	6.94	6.48	5.97	5.42	4.85	4.27	3.72
27.873	3.19	2.70	2.28	1.92	1.62	1.37	1.16
30.194	0.98	0.83	0.70	0.60	0.50	0.43	0.36

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
32.515	0.30	0.26	0.21	0.18	0.15	0.13	0.11
34.836	0.09	0.07	0.06	0.05			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.220		2.419		15.27	52.84	240.33

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
9.305	0.05	0.11	0.19	0.32	0.50	0.76	1.12
11.626	1.68	3.24	6.25	10.40	15.83	22.80	30.98
13.947	38.69	44.90	49.28	51.72	52.84	52.14	50.42
16.268	47.94	44.53	40.26	36.17	32.82	29.88	27.29
18.589	25.07	23.10	21.24	19.58	18.15	16.85	15.67
20.910	14.61	13.67	12.78	12.01	11.31	10.68	10.11
23.231	9.62	9.16	8.77	8.40	8.06	7.71	7.33
25.552	6.94	6.48	5.97	5.42	4.85	4.27	3.72
27.873	3.19	2.70	2.28	1.92	1.62	1.37	1.16
30.194	0.98	0.83	0.70	0.60	0.50	0.43	0.36
32.515	0.30	0.26	0.21	0.18	0.15	0.13	0.11
34.836	0.09	0.07	0.06	0.05			

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 25-Yr

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

STORM 50-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Cal PS	0.220		3.129		15.41	68.86	313.22

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.450	0.05	0.10	0.18	0.30	0.47	0.69	0.99
10.771	1.38	1.88	2.55	3.73	6.50	11.11	17.13
13.092	24.90	34.57	45.18	54.51	61.58	66.16	68.39
15.413	68.86	67.11	64.31	60.52	55.53	49.78	44.67
17.734	40.53	36.84	33.63	30.88	28.38	26.05	24.00
20.055	22.23	20.61	19.16	17.85	16.68	15.59	14.64
22.376	13.78	13.01	12.33	11.72	11.17	10.69	10.23
24.697	9.80	9.35	8.87	8.35	7.76	7.10	6.40
27.018	5.68	4.98	4.30	3.67	3.09	2.61	2.19
29.339	1.85	1.57	1.33	1.12	0.95	0.81	0.68
31.660	0.58	0.49	0.41	0.35	0.29	0.25	0.21
33.981	0.17	0.15	0.12	0.10	0.08	0.07	0.06

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.220		3.129		15.41	68.86	313.22

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.450	0.05	0.10	0.18	0.30	0.47	0.69	0.99
10.771	1.38	1.88	2.55	3.73	6.50	11.11	17.13
13.092	24.90	34.57	45.18	54.51	61.58	66.16	68.39
15.413	68.86	67.11	64.31	60.52	55.53	49.78	44.67
17.734	40.53	36.84	33.63	30.88	28.38	26.05	24.00
20.055	22.23	20.61	19.16	17.85	16.68	15.59	14.64
22.376	13.78	13.01	12.33	11.72	11.17	10.69	10.23
24.697	9.80	9.35	8.87	8.35	7.76	7.10	6.40
27.018	5.68	4.98	4.30	3.67	3.09	2.61	2.19
29.339	1.85	1.57	1.33	1.12	0.95	0.81	0.68
31.660	0.58	0.49	0.41	0.35	0.29	0.25	0.21
33.981	0.17	0.15	0.12	0.10	0.08	0.07	0.06

STORM 100-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)

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River Interior Drainage (continued)
Project No. 120330

STORM 100-Yr

SUB-AREA:

Cal PS	Outlet	.21986	80.	5.25	

STREAM REACH:

Cal PS	0.220	3.916	15.36	86.53	393.59

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
7.730	0.06	0.12	0.20	0.33	0.50	0.73	1.02
10.051	1.39	1.85	2.42	3.13	4.03	5.42	8.70
12.372	14.34	21.68	31.12	42.96	56.23	68.03	77.03
14.693	82.93	85.77	86.53	84.35	80.84	76.14	69.96
17.014	62.65	56.08	50.78	46.07	41.96	38.46	35.31
19.335	32.34	29.74	27.50	25.46	23.63	21.97	20.51
21.656	19.13	17.94	16.86	15.90	15.04	14.29	13.60
23.977	13.00	12.43	11.91	11.36	10.78	10.17	9.46
26.298	8.68	7.84	6.98	6.13	5.30	4.53	3.82
28.619	3.22	2.71	2.28	1.93	1.64	1.39	1.18
30.940	1.00	0.84	0.71	0.60	0.51	0.43	0.36
33.261	0.30	0.25	0.21	0.18	0.15	0.13	0.10
35.582	0.09	0.07	0.06				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.220		3.916		15.36	86.53	393.59

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
7.730	0.06	0.12	0.20	0.33	0.50	0.73	1.02
10.051	1.39	1.85	2.42	3.13	4.03	5.42	8.70
12.372	14.34	21.68	31.12	42.96	56.23	68.03	77.03
14.693	82.93	85.77	86.53	84.35	80.84	76.14	69.96
17.014	62.65	56.08	50.78	46.07	41.96	38.46	35.31
19.335	32.34	29.74	27.50	25.46	23.63	21.97	20.51
21.656	19.13	17.94	16.86	15.90	15.04	14.29	13.60
23.977	13.00	12.43	11.91	11.36	10.78	10.17	9.46
26.298	8.68	7.84	6.98	6.13	5.30	4.53	3.82
28.619	3.22	2.71	2.28	1.93	1.64	1.39	1.18
30.940	1.00	0.84	0.71	0.60	0.51	0.43	0.36
33.261	0.30	0.25	0.21	0.18	0.15	0.13	0.10
35.582	0.09	0.07	0.06				

STORM 1-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Cal PS	0.220		0.532		15.56	10.43	47.42

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River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
11.916	0.13	0.52	1.15	2.03	3.23	4.77	6.38
14.237	7.82	8.95	9.74	10.25	10.43	10.34	10.09
16.558	9.64	8.97	8.24	7.60	7.05	6.54	6.10
18.879	5.71	5.34	4.99	4.69	4.41	4.16	3.92
21.200	3.71	3.51	3.33	3.16	3.01	2.88	2.75
23.521	2.64	2.55	2.46	2.37	2.28	2.18	2.07
25.842	1.95	1.80	1.64	1.48	1.31	1.14	0.99
28.164	0.84	0.71	0.60	0.50	0.43	0.36	0.31
30.485	0.26	0.22	0.19	0.16	0.13	0.11	0.09
32.806	0.08	0.07	0.06				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.220		0.532		15.56	10.43	47.42

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
11.916	0.13	0.52	1.15	2.03	3.23	4.77	6.38
14.237	7.82	8.95	9.74	10.25	10.43	10.34	10.09
16.558	9.64	8.97	8.24	7.60	7.05	6.54	6.10
18.879	5.71	5.34	4.99	4.69	4.41	4.16	3.92

Line Start Time (hr)	Flow Values @ time increment of 0.332 hr (cfs)						
21.200	3.71	3.51	3.33	3.16	3.01	2.88	2.75
23.521	2.64	2.55	2.46	2.37	2.28	2.18	2.07
25.842	1.95	1.80	1.64	1.48	1.31	1.14	0.99
28.164	0.84	0.71	0.60	0.50	0.43	0.36	0.31
30.485	0.26	0.22	0.19	0.16	0.13	0.11	0.09
32.806	0.08	0.07	0.06				

WinTR-20: Version 1.10 0 0 0.05
 River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
 Cal PS Outlet .21986 80. 5.25

STREAM REACH:

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	50-Yr (cfs)
Cal PS	0.220		16.29	26.31	35.55	52.84	68.86
OUTLET	0.220		16.29	26.31	35.55	52.84	68.86

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 100-Yr (cfs)	1-Yr (cfs)	(cfs)	(cfs)	(cfs)
Cal PS	0.220		86.53	10.43			
OUTLET	0.220		86.53	10.43			

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River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Cal PS Outlet .21986 80. 5.25

STREAM REACH:

Palmer Street Pump Station Watershed

Grand River Interior Drainage
Project No. 120330
Kent County, Michigan

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	5-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	25-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)	1-Yr (cfs)	(hr)
SUBAREAS														
Palmer PS	4.63	14.51	8.08	14.50	11.23	14.57	17.58	14.42	23.44	14.30	30.09	14.46	2.72	14.79
REACHES														
OUTLET	4.63		8.08		11.23		17.58		23.44		30.09		2.72	

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Grand River Interior Drainage
Project No. 120330

SUB-AREA:
  Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

STORM ANALYSIS:
  2-Yr 2.37 Type II 2
  5-Yr 3.0 Type II 2
  10-Yr 3.52 Type II 2
  25-Yr 4.45 Type II 2
  50-Yr 5.27 Type II 2
  100-Yr 6.15 Type II 2
  1-Yr 1.95 Type II 2

STRUCTURE RATING:

GLOBAL OUTPUT:
  2 0.05 YYYYN YYYYNN

WinTR-20 Printed Page File End of Input Data List

Grand River Interior Drainage
Project No. 120330

Name of printed page file:
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STORM 2-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		0.616		14.51	4.63	68.84

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
12.080	0.16	0.41	0.77	1.26	1.90	2.62	3.30
13.778	3.84	4.24	4.49	4.63	4.61	4.52	4.34
15.476	4.07	3.74	3.44	3.18	2.95	2.75	2.57
17.173	2.40	2.25	2.11	1.98	1.87	1.77	1.67
18.871	1.59	1.51	1.44	1.38	1.32	1.27	1.22
20.569	1.17	1.13	1.08	1.04	1.01	0.97	0.94
22.266	0.91	0.89	0.86	0.84	0.82	0.80	0.79
23.964	0.77	0.76	0.74	0.72	0.70	0.67	0.63
25.662	0.58	0.53	0.48	0.42	0.37	0.32	0.27
27.359	0.23	0.20	0.16	0.14	0.12	0.10	0.09
29.057	0.07	0.06	0.05				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		0.616		14.51	4.63	68.84

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						

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River Interior Drainage (continued)
Project No. 120330

STORM 2-Yr

SUB-AREA:
Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

12.080	0.16	0.41	0.77	1.26	1.90	2.62	3.30
13.778	3.84	4.24	4.49	4.63	4.61	4.52	4.34
15.476	4.07	3.74	3.44	3.18	2.95	2.75	2.57
17.173	2.40	2.25	2.11	1.98	1.87	1.77	1.67
18.871	1.59	1.51	1.44	1.38	1.32	1.27	1.22
20.569	1.17	1.13	1.08	1.04	1.01	0.97	0.94
22.266	0.91	0.89	0.86	0.84	0.82	0.80	0.79
23.964	0.77	0.76	0.74	0.72	0.70	0.67	0.63
25.662	0.58	0.53	0.48	0.42	0.37	0.32	0.27
27.359	0.23	0.20	0.16	0.14	0.12	0.10	0.09
29.057	0.07	0.06	0.05				

STORM 5-Yr

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		1.014		14.50	8.08	120.26

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
11.832	0.10	0.37	0.86	1.52	2.43	3.58	4.86
13.530	6.01	6.92	7.55	7.93	8.08	7.98	7.75
15.227	7.38	6.85	6.24	5.69	5.23	4.82	4.46
16.925	4.14	3.85	3.57	3.33	3.12	2.93	2.75
18.623	2.60	2.45	2.32	2.21	2.11	2.01	1.92
20.320	1.84	1.77	1.69	1.63	1.56	1.50	1.45
22.018	1.40	1.36	1.32	1.28	1.25	1.21	1.18
23.716	1.16	1.13	1.11	1.09	1.06	1.03	0.98
25.414	0.93	0.86	0.78	0.70	0.62	0.54	0.47
27.111	0.40	0.34	0.29	0.24	0.21	0.17	0.15
28.809	0.13	0.11	0.09	0.08	0.06	0.05	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		1.014		14.50	8.08	120.26

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
11.832	0.10	0.37	0.86	1.52	2.43	3.58	4.86
13.530	6.01	6.92	7.55	7.93	8.08	7.98	7.75

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 River Interior Drainage (continued)
Project No. 120330

STORM 5-Yr

SUB-AREA:
 Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

15.227	7.38	6.85	6.24	5.69	5.23	4.82	4.46
16.925	4.14	3.85	3.57	3.33	3.12	2.93	2.75
18.623	2.60	2.45	2.32	2.21	2.11	2.01	1.92
20.320	1.84	1.77	1.69	1.63	1.56	1.50	1.45
22.018	1.40	1.36	1.32	1.28	1.25	1.21	1.18
23.716	1.16	1.13	1.11	1.09	1.06	1.03	0.98
25.414	0.93	0.86	0.78	0.70	0.62	0.54	0.47
27.111	0.40	0.34	0.29	0.24	0.21	0.17	0.15
28.809	0.13	0.11	0.09	0.08	0.06	0.05	

STORM 10-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		1.378		14.57	11.23	167.18

Grand River Interior Drainage
Project No. 120330

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
11.415	0.05	0.11	0.34	0.87	1.67	2.74	4.15
13.113	5.87	7.59	9.05	10.14	10.84	11.21	11.23
14.810	10.98	10.55	9.92	9.09	8.23	7.50	6.88
16.508	6.32	5.84	5.41	5.01	4.64	4.32	4.04
18.206	3.78	3.55	3.34	3.15	2.98	2.83	2.70
19.903	2.57	2.46	2.35	2.25	2.15	2.07	1.99
21.601	1.91	1.84	1.78	1.72	1.67	1.62	1.58
23.299	1.54	1.50	1.46	1.44	1.41	1.38	1.34
24.996	1.29	1.23	1.15	1.06	0.96	0.86	0.76
26.694	0.66	0.57	0.49	0.41	0.35	0.29	0.25
28.392	0.21	0.18	0.15	0.13	0.11	0.09	0.08
30.090	0.07	0.06					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		1.378		14.57	11.23	167.18

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
11.415	0.05	0.11	0.34	0.87	1.67	2.74	4.15
13.113	5.87	7.59	9.05	10.14	10.84	11.21	11.23
14.810	10.98	10.55	9.92	9.09	8.23	7.50	6.88
16.508	6.32	5.84	5.41	5.01	4.64	4.32	4.04
18.206	3.78	3.55	3.34	3.15	2.98	2.83	2.70

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River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

19.903	2.57	2.46	2.35	2.25	2.15	2.07	1.99
21.601	1.91	1.84	1.78	1.72	1.67	1.62	1.58
23.299	1.54	1.50	1.46	1.44	1.41	1.38	1.34
24.996	1.29	1.23	1.15	1.06	0.96	0.86	0.76
26.694	0.66	0.57	0.49	0.41	0.35	0.29	0.25
28.392	0.21	0.18	0.15	0.13	0.11	0.09	0.08
30.090	0.07	0.06					

STORM 25-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		2.088		14.42	17.58	261.65

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
10.535	0.06	0.10	0.15	0.23	0.35	0.57	1.17
12.232	2.25	3.70	5.61	8.03	10.77	13.26	15.22
13.930	16.56	17.29	17.58	17.28	16.68	15.82	14.64

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
15.628	13.22	11.93	10.87	9.92	9.10	8.39	7.74
17.325	7.13	6.60	6.14	5.71	5.34	5.00	4.70
19.023	4.42	4.18	3.97	3.77	3.59	3.42	3.27
20.721	3.13	2.99	2.87	2.75	2.64	2.55	2.46
22.418	2.38	2.31	2.24	2.18	2.12	2.07	2.02
24.116	1.98	1.94	1.89	1.83	1.76	1.67	1.55
25.814	1.42	1.28	1.14	1.00	0.87	0.75	0.64
27.512	0.54	0.45	0.38	0.33	0.28	0.23	0.20
29.209	0.17	0.14	0.12	0.10	0.09	0.07	0.06
30.907	0.05						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		2.088		14.42	17.58	261.65

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
10.535	0.06	0.10	0.15	0.23	0.35	0.57	1.17
12.232	2.25	3.70	5.61	8.03	10.77	13.26	15.22
13.930	16.56	17.29	17.58	17.28	16.68	15.82	14.64
15.628	13.22	11.93	10.87	9.92	9.10	8.39	7.74
17.325	7.13	6.60	6.14	5.71	5.34	5.00	4.70

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River Interior Drainage (continued)
Project No. 120330

STORM 25-Yr

SUB-AREA:
Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

19.023	4.42	4.18	3.97	3.77	3.59	3.42	3.27
20.721	3.13	2.99	2.87	2.75	2.64	2.55	2.46
22.418	2.38	2.31	2.24	2.18	2.12	2.07	2.02
24.116	1.98	1.94	1.89	1.83	1.76	1.67	1.55
25.814	1.42	1.28	1.14	1.00	0.87	0.75	0.64
27.512	0.54	0.45	0.38	0.33	0.28	0.23	0.20
29.209	0.17	0.14	0.12	0.10	0.09	0.07	0.06
30.907	0.05						

STORM 50-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		2.758		14.30	23.44	348.84

Line Start Time (hr) — Flow Values @ time increment of 0.243 hr (cfs)

9.691	0.05	0.08	0.13	0.19	0.27	0.37	0.51
11.388	0.68	0.93	1.51	2.67	4.39	6.65	9.54
13.086	13.00	16.49	19.42	21.55	22.84	23.44	23.33
14.784	22.64	21.60	20.19	18.38	16.51	14.91	13.57

Line Start Time (hr) — Flow Values @ time increment of 0.243 hr (cfs)

16.481	12.38	11.36	10.45	9.62	8.85	8.19	7.61
18.179	7.08	6.61	6.19	5.81	5.47	5.17	4.90
19.877	4.66	4.43	4.23	4.03	3.85	3.68	3.53
21.574	3.39	3.26	3.14	3.04	2.94	2.85	2.76
23.272	2.69	2.61	2.55	2.50	2.45	2.39	2.33
24.970	2.24	2.14	2.01	1.85	1.69	1.51	1.34
26.667	1.16	1.00	0.86	0.73	0.61	0.52	0.44
28.365	0.37	0.32	0.27	0.23	0.19	0.16	0.14
30.063	0.12	0.10	0.08	0.07	0.06		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		2.758		14.30	23.44	348.84

Line Start Time (hr) — Flow Values @ time increment of 0.243 hr (cfs)

9.691	0.05	0.08	0.13	0.19	0.27	0.37	0.51
11.388	0.68	0.93	1.51	2.67	4.39	6.65	9.54
13.086	13.00	16.49	19.42	21.55	22.84	23.44	23.33
14.784	22.64	21.60	20.19	18.38	16.51	14.91	13.57

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 River Interior Drainage (continued)
Project No. 120330

STORM 50-Yr

SUB-AREA:
 Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

16.481	12.38	11.36	10.45	9.62	8.85	8.19	7.61
18.179	7.08	6.61	6.19	5.81	5.47	5.17	4.90
19.877	4.66	4.43	4.23	4.03	3.85	3.68	3.53
21.574	3.39	3.26	3.14	3.04	2.94	2.85	2.76
23.272	2.69	2.61	2.55	2.50	2.45	2.39	2.33
24.970	2.24	2.14	2.01	1.85	1.69	1.51	1.34
26.667	1.16	1.00	0.86	0.73	0.61	0.52	0.44
28.365	0.37	0.32	0.27	0.23	0.19	0.16	0.14
30.063	0.12	0.10	0.08	0.07	0.06		

STORM 100-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		3.508		14.46	30.09	447.82

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
9.123	0.08	0.12	0.17	0.24	0.33	0.44	0.57
10.821	0.72	0.92	1.15	1.46	2.01	3.26	5.28
12.519	7.92	11.33	15.54	20.11	24.10	27.10	29.03
14.216	29.95	30.09	29.29	28.04	26.35	24.15	21.64
15.914	19.44	17.64	16.04	14.65	13.46	12.37	11.35

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
17.612	10.46	9.69	9.00	8.38	7.82	7.33	6.88
19.309	6.49	6.14	5.82	5.53	5.27	5.02	4.79
21.007	4.57	4.38	4.19	4.02	3.88	3.74	3.62
22.705	3.50	3.39	3.30	3.21	3.12	3.05	2.99
24.402	2.92	2.85	2.76	2.64	2.49	2.31	2.11
26.100	1.90	1.69	1.48	1.28	1.10	0.93	0.79
27.798	0.66	0.56	0.48	0.40	0.34	0.29	0.25
29.495	0.21	0.18	0.15	0.13	0.11	0.09	0.08
31.193	0.06	0.05					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		3.508		14.46	30.09	447.82

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
9.123	0.08	0.12	0.17	0.24	0.33	0.44	0.57
10.821	0.72	0.92	1.15	1.46	2.01	3.26	5.28

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River Interior Drainage (continued)
Project No. 120330

STORM 100-Yr

SUB-AREA:
Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

12.519	7.92	11.33	15.54	20.11	24.10	27.10	29.03
14.216	29.95	30.09	29.29	28.04	26.35	24.15	21.64
15.914	19.44	17.64	16.04	14.65	13.46	12.37	11.35
17.612	10.46	9.69	9.00	8.38	7.82	7.33	6.88
19.309	6.49	6.14	5.82	5.53	5.27	5.02	4.79
21.007	4.57	4.38	4.19	4.02	3.88	3.74	3.62
22.705	3.50	3.39	3.30	3.21	3.12	3.05	2.99
24.402	2.92	2.85	2.76	2.64	2.49	2.31	2.11
26.100	1.90	1.69	1.48	1.28	1.10	0.93	0.79
27.798	0.66	0.56	0.48	0.40	0.34	0.29	0.25
29.495	0.21	0.18	0.15	0.13	0.11	0.09	0.08
31.193	0.06	0.05					

STORM 1-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Palmer PS	0.067		0.387		14.79	2.72	40.42

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
12.121	0.10	0.24	0.44	0.73	1.10	1.51	1.90
13.819	2.22	2.46	2.62	2.71	2.72	2.68	2.59
15.516	2.45	2.27	2.11	1.97	1.85	1.73	1.63
17.214	1.53	1.44	1.36	1.29	1.22	1.16	1.11

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
18.912	1.06	1.01	0.97	0.93	0.89	0.86	0.83
20.609	0.80	0.77	0.74	0.72	0.69	0.67	0.65
22.307	0.63	0.61	0.60	0.59	0.57	0.56	0.55
24.005	0.54	0.53	0.52	0.51	0.49	0.47	0.44
25.702	0.41	0.37	0.33	0.29	0.25	0.22	0.19
27.400	0.16	0.13	0.11	0.10	0.08	0.07	0.06

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.067		0.387		14.79	2.72	40.42

Line Start Time (hr)	Flow Values @ time increment of 0.243 hr (cfs)						
12.121	0.10	0.24	0.44	0.73	1.10	1.51	1.90
13.819	2.22	2.46	2.62	2.71	2.72	2.68	2.59
15.516	2.45	2.27	2.11	1.97	1.85	1.73	1.63

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

17.214	1.53	1.44	1.36	1.29	1.22	1.16	1.11
18.912	1.06	1.01	0.97	0.93	0.89	0.86	0.83
20.609	0.80	0.77	0.74	0.72	0.69	0.67	0.65
22.307	0.63	0.61	0.60	0.59	0.57	0.56	0.55
24.005	0.54	0.53	0.52	0.51	0.49	0.47	0.44
25.702	0.41	0.37	0.33	0.29	0.25	0.22	0.19
27.400	0.16	0.13	0.11	0.10	0.08	0.07	0.06

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	50-Yr (cfs)
Palmer PS	0.067		4.63	8.08	11.23	17.58	23.44
OUTLET	0.067		4.63	8.08	11.23	17.58	23.44

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 100-Yr (cfs)	1-Yr (cfs)			
Palmer PS	0.067		30.09	2.72			
OUTLET	0.067		30.09	2.72			

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TR20.inp

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Palmer PS Outlet .06719 76. 3.84

STREAM REACH:

Indian Mill Creek Pump Station Watershed

Grand River Interior Drainage
Project No. 120330
Kent County, Michigan

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	5-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	25-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)	1-Yr (cfs)	(hr)
SUBAREAS														
Indian PS	13.83	13.10	19.93	13.15	25.07	13.04	34.53	13.06	42.88	13.05	51.79	13.02	9.93	13.10
REACHES														
OUTLET	13.83		19.93		25.07		34.53		42.88		51.79		9.93	

WinTR-20 Printed Page File Beginning of Input Data List
TR20.inp

WinTR-20: Version 1.10 0 0 0.05
Grand River Interior Drainage
Project No. 120330

SUB-AREA:
  Indian PS Outlet .05089 88. 1.96

STREAM REACH:

STORM ANALYSIS:
  2-Yr 2.37 Type II 2
  5-Yr 3.0 Type II 2
  10-Yr 3.52 Type II 2
  25-Yr 4.45 Type II 2
  50-Yr 5.27 Type II 2
  100-Yr 6.15 Type II 2
  1-Yr 1.95 Type II 2

STRUCTURE RATING:

GLOBAL OUTPUT:
  2 0.05 YYYYN YYYYNN

WinTR-20 Printed Page File End of Input Data List

Grand River Interior Drainage
Project No. 120330

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STORM 2-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Indian PS	0.051		1.269		13.10	13.83	271.81

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
9.383	0.06	0.08	0.09	0.11	0.14	0.16	0.19
10.250	0.21	0.24	0.28	0.32	0.36	0.41	0.46
11.116	0.52	0.60	0.68	0.78	0.91	1.11	1.49
11.983	2.19	3.21	4.55	6.23	8.16	10.10	11.72
12.849	12.88	13.57	13.83	13.72	13.27	12.60	11.72
13.716	10.67	9.58	8.63	7.83	7.13	6.51	5.97
14.582	5.48	5.03	4.64	4.30	3.99	3.72	3.48
15.449	3.26	3.07	2.90	2.75	2.62	2.49	2.38
16.315	2.28	2.18	2.09	2.01	1.94	1.87	1.81
17.182	1.75	1.70	1.64	1.60	1.55	1.51	1.47
18.048	1.44	1.41	1.38	1.36	1.33	1.31	1.29
18.915	1.27	1.25	1.22	1.20	1.18	1.16	1.14
19.781	1.12	1.10	1.08	1.06	1.04	1.02	1.01
20.648	0.99	0.97	0.95	0.94	0.92	0.91	0.90
21.514	0.89	0.88	0.87	0.86	0.85	0.84	0.84
22.381	0.83	0.83	0.82	0.82	0.81	0.81	0.80
23.247	0.80	0.79	0.79	0.78	0.78	0.78	0.77
24.114	0.77	0.76	0.74	0.72	0.69	0.66	0.61
24.980	0.56	0.50	0.44	0.39	0.34	0.29	0.24
25.847	0.20	0.17	0.15	0.12	0.11	0.09	0.08
26.714	0.06	0.05					

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 2-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.051		1.269		13.10	13.83	271.81

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
9.383	0.06	0.08	0.09	0.11	0.14	0.16	0.19
10.250	0.21	0.24	0.28	0.32	0.36	0.41	0.46
11.116	0.52	0.60	0.68	0.78	0.91	1.11	1.49
11.983	2.19	3.21	4.55	6.23	8.16	10.10	11.72
12.849	12.88	13.57	13.83	13.72	13.27	12.60	11.72
13.716	10.67	9.58	8.63	7.83	7.13	6.51	5.97
14.582	5.48	5.03	4.64	4.30	3.99	3.72	3.48
15.449	3.26	3.07	2.90	2.75	2.62	2.49	2.38

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
16.315	2.28	2.18	2.09	2.01	1.94	1.87	1.81
17.182	1.75	1.70	1.64	1.60	1.55	1.51	1.47
18.048	1.44	1.41	1.38	1.36	1.33	1.31	1.29
18.915	1.27	1.25	1.22	1.20	1.18	1.16	1.14
19.781	1.12	1.10	1.08	1.06	1.04	1.02	1.01
20.648	0.99	0.97	0.95	0.94	0.92	0.91	0.90
21.514	0.89	0.88	0.87	0.86	0.85	0.84	0.84
22.381	0.83	0.83	0.82	0.82	0.81	0.81	0.80
23.247	0.80	0.79	0.79	0.78	0.78	0.78	0.77
24.114	0.77	0.76	0.74	0.72	0.69	0.66	0.61
24.980	0.56	0.50	0.44	0.39	0.34	0.29	0.24
25.847	0.20	0.17	0.15	0.12	0.11	0.09	0.08
26.714	0.06	0.05					

STORM 5-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Indian PS	0.051		1.817		13.15	19.93	391.65

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
8.196	0.06	0.07	0.09	0.11	0.13	0.15	0.17
9.063	0.20	0.22	0.26	0.29	0.32	0.36	0.40
9.929	0.44	0.48	0.53	0.58	0.63	0.69	0.75
10.796	0.82	0.91	1.00	1.10	1.23	1.37	1.54

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 5-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

11.662	1.78	2.17	2.91	4.14	5.81	7.93	10.50
12.529	13.31	15.90	17.89	19.20	19.85	19.93	19.48
13.395	18.62	17.49	16.08	14.48	12.96	11.68	10.59
14.262	9.63	8.80	8.05	7.37	6.77	6.24	5.77
15.128	5.36	4.99	4.66	4.37	4.11	3.88	3.68
15.995	3.50	3.33	3.18	3.04	2.91	2.79	2.68
16.861	2.58	2.49	2.41	2.33	2.26	2.19	2.13
17.728	2.07	2.01	1.96	1.92	1.88	1.84	1.81
18.594	1.78	1.75	1.72	1.69	1.66	1.63	1.60
19.461	1.57	1.55	1.52	1.49	1.47	1.44	1.41
20.327	1.39	1.36	1.34	1.31	1.29	1.27	1.24
21.194	1.23	1.21	1.19	1.18	1.17	1.15	1.14
22.061	1.13	1.12	1.12	1.11	1.10	1.09	1.09
22.927	1.08	1.07	1.07	1.06	1.05	1.05	1.04
23.794	1.04	1.03	1.03	1.02	1.00	0.98	0.95
24.660	0.91	0.85	0.78	0.71	0.64	0.56	0.49
25.527	0.42	0.36	0.30	0.25	0.22	0.18	0.16
26.393	0.13	0.11	0.10	0.08	0.07	0.06	

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.051		1.817		13.15	19.93	391.65

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
8.196	0.06	0.07	0.09	0.11	0.13	0.15	0.17
9.063	0.20	0.22	0.26	0.29	0.32	0.36	0.40
9.929	0.44	0.48	0.53	0.58	0.63	0.69	0.75
10.796	0.82	0.91	1.00	1.10	1.23	1.37	1.54
11.662	1.78	2.17	2.91	4.14	5.81	7.93	10.50
12.529	13.31	15.90	17.89	19.20	19.85	19.93	19.48
13.395	18.62	17.49	16.08	14.48	12.96	11.68	10.59
14.262	9.63	8.80	8.05	7.37	6.77	6.24	5.77
15.128	5.36	4.99	4.66	4.37	4.11	3.88	3.68
15.995	3.50	3.33	3.18	3.04	2.91	2.79	2.68
16.861	2.58	2.49	2.41	2.33	2.26	2.19	2.13
17.728	2.07	2.01	1.96	1.92	1.88	1.84	1.81
18.594	1.78	1.75	1.72	1.69	1.66	1.63	1.60
19.461	1.57	1.55	1.52	1.49	1.47	1.44	1.41
20.327	1.39	1.36	1.34	1.31	1.29	1.27	1.24
21.194	1.23	1.21	1.19	1.18	1.17	1.15	1.14
22.061	1.13	1.12	1.12	1.11	1.10	1.09	1.09
22.927	1.08	1.07	1.07	1.06	1.05	1.05	1.04
23.794	1.04	1.03	1.03	1.02	1.00	0.98	0.95
24.660	0.91	0.85	0.78	0.71	0.64	0.56	0.49
25.527	0.42	0.36	0.30	0.25	0.22	0.18	0.16
26.393	0.13	0.11	0.10	0.08	0.07	0.06	

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 5-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

STORM 10-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Indian PS	0.051		2.285		13.04	25.07	492.60

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
7.344	0.06	0.07	0.09	0.11	0.13	0.15	0.17
8.211	0.19	0.22	0.24	0.27	0.30	0.33	0.37
9.077	0.40	0.44	0.49	0.53	0.58	0.63	0.69
9.944	0.74	0.80	0.86	0.93	1.00	1.08	1.17
10.810	1.26	1.37	1.50	1.64	1.81	2.00	2.23
11.677	2.56	3.10	4.10	5.71	7.87	10.60	13.86
12.543	17.36	20.51	22.88	24.40	25.07	25.06	24.38
13.410	23.23	21.73	19.90	17.87	15.97	14.39	13.03
14.276	11.83	10.80	9.88	9.03	8.28	7.63	7.05
15.143	6.54	6.08	5.68	5.32	5.00	4.72	4.47

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
16.009	4.25	4.05	3.86	3.69	3.53	3.38	3.25
16.876	3.12	3.01	2.91	2.82	2.73	2.65	2.57
17.743	2.49	2.43	2.36	2.31	2.27	2.23	2.18
18.609	2.15	2.11	2.07	2.04	2.00	1.97	1.93
19.476	1.90	1.87	1.83	1.80	1.77	1.73	1.70
20.342	1.67	1.64	1.61	1.58	1.55	1.52	1.50
21.209	1.48	1.46	1.44	1.42	1.40	1.39	1.38
22.075	1.37	1.35	1.34	1.33	1.33	1.32	1.31
22.942	1.30	1.29	1.29	1.28	1.27	1.26	1.26
23.808	1.25	1.24	1.24	1.22	1.21	1.18	1.14
24.675	1.08	1.01	0.93	0.85	0.76	0.67	0.58
25.541	0.50	0.42	0.36	0.30	0.25	0.22	0.18
26.408	0.16	0.13	0.11	0.10	0.08	0.07	0.06

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.051		2.285		13.04	25.07	492.60

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
7.344	0.06	0.07	0.09	0.11	0.13	0.15	0.17
8.211	0.19	0.22	0.24	0.27	0.30	0.33	0.37

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River Interior Drainage (continued)
Project No. 120330

STORM 10-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

9.077	0.40	0.44	0.49	0.53	0.58	0.63	0.69
9.944	0.74	0.80	0.86	0.93	1.00	1.08	1.17
10.810	1.26	1.37	1.50	1.64	1.81	2.00	2.23
11.677	2.56	3.10	4.10	5.71	7.87	10.60	13.86
12.543	17.36	20.51	22.88	24.40	25.07	25.06	24.38
13.410	23.23	21.73	19.90	17.87	15.97	14.39	13.03
14.276	11.83	10.80	9.88	9.03	8.28	7.63	7.05
15.143	6.54	6.08	5.68	5.32	5.00	4.72	4.47
16.009	4.25	4.05	3.86	3.69	3.53	3.38	3.25
16.876	3.12	3.01	2.91	2.82	2.73	2.65	2.57
17.743	2.49	2.43	2.36	2.31	2.27	2.23	2.18
18.609	2.15	2.11	2.07	2.04	2.00	1.97	1.93
19.476	1.90	1.87	1.83	1.80	1.77	1.73	1.70
20.342	1.67	1.64	1.61	1.58	1.55	1.52	1.50
21.209	1.48	1.46	1.44	1.42	1.40	1.39	1.38
22.075	1.37	1.35	1.34	1.33	1.33	1.32	1.31
22.942	1.30	1.29	1.29	1.28	1.27	1.26	1.26
23.808	1.25	1.24	1.24	1.22	1.21	1.18	1.14
24.675	1.08	1.01	0.93	0.85	0.76	0.67	0.58
25.541	0.50	0.42	0.36	0.30	0.25	0.22	0.18
26.408	0.16	0.13	0.11	0.10	0.08	0.07	0.06

STORM 25-Yr

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Indian PS	0.051		3.148		13.06	34.53	678.61

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
6.254	0.05	0.07	0.09	0.11	0.14	0.16	0.19
7.120	0.22	0.25	0.28	0.31	0.34	0.38	0.41
7.987	0.45	0.49	0.53	0.57	0.61	0.65	0.70
8.853	0.74	0.80	0.86	0.92	0.99	1.06	1.13
9.720	1.21	1.30	1.38	1.47	1.56	1.66	1.76
10.586	1.88	2.01	2.15	2.31	2.50	2.71	2.96
11.453	3.25	3.60	4.10	4.97	6.54	8.92	12.03
12.320	15.92	20.48	25.18	29.22	32.15	33.89	34.53
13.186	34.25	33.09	31.36	29.15	26.52	23.72	21.20
14.053	19.08	17.26	15.67	14.29	13.04	11.91	10.91
14.919	10.05	9.28	8.59	7.99	7.46	6.98	6.56
15.786	6.19	5.86	5.57	5.30	5.05	4.82	4.61
16.652	4.42	4.24	4.08	3.93	3.80	3.68	3.56
17.519	3.45	3.35	3.25	3.16	3.08	3.02	2.96
18.385	2.90	2.85	2.80	2.75	2.70	2.65	2.61
19.252	2.56	2.52	2.47	2.43	2.39	2.34	2.30
20.118	2.26	2.22	2.17	2.13	2.09	2.05	2.02
20.985	1.98	1.95	1.92	1.89	1.87	1.85	1.83

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 25-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

21.851	1.81	1.79	1.78	1.76	1.75	1.74	1.73
22.718	1.71	1.70	1.69	1.68	1.67	1.66	1.65
23.584	1.64	1.64	1.63	1.62	1.61	1.59	1.56
24.451	1.53	1.47	1.40	1.30	1.19	1.08	0.96
25.317	0.84	0.73	0.63	0.53	0.45	0.38	0.32
26.184	0.27	0.23	0.20	0.17	0.14	0.12	0.10
27.050	0.09	0.07	0.06	0.05			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.051		3.148		13.06	34.53	678.61

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
6.254	0.05	0.07	0.09	0.11	0.14	0.16	0.19
7.120	0.22	0.25	0.28	0.31	0.34	0.38	0.41
7.987	0.45	0.49	0.53	0.57	0.61	0.65	0.70
8.853	0.74	0.80	0.86	0.92	0.99	1.06	1.13
9.720	1.21	1.30	1.38	1.47	1.56	1.66	1.76
10.586	1.88	2.01	2.15	2.31	2.50	2.71	2.96
11.453	3.25	3.60	4.10	4.97	6.54	8.92	12.03
12.320	15.92	20.48	25.18	29.22	32.15	33.89	34.53
13.186	34.25	33.09	31.36	29.15	26.52	23.72	21.20

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
14.053	19.08	17.26	15.67	14.29	13.04	11.91	10.91
14.919	10.05	9.28	8.59	7.99	7.46	6.98	6.56
15.786	6.19	5.86	5.57	5.30	5.05	4.82	4.61
16.652	4.42	4.24	4.08	3.93	3.80	3.68	3.56
17.519	3.45	3.35	3.25	3.16	3.08	3.02	2.96
18.385	2.90	2.85	2.80	2.75	2.70	2.65	2.61
19.252	2.56	2.52	2.47	2.43	2.39	2.34	2.30
20.118	2.26	2.22	2.17	2.13	2.09	2.05	2.02
20.985	1.98	1.95	1.92	1.89	1.87	1.85	1.83
21.851	1.81	1.79	1.78	1.76	1.75	1.74	1.73
22.718	1.71	1.70	1.69	1.68	1.67	1.66	1.65
23.584	1.64	1.64	1.63	1.62	1.61	1.59	1.56
24.451	1.53	1.47	1.40	1.30	1.19	1.08	0.96
25.317	0.84	0.73	0.63	0.53	0.45	0.38	0.32
26.184	0.27	0.23	0.20	0.17	0.14	0.12	0.10
27.050	0.09	0.07	0.06	0.05			

STORM 50-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 50-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

Indian PS 0.051 3.925 13.05 42.88 842.59

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
5.625	0.07	0.09	0.11	0.13	0.16	0.19	0.23
6.491	0.26	0.30	0.33	0.37	0.41	0.46	0.50
7.358	0.54	0.59	0.63	0.68	0.73	0.77	0.82
8.224	0.87	0.92	0.98	1.03	1.09	1.16	1.23
9.091	1.30	1.38	1.47	1.57	1.67	1.77	1.88
9.957	1.98	2.10	2.21	2.34	2.47	2.62	2.78
10.824	2.97	3.17	3.41	3.68	3.99	4.35	4.79
11.690	5.41	6.46	8.33	11.22	15.01	19.75	25.32
12.557	31.12	36.16	39.85	42.06	42.88	42.56	41.14
13.423	38.99	36.27	33.01	29.52	26.33	23.68	21.39
14.290	19.39	17.66	16.11	14.69	13.45	12.36	11.40
15.156	10.55	9.80	9.14	8.54	8.02	7.56	7.15
16.023	6.78	6.45	6.14	5.86	5.60	5.37	5.15
16.889	4.95	4.77	4.61	4.46	4.31	4.18	4.05
17.756	3.93	3.82	3.72	3.64	3.57	3.50	3.44
18.622	3.38	3.32	3.26	3.20	3.15	3.09	3.04
19.489	2.98	2.93	2.88	2.83	2.78	2.72	2.67
20.355	2.62	2.57	2.52	2.48	2.43	2.39	2.35
21.222	2.32	2.28	2.25	2.23	2.20	2.18	2.16
22.089	2.14	2.12	2.11	2.09	2.08	2.06	2.05
22.955	2.04	2.03	2.01	2.00	1.99	1.98	1.97
23.822	1.96	1.95	1.94	1.92	1.88	1.84	1.78

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
24.688	1.69	1.58	1.45	1.31	1.17	1.03	0.89
25.555	0.77	0.65	0.55	0.46	0.39	0.33	0.28
26.421	0.24	0.20	0.17	0.15	0.12	0.11	0.09
27.288	0.08	0.06	0.05				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.051		3.925		13.05	42.88	842.59

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
5.625	0.07	0.09	0.11	0.13	0.16	0.19	0.23
6.491	0.26	0.30	0.33	0.37	0.41	0.46	0.50
7.358	0.54	0.59	0.63	0.68	0.73	0.77	0.82
8.224	0.87	0.92	0.98	1.03	1.09	1.16	1.23
9.091	1.30	1.38	1.47	1.57	1.67	1.77	1.88

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River Interior Drainage (continued)
Project No. 120330

STORM 50-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

9.957	1.98	2.10	2.21	2.34	2.47	2.62	2.78
10.824	2.97	3.17	3.41	3.68	3.99	4.35	4.79
11.690	5.41	6.46	8.33	11.22	15.01	19.75	25.32
12.557	31.12	36.16	39.85	42.06	42.88	42.56	41.14
13.423	38.99	36.27	33.01	29.52	26.33	23.68	21.39
14.290	19.39	17.66	16.11	14.69	13.45	12.36	11.40
15.156	10.55	9.80	9.14	8.54	8.02	7.56	7.15
16.023	6.78	6.45	6.14	5.86	5.60	5.37	5.15
16.889	4.95	4.77	4.61	4.46	4.31	4.18	4.05
17.756	3.93	3.82	3.72	3.64	3.57	3.50	3.44
18.622	3.38	3.32	3.26	3.20	3.15	3.09	3.04
19.489	2.98	2.93	2.88	2.83	2.78	2.72	2.67
20.355	2.62	2.57	2.52	2.48	2.43	2.39	2.35
21.222	2.32	2.28	2.25	2.23	2.20	2.18	2.16
22.089	2.14	2.12	2.11	2.09	2.08	2.06	2.05
22.955	2.04	2.03	2.01	2.00	1.99	1.98	1.97
23.822	1.96	1.95	1.94	1.92	1.88	1.84	1.78
24.688	1.69	1.58	1.45	1.31	1.17	1.03	0.89
25.555	0.77	0.65	0.55	0.46	0.39	0.33	0.28
26.421	0.24	0.20	0.17	0.15	0.12	0.11	0.09
27.288	0.08	0.06	0.05				

STORM 100-Yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Indian PS	0.051		4.769		13.02	51.79	1017.60

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
4.974	0.06	0.08	0.10	0.13	0.16	0.19	0.23
5.841	0.27	0.31	0.35	0.40	0.44	0.49	0.54
6.707	0.59	0.64	0.70	0.75	0.80	0.86	0.92
7.574	0.98	1.04	1.09	1.16	1.22	1.28	1.34
8.440	1.41	1.48	1.55	1.63	1.71	1.80	1.91
9.307	2.02	2.13	2.26	2.39	2.52	2.65	2.79
10.173	2.93	3.09	3.25	3.43	3.62	3.84	4.09
11.040	4.37	4.70	5.07	5.50	6.01	6.70	7.81
11.906	9.83	13.06	17.41	22.87	29.39	36.42	42.76
12.773	47.53	50.52	51.79	51.64	50.14	47.65	44.48
13.639	40.65	36.41	32.43	29.09	26.25	23.76	21.60
14.506	19.69	17.95	16.40	15.06	13.87	12.82	11.88
15.372	11.06	10.33	9.68	9.12	8.61	8.16	7.75
16.239	7.38	7.04	6.72	6.43	6.17	5.92	5.70
17.105	5.51	5.32	5.15	4.99	4.83	4.69	4.55
17.972	4.43	4.33	4.24	4.16	4.09	4.01	3.94
18.839	3.87	3.80	3.74	3.67	3.61	3.54	3.48
19.705	3.42	3.36	3.30	3.23	3.17	3.11	3.05

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River Interior Drainage (continued)
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STORM 100-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

20.572	3.00	2.94	2.89	2.84	2.79	2.75	2.71
21.438	2.67	2.64	2.61	2.58	2.56	2.53	2.51
22.305	2.49	2.48	2.46	2.44	2.43	2.41	2.40
23.171	2.38	2.37	2.35	2.34	2.33	2.31	2.30
24.038	2.29	2.27	2.23	2.19	2.12	2.02	1.90
24.904	1.75	1.59	1.42	1.25	1.09	0.94	0.80
25.771	0.68	0.57	0.48	0.41	0.35	0.30	0.25
26.637	0.21	0.18	0.15	0.13	0.11	0.09	0.08
27.504	0.07	0.06					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.051		4.769		13.02	51.79	1017.60

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
4.974	0.06	0.08	0.10	0.13	0.16	0.19	0.23
5.841	0.27	0.31	0.35	0.40	0.44	0.49	0.54
6.707	0.59	0.64	0.70	0.75	0.80	0.86	0.92
7.574	0.98	1.04	1.09	1.16	1.22	1.28	1.34
8.440	1.41	1.48	1.55	1.63	1.71	1.80	1.91
9.307	2.02	2.13	2.26	2.39	2.52	2.65	2.79
10.173	2.93	3.09	3.25	3.43	3.62	3.84	4.09
11.040	4.37	4.70	5.07	5.50	6.01	6.70	7.81
11.906	9.83	13.06	17.41	22.87	29.39	36.42	42.76
12.773	47.53	50.52	51.79	51.64	50.14	47.65	44.48
13.639	40.65	36.41	32.43	29.09	26.25	23.76	21.60
14.506	19.69	17.95	16.40	15.06	13.87	12.82	11.88
15.372	11.06	10.33	9.68	9.12	8.61	8.16	7.75

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)						
16.239	7.38	7.04	6.72	6.43	6.17	5.92	5.70
17.105	5.51	5.32	5.15	4.99	4.83	4.69	4.55
17.972	4.43	4.33	4.24	4.16	4.09	4.01	3.94
18.839	3.87	3.80	3.74	3.67	3.61	3.54	3.48
19.705	3.42	3.36	3.30	3.23	3.17	3.11	3.05
20.572	3.00	2.94	2.89	2.84	2.79	2.75	2.71
21.438	2.67	2.64	2.61	2.58	2.56	2.53	2.51
22.305	2.49	2.48	2.46	2.44	2.43	2.41	2.40
23.171	2.38	2.37	2.35	2.34	2.33	2.31	2.30
24.038	2.29	2.27	2.23	2.19	2.12	2.02	1.90
24.904	1.75	1.59	1.42	1.25	1.09	0.94	0.80
25.771	0.68	0.57	0.48	0.41	0.35	0.30	0.25
26.637	0.21	0.18	0.15	0.13	0.11	0.09	0.08
27.504	0.07	0.06					

STORM 1-Yr

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Indian PS	0.051		0.924		13.10	9.93	195.11

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.254	0.05	0.07	0.09	0.11	0.13	0.16	0.19
11.120	0.23	0.28	0.33	0.40	0.48	0.62	0.88
11.987	1.38	2.12	3.08	4.30	5.71	7.13	8.32
12.853	9.19	9.71	9.93	9.88	9.57	9.12	8.51
13.720	7.76	6.99	6.31	5.74	5.24	4.80	4.41
14.586	4.06	3.74	3.46	3.21	2.99	2.79	2.61
15.453	2.46	2.32	2.19	2.08	1.98	1.89	1.81
16.319	1.73	1.66	1.60	1.54	1.48	1.43	1.38
17.186	1.34	1.30	1.26	1.23	1.19	1.16	1.13
18.052	1.11	1.09	1.07	1.05	1.03	1.01	0.99
18.919	0.98	0.96	0.95	0.93	0.91	0.90	0.88
19.785	0.87	0.85	0.84	0.82	0.81	0.79	0.78
20.652	0.76	0.75	0.74	0.73	0.71	0.70	0.69
21.518	0.69	0.68	0.67	0.67	0.66	0.65	0.65
22.385	0.64	0.64	0.64	0.63	0.63	0.63	0.62
23.252	0.62	0.62	0.61	0.61	0.61	0.60	0.60
24.118	0.60	0.59	0.58	0.56	0.54	0.51	0.47
24.985	0.43	0.39	0.34	0.30	0.26	0.22	0.19
25.851	0.16	0.13	0.11	0.10	0.08	0.07	0.06

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.051		0.924		13.10	9.93	195.11

Line Start Time (hr)	Flow Values @ time increment of 0.124 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.254	0.05	0.07	0.09	0.11	0.13	0.16	0.19
11.120	0.23	0.28	0.33	0.40	0.48	0.62	0.88
11.987	1.38	2.12	3.08	4.30	5.71	7.13	8.32
12.853	9.19	9.71	9.93	9.88	9.57	9.12	8.51
13.720	7.76	6.99	6.31	5.74	5.24	4.80	4.41
14.586	4.06	3.74	3.46	3.21	2.99	2.79	2.61
15.453	2.46	2.32	2.19	2.08	1.98	1.89	1.81
16.319	1.73	1.66	1.60	1.54	1.48	1.43	1.38

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

17.186	1.34	1.30	1.26	1.23	1.19	1.16	1.13
18.052	1.11	1.09	1.07	1.05	1.03	1.01	0.99
18.919	0.98	0.96	0.95	0.93	0.91	0.90	0.88
19.785	0.87	0.85	0.84	0.82	0.81	0.79	0.78
20.652	0.76	0.75	0.74	0.73	0.71	0.70	0.69
21.518	0.69	0.68	0.67	0.67	0.66	0.65	0.65
22.385	0.64	0.64	0.64	0.63	0.63	0.63	0.62
23.252	0.62	0.62	0.61	0.61	0.61	0.60	0.60
24.118	0.60	0.59	0.58	0.56	0.54	0.51	0.47
24.985	0.43	0.39	0.34	0.30	0.26	0.22	0.19
25.851	0.16	0.13	0.11	0.10	0.08	0.07	0.06

Grand River Interior Drainage
Project No. 120330

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 2-Yr (cfs)	5-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	50-Yr (cfs)
Indian PS	0.051		13.83	19.93	25.07	34.53	42.88
OUTLET	0.051		13.83	19.93	25.07	34.53	42.88

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 100-Yr (cfs)	1-Yr (cfs)	(cfs)	(cfs)	(cfs)
Indian PS	0.051		51.79	9.93			
OUTLET	0.051		51.79	9.93			

WinTR-20: Version 1.10 0 0 0.05
River Interior Drainage (continued)
Project No. 120330

STORM 1-Yr

SUB-AREA:
Indian PS Outlet .05089 88. 1.96

STREAM REACH:

Grand River Flood Protection System
44 CFR 65.10 (c&d)
Emergency Action Plan

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

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1515 Arboretum Drive, SE
Grand Rapids, Michigan 49546

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Grand River Flood Protection System
44 CFR 65.10 (c&d)
Emergency Action Plan

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

January 30, 2020
Project No. 120330LMP

Final

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Appendix D	Emergency Response Contractors
Appendix E	Approval of the EAP

List of Abbreviations/Acronyms

City	City of Grand Rapids, Michigan
EAP	Emergency Action Plan
GRFPS	Grand River Flood Protection System
NIMS	National Incident Management System
NWS	National Weather Service
OM&I	Operations, Maintenance & Inspection
USGS	U.S. Geological Survey

Statement of Purpose

The purpose of this Emergency Action Plan (EAP) is to minimize the hazard to life and property during a flood emergency event in the City of Grand Rapids, Michigan (City). The functionality of the City's response to any emergency situation is dictated by the National Incident Management System (NIMS) with an Incident Commander (City Manager) responsible for weighing the responsibility for each City department. This EAP is a subpart of this command structure. This EAP is specific to a flood emergency and should be coordinated with the overall emergency response provisions of the City's Emergency Action Guidelines.

The City, which encompasses an area approximately bordered by the City of Walker and Plainfield Charter and Grand Rapids Charter Townships to the east; and the Cities of Wyoming and Kentwood to the south, could be flooded to varying degrees depending on the water level in the Grand River and the nature of an unusual or emergency event. Should the City experience an emergency event that exceeds the GRFPS level of protection, portions of the protected area could be inundated by flood waters. In addition to residential structures (including their contents) and public infrastructure (roadways, railroads, and utilities), schools, industrial facilities, and commercial establishments could be damaged.

Communication of the emergency situation will be on cellular telephones with the Kent County 800 MHz Radio System as a backup. All City, County, and State officials will observe rules of jurisdiction and proper chains of command.

City departments are responsible for monitoring the situation during major floods, when a potentially hazardous condition is developing, and when levee and/or floodwall failure is imminent or has occurred. City departments will respond in accordance with this document. Refer to the Emergency Notification Chart Figures 1 and 2. It is the responsibility of every EAP participant to be fully aware of his/her duties and to execute those duties to the best of their ability.

System Description

The Grand River Flood Protection System (GRFPS) consists of a combination of four types of protective structures built along the banks of the Grand River. These protective structures may be generally classified as: 1) concrete flood walls; 2) low earth levees/embankments constructed atop natural stream banks; 3) highway embankments; 4) railroad embankments; and 5) bridge abutments. The interior flood control system consists of six pump stations, the stormwater collection system, and a series of floodwall backflow devices that drain to the Grand River. Under non-flood conditions in the Grand River, stormwater discharges directly to the river through pipe penetrations through the floodwalls and storm drains installed in the natural stream banks. In the event that flood stages in the river are high enough to close the backflow devices on the stormwater drain outlets, the stormwater flow is diverted to the permanent pump stations and portable pump systems.

The GRFPS was designed to protect approximately 1,420 acres on the right (west) bank and 195 acres on the left (east) bank of residential, commercial, institutional, and industrial properties within the City boundaries from the 100-year flood. The project also provides pumping capacities, stormwater interceptors, and gravity outfalls to discharge interior runoff during a rainfall event. A brief description of each flood protection component is provided in Tables 1, 2, and 3 and the location of each component is shown in Figure 3.

Table 1
Grand River Flood Protection System
Eastside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Levee	2,041	Protective levee around Wastewater Treatment Plant. Length shown is along river. Total ring levee length equals 7,425’
Embankment	2,100	Earth and urban fill along I-196 extending behind CSX Railyard, across Marquette Park and along Plaster Creek
Embankment	1,750	Earth and urban fill along top of stream bank from Plaster Creek to the Market Avenue Retention Basin
Concrete Floodwall	3,420	Market Avenue Retention Basin to downstream face of Wealthy Street Bridge abutment
Concrete Bridge Abutment	75	Wealthy Street Bridge abutment
Embankment	375	Urban fill along top of stream bank from the upstream face of Wealthy Street Bridge abutment to a distance 370’ upstream
Embankment & Sheet Pile	120	370’ upstream of Wealthy Street Bridge to CSX railroad bridge – steel sheet pile installed through urban fill capped by riprap
Concrete Bridge Abutment	35	CSX railroad bridge abutment
Embankment & Sheet Pile	85	CSX railroad bridge to 100’ upstream – steel sheet pile installed through urban fill capped by riprap
Concrete Floodwall	680	100’ upstream of CSX railroad bridge to City Yard
Embankment	740	Urban fill along top of stream bank from the City Yard to the downstream face of the U.S. Route 131 Bridge abutment
Concrete Bridge Abutment	320	U.S. Route 131 Bridge abutment

Table 1
Grand River Flood Protection System
Eastside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Embankment	440	Urban fill along top of bank from the upstream face of the U.S. Route 131 Bridge abutment to parking lot downstream of Fulton Street
Concrete Retaining Wall with Embankment	100	Parking lot downstream of Fulton Street to the downstream face of the Fulton Street Bridge abutment. The embankment consists of low-height urban fill placed atop a concrete retaining wall
Concrete Bridge Abutment	90	Fulton Street Bridge abutment
Concrete Retaining Wall with Embankment	30	Upstream face of Fulton Street Bridge abutment to a point 30' upstream. The embankment consists of urban fill placed atop a concrete retaining wall
Embankment	160	30' upstream of the Fulton Street Bridge to a point 190' upstream of the Fulton Street Bridge. Urban fill embankment faced with grouted and loose concrete pieces; lawn and sidewalk above
Concrete Retaining Wall with Embankment	50	190' upstream of the Fulton Street Bridge to the concrete water sculpture wall. The embankment consists of urban fill placed atop a concrete retaining wall
Concrete Retaining Wall with Embankment	130	Urban fill placed atop a concrete water sculpture wall
Concrete Bridge Abutment	50	Concrete floodwall under Blue Bridge and along Riverwalk
Concrete and Brick Building Wall - including windows	300	Buildings are part of Riverfront Plaza complex and the windows are below the Base Flood Elevation
Concrete Floodwall	220	Concrete floodwall and foundation for the J.W. Marriott Hotel
Stone Masonry and Concrete Wall	115	Retaining wall and building foundation wall consisting of a structurally stitched and grouted natural stone wall capped with a concrete wall (brick building at 250-252 Pearl Street)
Concrete Bridge Abutment	65	Pearl Street Bridge abutment
Stone Masonry and Concrete Wall	90	Retaining wall and building foundation wall consisting of a natural stone wall capped with a concrete wall (part of Amway Grand Plaza Hotel)
Concrete Floodwall	100	Floodwall and concrete building foundation wall for the Amway Grand Plaza Hotel
Concrete Floodwall	95	Concrete amphitheater built into floodwall at the west end of Lyon Street
Concrete Floodwall	40	Wall extends from the concrete amphitheater at the west end of Lyon Street to the downstream end of the pedestrian bridge abutment just upstream of Lyon Street
Concrete Bridge Abutment	35	Gillette Pedestrian Bridge abutment just upstream of Lyon Street

Table 1
Grand River Flood Protection System
Eastside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Concrete Floodwall	995	Upstream end of the Gillette Pedestrian Bridge abutment to the downstream end of the Bridge Street Bridge abutment
Concrete Bridge Abutment	110	Bridge Street Bridge abutment
Concrete Floodwall	40	Upstream end of the Bridge Street Bridge abutment to a point 40' upstream of the bridge. The concrete floodwall is also the foundation wall for the U.S. Post Office
Steel Sheet Pile and Concrete Floodwall	500	40' upstream of the Bridge Street Bridge to the downstream edge of the embankment for I-196. The concrete wall sits atop the steel sheet pile wall and is the foundation for the U.S. Post Office
Steel Sheet Pile and Concrete Floodwall	55	Downstream end of I-196 embankment to eastbound bridge pier. Steel sheet pile retaining wall at waterline with concrete and/or modular block retaining walls on slope
Concrete Retaining Wall & Bridge Pier	60	Bridge pier for eastbound I-196 acts as retaining wall. A low height concrete retaining wall is located at waterline
Concrete Retaining Walls	15	Concrete retaining wall on slope between eastbound and westbound I-196 bridges. A low height concrete retaining wall is located at waterline
Concrete Retaining Wall & Bridge Pier	70	Bridge pier for westbound I-196 acts as retaining wall. A low height concrete retaining wall is located at waterline
Concrete Retaining Walls	240	Concrete retaining wall on slope upstream of westbound I-196 bridge. A low height concrete retaining wall is located at waterline
Concrete Retaining Wall, Modular Block Retaining Wall & Embankment	475	240' upstream of I-196 to the 6th Street Dam. Concrete retaining wall at waterline with combinations of urban fill embankments, modular block walls and concrete retaining walls
Concrete Retaining Wall & Embankment	725	6th Street Park from the dam to the downstream edge of the 6th Street Bridge abutment. Concrete retaining wall at river's edge with clay levee built on natural ground above concrete wall
Stone Masonry Bridge Abutment	75	6th Street Bridge abutment
Concrete Retaining Wall, Modular Block Retaining Wall & Embankment	2,020	Upstream edge of 6th Street Bridge abutment to upstream end of Canal Park. Concrete retaining wall at river's edge with natural ground and intermittent modular block retaining walls
Concrete Retaining Wall & Embankment	950	Upstream end of Canal Park to just upstream of Leonard Street Bridge. Concrete retaining wall at river's edge with natural ground sloping up from wall to former railroad bed
Urban Fill and RR Embankment	1,510	Just upstream of the Leonard Street Bridge to the Water Department Yard. Railroad embankment constructed above urban fill. 670' section of earth embankment placed atop railroad embankment

Table 1
Grand River Flood Protection System
Eastside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Concrete Retaining Wall & Embankment	280	Water Department Yard. Concrete retaining wall at river's edge with railroad embankment constructed above on urban fill
Urban Fill and RR Embankment	920	Water Department Yard to the downstream edge of the CSX Railroad Bridge. Railroad embankment constructed above urban fill
Concrete Bridge Abutment & Embankment	30	CSX Railroad Bridge abutment. Urban fill embankment at abutment
Urban Fill and RR Embankment	870	Upstream edge of CSX Railroad Bridge abutment to Palmer Street Pump Station. Railroad embankment constructed above urban fill
Embankment	250	Palmer Street Pump Station to downstream edge of the Ann Street Bridge abutment. Urban fill embankment
Concrete Bridge Abutment	100	Ann Street Bridge abutment
Embankment	1,450	Upstream edge of Ann Street Bridge abutment to Knapp Street entrance to Comstock Riverside Park. Urban fill and earth embankments with pedestrian path on top
Embankment	120	Knapp Street to Parade Drive along Monroe Avenue. Earth embankment along west side of Monroe Avenue
Natural Topography & Embankment	2,300	Parade Drive to Guild Street. Short (50') earthen embankment between low spots in natural topography along west side of Monroe Avenue and raised entrance (60') to Comstock Riverside Park at Guild Street
Natural Topography & Embankment	2,200	Guild Street to Sligh Boulevard. Short earthen embankment between low spots in natural topography along west side of Monroe Avenue
Natural Topography	4,670	Sligh Boulevard to downstream edge of I-96 Bridge abutment. Natural topography
Concrete Bridge Abutment	180	I-96 (eastbound & westbound) Bridge abutment. Concrete bridge abutment and approach embankment connection to natural topography
Natural Topography	310	Upstream edge of I-96 Bridge abutment to downstream edge of North Park Street Bridge abutment
Concrete Bridge Abutment	170	North Park Street Bridge abutment
Natural Topography	300	Upstream edge of North Park Street Bridge abutment to upstream City Limits

* The distances along the river used in this EAP are referenced to a survey baseline along the centerline of the Grand River that begins at the right lane edge of pavement on the east bound lanes of the I-196 bridge located downstream of the Grand Rapids Wastewater Treatment Plant.

Table 2 Grand River Flood Protection System Westside Riverbank		
Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Natural Topography	2,200	Downstream City Limits to the I-196 Bridge embankment
Bridge Embankment	350	I-196 (eastbound & westbound) Bridge embankment
Natural Topography	3,270	Upstream edge of I-196 Bridge embankment to the West Side Ditch
Natural Topography	70	Length across West Side Ditch confluence with Grand River
Natural Topography	1,560	West Side Ditch to downstream edge of Consumers Energy property
Embankment	950	Downstream edge of Consumers Energy property to downstream edge of Wealthy Street Pump Station outfall. Clay levee atop natural ground
Concrete Retaining Wall	50	Concrete headwall for Wealthy Street Pump Station outfall
Embankment	630	Upstream edge of Wealthy Street Pump Station outfall to downstream edge of Oxford Street Trail Bridge embankment. Clay levee atop natural ground
Embankment	320	Oxford Street Trail Bridge embankment
Natural Topography	690	Upstream edge of the Oxford Street Trail Bridge embankment to a point 180’ downstream of the Wealthy Street Bridge
Concrete Floodwall	160	180’ downstream of the Wealthy Street Bridge to the downstream edge of the Wealthy Street Bridge abutment. Concrete floodwall along river’s edge
Concrete Bridge Abutment	100	Wealthy Street Bridge abutment
Concrete Floodwall	1,090	Upstream edge of Wealthy Street Bridge abutment to downstream edge of CSX Railroad Bridge abutment
Concrete Bridge Abutment	30	CSX Railroad Bridge abutment
Concrete Floodwall	1,395	Upstream edge of CSX Railroad Bridge abutment to downstream edge of U.S. Route 131 Bridge abutment
Concrete Bridge Abutment	235	U.S. Route 131 Bridge abutment
Concrete Floodwall	260	Upstream edge of U.S. Route 131 Bridge abutment to downstream edge of Fulton Street Bridge abutment
Concrete Bridge Abutment	100	Fulton Street Bridge abutment

Table 2
Grand River Flood Protection System
Westside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Embankment & Concrete Retaining Wall	520	Upstream edge of Fulton Street Bridge abutment to downstream edge of Blue Pedestrian Bridge abutment. Concrete retaining wall constructed at top of natural ground slope
Concrete Bridge Abutment	40	Blue Pedestrian Bridge abutment
Embankment	280	Upstream edge of Blue Pedestrian Bridge abutment to Carrousel at Grand Rapids Public Museum. Natural ground embankment
Embankment & Concrete Retaining Wall	200	Carrousel at Grand Rapids Public Museum. Concrete retaining wall constructed at top of natural ground slope
Embankment	110	Upstream edge of Carrousel at Grand Rapids Public Museum to a point 100' downstream of the Pearl Street Bridge. Natural ground embankment
Concrete Retaining Wall & Embankment	110	100' downstream of the Pearl Street Bridge to the downstream edge of the Pearl Street Bridge abutment. Concrete retaining wall near bottom of slope with natural embankment above
Concrete Bridge Abutment	80	Pearl Street Bridge abutment
Embankment	210	Upstream edge of the Pearl Street Bridge abutment to downstream edge of Pedestrian Bridge (Indian Mounds Park). Natural ground embankment
Concrete Bridge Abutment	140	Pedestrian Bridge abutment
Levee & Embankment	600	Upstream edge of Pedestrian Bridge abutment to downstream edge of the Gerald R. Ford Museum parking lot (Ah-Nab-Awen Park). Earth levee constructed atop natural ground embankment
Embankment	400	Downstream edge of Gerald R. Ford Museum parking lot to downstream edge of Bridge Street Bridge abutment. Natural ground embankment
Concrete Bridge Abutment	80	Bridge Street Bridge abutment
Concrete Retaining Walls & Embankments	570	Upstream edge of the Bridge Street Bridge abutment to downstream edge of I-196 embankment. Combination of concrete retaining walls and natural ground embankments in front of Bridgewater Place

Table 2
Grand River Flood Protection System
Westside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Concrete Bridge Abutment & Embankment	260	Downstream edge of I-196 embankment to upstream end of I-196 embankment. Natural ground embankment and concrete bridge abutment
Embankment & Modular Block Retaining Wall	140	Upstream edge of I-196 embankment to upstream end of Scribner Avenue embankment. Road embankment fill and modular block retaining wall
Embankment	360	Upstream end of Scribner Avenue embankment to fish ladder structure. Natural ground embankment
Concrete Floodwall	895	Fish ladder structure to downstream edge of the 6th Street Bridge abutment. Concrete fish ladder structure continues as floodwall
Concrete Bridge Abutment	35	6th Street Bridge abutment
Concrete Floodwall	2,870	Upstream edge of the 6th Street Bridge abutment to the downstream edge of the Leonard Street Bridge abutment
Concrete Bridge Abutment	75	Leonard Street Bridge abutment
Concrete Floodwall	2,215	Upstream edge of Leonard Street Bridge abutment to a point behind the main building at the Kent County Public Service Center
Levee	450	Behind the main building at the Kent County Public Service Center to the mid-point along the river shoreline of the Kent County Public Service Center yard. Earth levee constructed atop natural ground embankment
Embankment	380	Mid-point along the river shoreline of the Kent County Public Service Center yard to downstream edge of the CSX Railroad Bridge abutment. Natural ground embankment
Concrete Bridge Abutment	80	CSX Railroad Bridge abutment. Upstream edge of CSX Railroad Bridge abutment and railroad embankment parallel the Indian Mill Creek confluence with the Grand River
Embankment	280	Upstream edge of Indian Mill Creek confluence with the Grand River to downstream edge of hotel & restaurant on downstream side of Ann Street. Natural ground embankment
Concrete Retaining Wall	420	Downstream edge of hotel & restaurant to downstream edge of Ann Street Bridge abutment
Concrete Bridge Abutment	70	Ann Street Bridge abutment

Table 2
Grand River Flood Protection System
Westside Riverbank

Component (Downstream to Upstream)	Length Referenced to River Centerline* (feet)	Location/Description
Embankment	2,330	Upstream edge of Ann Street Bridge abutment to City Limits. Natural ground embankment

* The distances along the river used in this EAP are referenced to a survey baseline along the centerline of the Grand River that begins at the right lane edge of pavement on the east bound lanes of the Interstate 196 (I-196) Bridge located downstream of the Grand Rapids Wastewater Treatment Plant.

Table 3
Grand River Flood Protection System
Stormwater Pump Stations

Pump Station	Number of Pumps (Capacity in Gallons Per Minute)	Location
Market Avenue Pump Station	4 (10,770)	East side of river at 741 Market Avenue; downstream of the Oxford Street Trail Bridge
Wealthy Street Pump Station	10 (53,125)	West side of river downstream of the Oxford Street Trail Bridge; access from the south side of Wealthy Street just east of the Indiana Avenue intersection
Front & Scribner Pump Station	6 (53,125)	West side of river just upstream of the I-196 Bridge and to the east of Scribner Avenue; access from parking lot just south of intersection of Front Avenue and 4th Street at the Fish Ladder Park
Indian Mill Creek Pump Station	3 (4,500)	West side of river along Indian Mill Creek upstream of the confluence with the Grand River; at west end of parking lot on the south side of Ann Street for building at 400 Ann Street
Caledonia Street Pump Station	3 (4,500)	East side of river in Water System Department yard at 1430 Monroe Avenue; along river bank and adjacent to abandoned railroad grade
Palmer Street Pump Station	3 (4,500)	East side of river downstream of the Ann Street Bridge; along river and adjacent to abandoned railroad grade at back of former Baker Furniture factory

Emergency Detection Evaluation, and Classification

Definition of Terms

- *Warning*: The flood stage is 18-feet or above as measured at the U.S. Geological Survey (USGS) gage upstream of the Fulton Street Bridge ("Gauge 0" Datum: 585.25 NAVD88). Alternatively, the levee, floodwall, or drain pipe backflow prevention devices have failed or actual failure is in progress and immediate warnings to evacuate are required. A (Warning) condition is the primary focus of this EAP.
- *Watch*: The flood stage is 12-feet and predicted to continue rising ("Gauge 0" Datum: 585.25 NAVD88). Alternatively, a condition exists that could potentially develop into an unsafe condition, but the immediate safety of the levee and/or floodwall is not in jeopardy. The deficient condition should be monitored closely, and a licensed professional engineer familiar with levee and floodwall safety should be contacted to recommend remedial measures. Provisions for addressing deficient conditions are included in the Operations, Maintenance, and Inspection Manual.

Inspection

The levee, floodwall, embankment, and retaining walls should be inspected as required by the Operations, Maintenance, and Inspection Manual. The person(s) responsible for maintaining and/or inspecting the levee and floodwall should be familiar with this section.

High Water Levels

Grand Rapids is subject to rising water levels depending on climatic and meteorological factors. There is an automatic water level recorder operated by the USGS along the Grand River (USGS Station No. 04119000) to determine the current state of the water levels.

Several water levels have been established to trigger specific actions by the City:

- USGS gauge water level = 8.45-feet (elevation 593.70-feet NAVD88) and rising: Street Maintenance Department begins road closure installations
- USGS gauge water level = 12-feet (elevation 597.25-feet NAVD88) and rising: (Watch) Alert issued for City Departments
- USGS gauge water level = 18-feet (elevation 603.25-feet NAVD88) and rising: City Incident Commander (City Manager) issues (Warning) Alert and Kent County Emergency Management & Homeland Security begins to set up Command Center at the Kent County Sheriff's Office
- USGS gauge water level = 21-feet (elevation 606.25-feet NAVD88): Command Center at Kent County Sheriff's Office fully operational

Regular "walk-by" inspections as dictated by the City Engineer should occur daily when the Grand River is at a flood level sufficient to trigger the high water (Warning) Alert by the City Manager. Visual observations from inspections should be documented to establish current event baseline conditions, any developing conditions, or damage assessment.

Potential Levee and Floodwall Problems

Almost all levee and floodwall failures can be directly related to seepage, piping, sediment loss, slope failure, settlement, concrete joints, or problems related to conduits through the levee embankment and/or floodwall. Each of these potential levee and floodwall problems is discussed in the following paragraphs.

Seepage

Depending on the water depth and duration of a particular water depth in a stream, all levees normally experience a minor degree of seepage as water from the stream seeks paths of least resistance through the levee embankment and the levee and/or floodwall foundations. However, excessive seepage or seepage that is visually different than previously observed can be indicative of major problems within the levee embankment and the levee and/or floodwall foundations. Seepage must be controlled in both velocity and quantity. Along the GRFPS, seepage is most likely to occur at the following locations:

Eastside

- Levee surrounding the wastewater treatment plant
- Abandoned railroad embankment between Leonard and Knapp Streets

Westside

- Floodwall from Wealthy to Fulton Streets
- Levee in front of Gerald R. Ford Museum
- Floodwall from the fish ladder structure in Fish Ladder Park just upstream of I-196 to behind the main building at the Kent County Public Service Center south of the intersection of Scribner Avenue and Richmond Street
- Levee in the Kent County Public Service Center Yard extending from the end of the floodwall at this location

Indicators

- Appearance of wet spots or springs in the protected (dry) face of the earth embankment or in areas immediately adjacent to the toe of the embankment or floodwall
- Areas that prematurely thaw, or where snow melts prematurely during the winter
- Areas of wetland-type vegetation (reeds, cattails, etc.) along the protected (dry) side toe of the levee embankment or floodwall
- Boils, seepage, piping (fine-grained material being ejected in a stream of water out of a hole in the levee embankment forming a small cone of material), appearing on the protected (dry) face of the levee embankment or in the area adjacent to the protected (dry) side toe of the embankment and/or floodwall
- Sinkholes or depressions occurring on the levee embankment or in the area adjacent to the toe of the embankment slope or floodwall
- Landslides on the protected (dry) side face of the levee embankment. Note that shallow depth landslides are not always caused by seepage
- Depressions formed in either side of the levee embankment and the levee crest including in the riprap protection on the river side of the levee. Depressions could also form along the paths of the buried drain pipes through the levee embankments and floodwall
- The appearance of a persistent whirlpool (vortex) in the Grand River adjacent to the levee embankment or floodwall during a high water event

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the Operations, Maintenance & Inspection (OM&I) Manual. Note that current river stage information can be obtained from the National Weather Service (NWS) Forecast Office, Grand Rapids, Michigan, Advanced Hydrologic Prediction Service at:

http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4

or the USGS Michigan Water Science Center at:

http://waterdata.usgs.gov/mi/nwis/sw

Piping of foundation and/or embankment material is normally indicated by a buildup of materials around the seepage area or a slope failure (e.g. boils, slumps, landslides, sinkholes). Catching some seepage water in a clear glass jar and looking through the water can often indicate particles in suspension during the initial stages of piping. If the seepage velocity is high, the water may just be cloudy or muddy and buildup of materials may be some distance from the actual seepage location. After the seepage is reported, the area should be photographed before any measures are taken to control the problem. Disturbance of any seepage indicator, such as the buildup of sediment around the seepage area, should be kept to a minimum. Any occurrence of a persistent (not dissipating and/or moving downstream) whirlpool in the Grand River adjacent to the levee and/or floodwall is an emergency (Warning) condition.

Temporary Controls (until more permanent repairs can be made)

- Changes in Seepage, Boils, and Whirlpools
  - Observe for various stream levels to determine the approximate elevation that initiates seepage and the location of the seepage source.
  - If the source of the seepage can be found or a suspected location identified, place a blanket of impervious material such as bentonite clay over the seepage source.
  - If the seepage is persistent, install a grout curtain inside the levee embankment or along the river face of the floodwall.
- Boils
  - Place a ring of sandbags or a large diameter pipe around the boil area to pond water above the ground surface at the boil location and reduce the velocity of the water emanating from the boil.
  - Never dump sand or similar material into a boil until an assessment of the sediment in the boil can be completed.
  - After an assessment of the sediment associated with the seep or boil, an overlay of an approved granular material may be selected as a control measure.
- Sinkholes, Settlement, and Depressions
  - The cause of any sinkholes, settlement, and depressions should be investigated by a qualified geotechnical engineering firm.
  - After documenting the location of sinkholes, settlement, or depressions, they should be filled with earth or rocks until more permanent measures can be taken to resolve the problem.
  - The option exists to perform a temporary control as recommended by a licensed professional engineer with expertise with flood control and safety and approved by the City Engineer.

Slope Failure

In general, slope failures occur gradually, and if detected in the early stages, measures can be taken to prevent total embankment failure. On the river (wet) levee and embankment slopes, failures may occur shortly after a rapid decrease in the river level following a protracted flood. On the protected (dry) levee slope, failures may occur after large rainfall events following a protracted period of hot, dry weather where the levee soils shrink and crack, allowing water to penetrate the surface instead of normally infiltrating. Slope failures can also occur in multiple areas and at different times, but are more likely during special operating or loading conditions or during extended periods of heavy rainfall. They may be initiated by excessive vibrations, seepage, earthquakes, or erosion. Massive slides can initiate catastrophic failure of a levee.

Indicators

- Slumping, sloughing, or sliding of soil material on either the river (wet) face or protected (dry) face of the levee or embankment.
- Displacement of riprap along the river (wet) face of the levee or embankment.
- Cracks in the levee or embankment. Transverse cracks appear across the levee or embankment and might indicate differential settlement within the embankment. Such cracks provide avenues for seepage water and piping could quickly develop. Longitudinal cracks run parallel to the levee or embankment and may signal the early stages of a slide or slump on either face of the embankment.
- Erosion of the river (wet) side or protected (dry) side of the levee or embankment caused by a rapid decrease in the river level following a protracted flood, rainfall, runoff, snow melt, river currents, wave action, lack of vegetation, foot-traffic, overtopping, or increased seepage through the levee or its foundation. Deep erosion gullies and levee waterline erosion can threaten the structural integrity of the embankment. Erosion along the base of the levee indicates potential deterioration of the foundation that could result in landslides or misalignment of the embankment.

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls (until more permanent repairs can be made)

- Slumps/Sloughs/Landslides/Erosion/Settlement
  - For slumps, sloughs, erosion, and settlement on the levee embankment, or at the toe of the embankment slope, fill the affected area with soil, rockfill, or sandbags until more permanent repairs can be made.
  - On the protected (dry) face of the levee embankment, cover the repaired area with plastic sheets or other erosion-resistant materials to prevent subsequent erosion during storms.
  - For landslides, stabilize the toe of the slide by weighting with soil, rock, or gravel. If necessary, fill materials should be placed at the top of the slide to restore freeboard after the toe is stabilized.
- Riprap Displacement
  - Temporarily repair displaced riprap by filling the affected area with additional riprap or sandbags until the cause of the displacement can be determined and more permanent repairs made.
  - Long-term repairs may include removing the riprap, re-grading the levee embankment slope, installing a permeable geotextile fabric filter, placing a layer of bedding gravel, and replacing the riprap stone.
- Cracks
  - Fill non-leaking cracks in the levee embankment with soil, rocks, cement grout, or sandbags until more permanent repairs can be made.
  - Improve (line) the drainage path from the crack to prevent further erosion.
  - A leaking crack is an emergency (Warning) situation. The crack should be filled immediately with an available material including bentonite clay, soil, hay bales, sandbags, and rocks to stop or slow the flow of water until the stream level recedes and a permanent repair is made.
- Levee Overtopping
  - If it is apparent that the floodwall segments of the GRFPS will be overtopped, this is an emergency (Warning) situation. The City Incident Commander and Kent County Emergency Management & Homeland Security Office should be notified to initiate evacuation procedures for the areas potentially affected by the coming flood.

Settlement

Settlement is the decrease in elevation of soil from its originally constructed elevation. To a certain degree, settlement of a levee embankment and floodwall foundation is normal and to be expected. Often settlement occurs because the soil was not fully compacted against a concrete structure or steel sheet pile wall. Settlement is most likely to occur along the levee crest, adjacent to pipe outfalls, adjacent to pump stations, and at the interface between the levee embankment or natural ground and the floodwalls. Settlement of the ground along the floodwall segments could indicate deterioration and seepage through the floodwall. Settlement of the ground may also result from gypsum voids in the underlying bedrock. Settlement along the path of drain pipes through the levee and floodwalls, which could be an indication that material is being removed within the levee or behind the floodwall along the pipe, is most likely and an emergency (Warning) situation.

Indicators

- A noticeable slump in the levee embankment crest.
- Depression in the ground along the path of the drainage pipes.
- Depression in the ground along the steel sheet pile floodwall.
- Depression at the interface between the levee embankment and the steel sheet pile floodwall.
- Settlement along the length of a portion of the concrete floodwall.

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls (until more permanent repairs can be made)

- Sandbags
  - Install sandbags in accordance with the Operations, Maintenance and Inspection Manual.
- Areas where settlement has occurred that are not actively continuing to settle should be filled with clay-type soil to return the levee crest or face to the as-constructed elevation. The clay-type soil should be compacted to 95 percent or above of maximum dry density at 1 percentage point below to 3 percentage points above optimum moisture content based on the Standard Proctor Density Test (ASTM D 698-78).
- Settlement may constitute a (Warning) and the City Engineer should be notified.

Floodwall Misalignment

Floodwall misalignment is the horizontal displacement or movement toward the river or the land. The misalignment of the concrete floodwalls along the Grand River could indicate significant foundation soil movement towards the river, impact of a large or heavy floating object during a flood, ice jam impact or loading, and/or a significant superimposed load adjacent to the floodwall. This also includes loads associated with a receding river stage in which the groundwater on the land side is lagging the river levels.

Indicators

- Cracked concrete on either side of the floodwall
- Tilting or bowed sections of floodwall
- Visible gap and/or lack of waterstops at the joints in the floodwall
- A misalignment of the concrete surfaces at a joint or crack
- Sediment loss

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls (until more permanent repairs can be made)

Misalignment of concrete monolith floodwalls is usually not a fast-moving problem and therefore should be considered a non-emergency (Watch) situation. If the wall is collapsing during a flood event, it is an emergency (Warning) situation. Any misalignment should be directed to the City Engineer and a strategic evaluation by a geotechnical and structural engineer for possible repair and realignment.

Backflow Device Problem

The flap gates and duckbill gates on the ends of the drainage pipes and pump station discharge lines through the levee and floodwall segments of the GRFPS are exposed to the flow in the Grand River and could be damaged or clogged by floating debris and ice impact. The flap gates in the structures adjacent to the pump stations can be jammed open by floating debris and ice.

Indicators

- Water flowing from storm sewer manholes and/or street stormwater inlets during high water conditions in the Grand River. This will typically be seen as water flowing down a street emanating from a manhole cover or catch basin; or ponding water at any location around a manhole cover or catch basin.
- Higher frequency of pump station operation

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls

- Flap Gates in Gate Well Structures
  - Close the sluice gates in the gate wells until the water level subsides and the gate well is dewatered. Once the flap gates can be accessed, the debris and/or ice clogging the gate shall be removed and the flap gates returned to service.
- Drainage Pipes through Levee and Floodwall
  - If the flap gates are not operational, the inlet end of the pipe should be sealed using an inflatable plug or sandbags. Once the water level subsides in the Grand River, the flap gates should be unclogged, repaired, and/or replaced.

Additional Comments

The types of levee and floodwall failures described above are often interrelated in a complex manner. For example, uncontrolled seepage may weaken the soil and lead to a slope failure. A slope failure may shorten the seepage path and lead to a piping failure. Minor defects such as cracks in the levee embankment may be the first visual sign of a major problem that could lead to failure of the structure. A licensed professional engineer experienced in levee and floodwall design and construction should evaluate the seriousness of all deficiencies and recommend appropriate permanent remedial measures.

Whenever a potential emergency situation is reported, the City Engineer or his/her designee should immediately visit the area of concern at the GRFPS and evaluate the situation as described in the above paragraphs. If the situation is severe enough that there is any concern that there could be an uncontrolled release of water into the

area protected by the GRFPS, the City Engineer shall initiate a levee failure (Warning) alert in accordance with the Emergency Notification Chart in Figures 1 and 2.

If upon visiting the potential problem area at the GRFPS, the City Engineer or his/her designee determines that the situation can be handled without danger of an uncontrolled release of water into the area protected by the GRFPS, the necessary work should be coordinated by the City Engineer with the asset management plan inspections, updates, and improvements.

Once a levee and/or floodwall problem progresses to the point that the levee and/or floodwall is failing, evacuation in the flood inundation zone, (see Inundation Map in Figure 6), may be necessary if emergency actions do not appear to be adequate to prevent flooding in the protected area.

Emergency Action

Emergency Action by River Stage

As the Grand River rises in the City, various actions are required to protect areas of the City from inundation by flood waters. Table 4 provides a list of actions by river stage that need to be performed. Note that Table 4 should be reviewed annually to ensure that it is up to date and reflects any modification to the GRFPS.

Preparedness

Levee Owner

The City is responsible for levee and floodwall inspections as outlined in the GRFPS Operations and Maintenance Manual. The City is also responsible for detecting emergency conditions and depending on the observed conditions, he/she is responsible for deciding the appropriate action under the NIMS Incident Commander and the appropriate Emergency Notification Chart in Figures 1 and 2 and in cooperation with the Environmental Services Department, Public Services Department, Water Systems Department, Traffic Control Department, Parks, Recreation and Forestry Department, Police Department, and Fire Department.

If flood (Watch) non-emergency conditions are predicted based on local observations and consultation with the NWS in Grand Rapids, the City Engineer should contact the Environmental Services Department to prepare to monitor pump station operations along the Grand River. If the water level reaches the (Watch) non-emergency condition and is continuing to rise, or if notification from the City Incident Commander and/or Kent County Emergency Management & Homeland Security Office is received, the Environmental Services Department and Public Services Department shall install the temporary flood control measures as described in Table 4. Personnel from the City Engineer's Office, Environmental Services Department, and Public Services Department should inspect the levee and floodwall daily to ensure that no problems are occurring that would trigger an emergency response. In the case that problems are detected, the problem area should be continuously monitored until the flood subsides and remedial measures can be implemented. After the flood subsides, the City Engineer's office should conduct an inspection of the levee, floodwall, and drainage structures, to determine if any damage has occurred that requires repair.

During flooding of the Grand River, the curious public and news media can create a major obstacle to performance of necessary tasks; therefore, levee and floodwall access control measures should be taken. In conjunction with any evacuation of residents in the area protected by the GRFPS, it will be necessary to provide easy access for equipment, supplies, and personnel involved in the effort to affect repairs. The City Engineer, Environmental Services Department, and Public Works Department should work closely with the City Incident Commander and Police and Fire Departments to prevent unauthorized access to the GRFPS and to facilitate movement of necessary equipment, supplies, and personnel to the levee and floodwall.

Notification

In the event of a flood (Warning) emergency condition or problems with the GRFPS, it is the shared responsibility of the City Engineer and Utilities Director to notify the City Incident Commander and Kent County Emergency Management & Homeland Security Office and brief them on the situation. The Kent County Emergency Management & Homeland Security Office will prepare and deliver a message for public release based on the existing conditions and information provided by the City Engineer and City Incident Commander. Preparation of (Warning) emergency messages should begin as soon as their potential need is apparent so that they can be issued promptly upon declaration of a (Warning) emergency condition. When time is available for their preparation, the initial message should contain all pertinent information. However, in some cases a (Warning) emergency condition may be declared with little or no advance notice. The following sample messages provide models for the first announcement in such cases. Subsequent announcements should provide additional details.

Announcement of Levee Failure in Progress

Urgent, Urgent: The City has announced that a portion of the levee (and/or floodwall) along the Grand River (has failed/is in imminent danger of failure).

Attempts to stabilize the levee (and/or floodwall) are underway, but their success cannot be determined as of yet. Residents living in the following areas should evacuate to high ground immediately:

- Name of area (location and extent)
- Name of area (location and extent)
- Name of area (location and extent)

Additional information will be released as soon as possible.

Announcement of Flood Crest Above Flood Protection Level

Urgent, Urgent: The City has announced that the Grand River is expected to crest at elevation (insert elevation), which is (insert number of feet) above the top of the flood protection levees and floodwalls in the City.

Residents living in the following areas should evacuate to high ground immediately:

- Name of area (location and extent)
- Name of area (location and extent)
- Name of area (location and extent)

Additional information will be released as soon as possible.

The simplest functioning means of communications will be used to maintain communications with authorities and construction contractors retained to stabilize the levee and/or floodwall. Notification will normally be on the Kent County 800 MHz Radio System or by cellular telephones.

The NWS will also be a primary source through which emergency announcements are released to the news media.

National Weather Service (Grand Rapids, Michigan): 24-hour telephone number 616.949.0643

The following radio and television stations should be contacted if the NWS cannot be contacted. These stations are considered to have broadcast areas covering Grand Rapids.

TELEVISION STATIONS	
WXSP 120 College Avenue, SE Grand Rapids, MI 49503 616.456.1818	**WZZM** 645 3 Mile Road, NW Grand Rapids, MI 49544 616.785.1313
WXMI 3117 Plaza Drive, NE Grand Rapids, MI 49525 616.364.8722	**WGVU/WGVK** 301 Fulton Street, NW Grand Rapids, MI 49504 800.442.2771
WZPX 2610 Horizon Drive, SE Grand Rapids, MI 49546 616.222.6443	**WOOD/WOTV** 120 College Avenue, SE Grand Rapids, MI 49503 616.456.8888
RADIO STATIONS - FM	
WTRV 50 Monroe Avenue, NW Grand Rapids, MI 49503 616.770.8200	**WBCT** 77 Monroe Center Street, NW Grand Rapids, MI 49503 616.242.0220
WHLT 50 Monroe Avenue, NW Grand Rapids, MI 49503 616.770.8957	**WTNR** 60 Monroe Center Street, NW Grand Rapids, MI 49503 616.774.9450
WFGR 50 Monroe Avenue, NW Grand Rapids, MI 49503 616.459.9889	**WOOD** 77 Monroe Center Street, NW Grand Rapids, MI 49503 616.774.2424
WGRD 50 Monroe Avenue, NW Grand Rapids, MI 49503 616.770-8200	**WBLU** 161 Ottawa Avenue, NW Grand Rapids, MI 49503 616.458.9258
WCSG 1159 East Beltline Avenue, NE Grand Rapids, MI 49525 616.942-1500	**WKLQ** 60 Monroe Center Street, NW Grand Rapids, MI 49503 616.774.9450

RADIO STATIONS - FM

WAYG
1159 E. Beltline Avenue, NE
Grand Rapids, MI 49525
616.974.3690

WLAV
60 Monroe Center Street, NW
Grand Rapids, MI 49503
616.456.5461

WGVU
301 Fulton Street, NW
Grand Rapids, MI 49504
616.331.6666

WPRR
3777 44th Street, NE
Grand Rapids, MI 49512
616.656.2619

WBFX
77 Monroe Center Street, NW
Grand Rapids, MI 49503
616.459.1919

WBBL
60 Monroe Center Street, NW
Grand Rapids, MI 49503
616.459.1180

WFUR
399 Garfield Avenue, SW
Grand Rapids, MI 49504
616.451.9387

WHTS
60 Monroe Center Street, NW
Grand Rapids, MI 49503
616.451.0105

WSNX
77 Monroe Center Street, NW
Grand Rapids, MI 49503
616.770.8104

RADIO STATIONS - AM

WMFN
2422 Burton Street, SE
Grand Rapids, MI 49546
616.451.0551

WNWZ
50 Monroe Avenue, NW, #500
Grand Rapids, MI 49503
616.451.4800

WDSS
3777 44th Street, SE
Grand Rapids, MI 49512
616.656.4052

WTKG
77 Monroe Center Street, NW
Grand Rapids, MI 49503
616.456.1230

WJRW
60 Monroe Center Street, NW
Grand Rapids, MI 49503
616.456.1340

Evacuations

The City Incident Commander, Kent County Emergency Management & Homeland Security Office, and Grand Rapids Police Department, are responsible for evacuation of the flood inundation area. The City Incident Commander and/or Kent County Emergency Management & Homeland Security Office will also contact the Kent County Sheriff and Michigan State Highway Patrol for area coordination, as needed. The City Engineer should not assume responsibility for evacuation but should coordinate with the appropriate officials.

Termination and Follow-Up

The City Engineer should monitor the emergency situation at the GRFPS and keep the City Incident Commander informed of developing conditions. The City Incident Commander and the Kent County Emergency Management & Homeland Security Office are responsible for terminating the (Watch) non-emergency condition or the (Warning) emergency condition for the area protected by the GRFPS.

Following the emergency situation, the City Engineer is responsible for performing a follow-up evaluation of this EAP with the participants involved in the emergency.

EAP Coordination

The City Engineer is responsible for the coordination of this EAP. The responsibility encompasses the following items:

- Revisions to the EAP.
- Coordination of EAP exercises in cooperation with the City Incident Commander and Kent County Emergency Management & Homeland Security Office.
- Establishment of EAP training seminars for the City Engineer's Office, Environmental Services Department, Public Services Department, Water Systems Department, and City Incident Commander.
- Serving as the EAP contact for emergencies (Warning) and non-emergencies (Watch) related to the GRFPS.

Access to the GRFPS

The primary route of access to the GRFPS is from Monroe Avenue, NW, and Market Avenue, SW, along the left (east) Grand River bank and Front Avenue, SW, and NW, and Scribner Avenue, NW, along the right (west) river bank. Although there are numerous bridge crossings along the project, access across bridges should be minimized due to the potential hazard to the bridges caused by the flood waters and any debris or ice in the flood flow.

Response During Periods of Adverse Weather

During periods of adverse weather, the City Engineer should be prepared to isolate and protect areas of potential levee and floodwall repair from rainfall, ice, and snow. This includes stockpiling repair materials, including sand bags, sand, plastic sheets, gravel, and clay soil, and having a list of available contractors, equipment, and equipment operators, including portable lighting, generators, heavy-duty electric cords, earth moving equipment (skid steers, backhoes, front end loaders, bulldozers, etc.)

Response During Periods of Darkness

For emergency situations that occur at night, the City Engineer, Environmental Services Department, and/or Public Services Department, shall provide lighting, either fixed or portable, for the GRFPS that is sufficient to illuminate the site. At least three or more portable generators, maintained in good working order, are to be provided for use in levee, floodwall, and/or drainage structure failure emergencies. The generators and associated electrical cords shall be capable of providing power to any emergency electrical equipment including emergency lighting and have an output capacity that meets or exceeds the power required by emergency equipment.

Alternate System of Communications

Cellular telephones are to be used as an alternate means of communications.

Emergency Supplies and Resources

For emergency use, the City Engineer, Environmental Services Department, the Public Services Department, and/or the Water Systems Department shall have the following materials and supplies available at their respective facilities with sufficient transport vehicles to ensure a timely response to an emergency situation:

- Flashlights to provide lighting where emergency lighting does not illuminate and for directing traffic
- Portable, petroleum-fueled generator(s)
- Extension cords (heavy duty) for use with the portable generators and emergency equipment including lights
- Fire extinguishers (preferably type ABC) for extinguishing any fire that may occur in the emergency equipment
- Portable electric floodlights
- Fill material to dump into any levee and/or floodwall breach and to fill sandbags
- Sandbags
- Backhoe, trackhoe, front end loader, and/or skid steer for hauling and placing fill material
- Four-wheel drive vehicle and dump truck for hauling fill material and equipment
- One or more portable pumps with flexible hoses to assist in pumping water from the pump station wet wells in the event that one or more pumps become disabled
- Plastic sheets for temporary crack repair and for protecting eroded areas on the levee embankment
- Rope to assist emergency personnel
- Personal flotation devices
- First aid kit
- Traffic control cones and/or barriers

A list of available City equipment for emergency operations is included in Appendix C.

Emergency Contractors and Suppliers

The City should have sufficient personnel, equipment, and materials to respond to emergencies at the GRFPS. In the event that additional personnel and equipment is required at the GRFPS site, the City Engineer shall procure the required services on an emergency basis. A list of emergency response contractors is provided in Appendix D.

Figures

FIGURE 1 - NOTIFICATION FLOWCHART - WARNING (EMERGENCY)

Grand River Flood Protection System (Warning) Emergency Level Contact Network

Flood Stage 18 Feet or Higher or
Active Failure of Levee, Floodwall, or Drainage Structure During Flood
(uncontrolled flow into protected area)

Incident Commander
City Manager
Phone: **(616) 456-3166**

Kent County
Emergency Management &
Homeland Security
Phone: **911** or
(616) 632-6100

City Engineer
Phone: **(616) 456-3060**

City Departments

- **Sewer/ESD** Phone: (616) 456-3625
- **Water** Phone: (616) 340-3056
- **Traffic Control** Phone: (616) 304-5238
- **Public Services** Phone: (616) 901-7624
- **Police** Phone: (616) 588-1774
- **Fire** Phone: (616) 260-8797
- **Staging Areas** Phone: (616) 262-4628
- **Damage Assessments** Phone: (616) 581-0979
- **Parks, Recreation & Forestry** (616) 456-3696

State and Federal Government Agencies

- **National Weather Service Grand Rapids** Phone: (616) 949-0643
- **MDOT Grand Region Bridge Operations** Phone: (616) 451-4884
- **U.S. Army Corps of Engineers Detroit District Emergency Response** Phone: (313) 226-1323
- **FEMA-Region V Regional Response Coordination Center** Phone: (800) 273-0890
- **U.S. Geological Survey Michigan Water Science Center** Phone:(517) 887-8903
- **Michigan Department of Environmental Quality Dam & Levee Safety** Phone: (517) 284-5567

Adjacent Levee Owner City of Walker

- **Walker Incident Commander City Manager** Phone: (616) 292-5954
- **Walker City Engineer** Phone: (616) 292-5991

Other Contacts

- **CSX Corporation Bridge & Rail Emergencies** Phone: (800) 232-0144
- **Consumers Energy** Phone: (800) 477-5050

FIGURE 2 - NOTIFICATION FLOWCHART - WATCH (NON-EMERGENCY)

Grand River Flood Protection System (Watch) Non-Emergency Level Contact Network

River Stage 12 Feet and Rising but Less than 18 Feet or
Leak, Landslide, Crack, Erosion, Sinkhole, Settlement, Boil, etc.
That Does Not Immediatly Threaten the Integrity of the Flood Protection System

Incident Commander
City Manager
Phone: **(616) 456-3166**

Kent County
Emergency Management
& Homeland Security
Phone: **911** or
(616) 632-6100

City Engineer
Phone: **(616) 456-3060**

City Departments

- **Sewer/ESD** Phone: (616) 456-3625
- **Water** Phone: (616) 340-3056
- **Traffic Control** Phone: (616) 304-5238
- **Public Services** Phone: (616) 901-7624
- **Police** Phone: (616) 588-1774
- **Fire** Phone: (616) 260-8797
- **Parks, Recreation & Forestry** (616) 456-3696

State and Federal Government Agencies

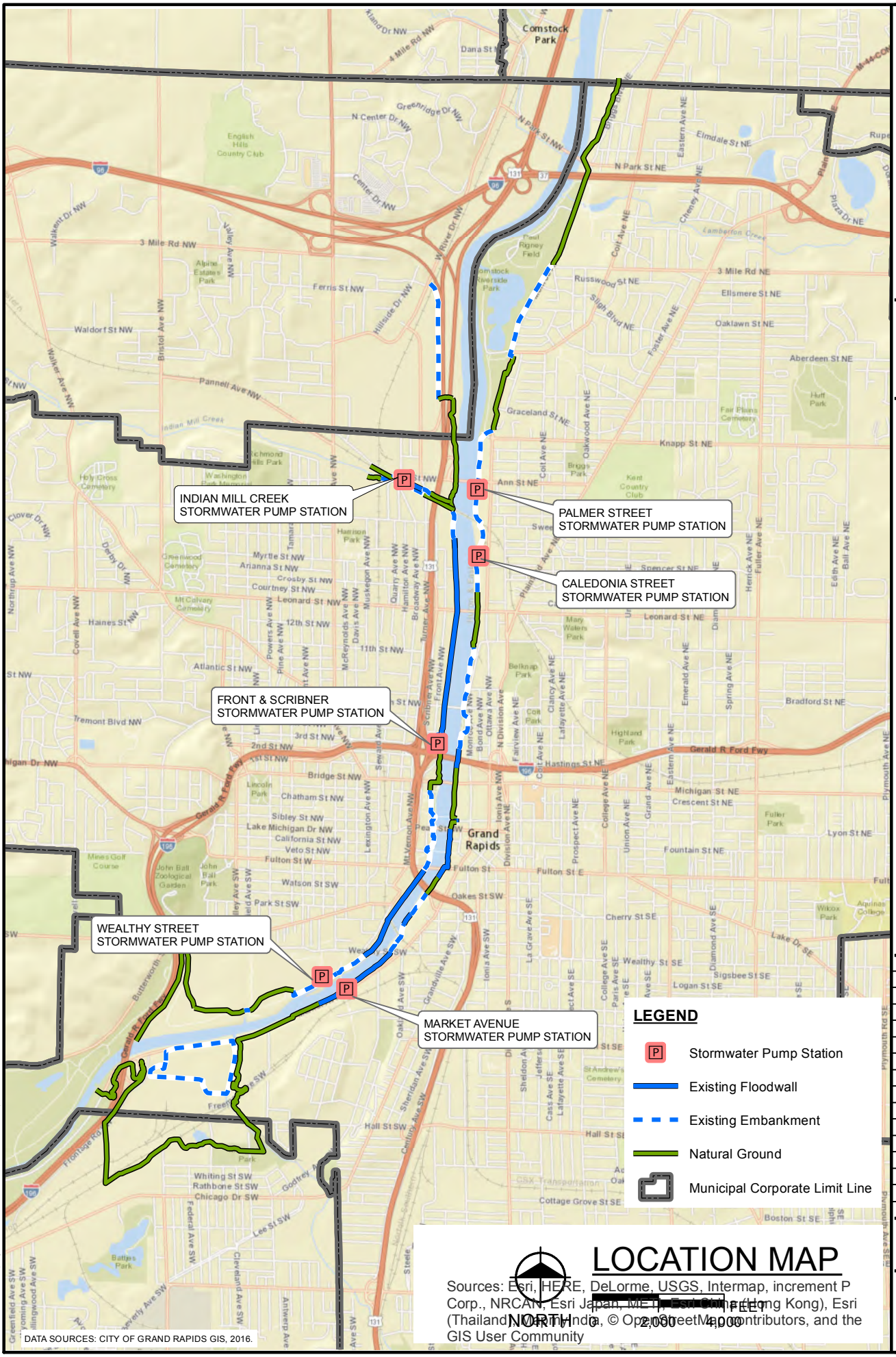
- **National Weather Service**
  Grand Rapids
  Phone: (616) 949-0643
- **MDOT Grand Region**
  Bridge Operations
  Phone: (616) 451-4884

Adjacent Levee Owner
City of Walker

- **Walker Incident Commander**
  City Manager
  Phone: (616) 292-5954
- **Walker**
  City Engineer
  Phone: (616) 292-5991

Other Contacts

- **CSX Corporation**
  Bridge & Rail Emergencies
  Phone: (800) 232-0144
- **Consumers Energy**
  Phone: (800) 477-5050



LOCATION MAP

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

DATA SOURCES: CITY OF GRAND RAPIDS GIS, 2016.

fish

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

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City of Grand Rapids
Kent County, Michigan

Grand River Flood Protection System

PROJECT NO.
G120330LMP

FIGURE NO.
3

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PLOT INFO: \\fbch\allprojects\2012\120330LMP\CAD\GIS\MapDoc\Flood Protection and Lift Station Location EAP.mxd Date: 4/27/2017 4:08:10 PM User: mcl

PLOT INFO: Z:\2012\120330GIS\CAD\GIS\MapDoc\Flood Protection Emergency Action Plan to FEMA.mxd Date: 4/4/2018 11:29:42 AM User: MCL



FIGURE NO. 4

PROJECT NO. G120330EAP

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City of Grand Rapids

Kent County, Michigan

Grand River Flood Protection System
Emergency Action Plan

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CITY OF GRAND RAPIDS MICHIGAN
www.ci.grand-rapids.mi.us

PLOT INFO: Z:\2012\120330GIS\CAD\GIS\MapDoc\Flood Protection Emergency Action Plan to FEMA.mxd Date: 7/31/2019 3:47:20 PM User: MCL



FIGURE NO. 5

PROJECT NO. G120330EAP

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City of Grand Rapids

Kent County, Michigan

Grand River Flood Protection System
Emergency Action Plan

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CITY OF GRAND RAPIDS MICHIGAN
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PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Flood Inundation Map.mxd Date: 4/27/2017 4:22:07 PM User: mcl

I-96
I-96
COMSTOCK RIVERSIDE PARK
3 MILE RD.
US-131
MONROE AVE.
KNAPP ST.
RR
ANN ST.
INDIAN MILL CREEK
ANN ST.
RICHMOND ST.
RR
ALPINE AVE.
US-131
LEONARD ST.
LEONARD ST.
RR
GRAND RIVER
WALKER AVE.
GARFIELD AVE.
6TH ST.
6TH ST.
6TH ST. DAM
I-196
I-196
BRIDGE ST.
MICHIGAN ST.
RR
US-131
LAKE MI DR.
PEARL ST.
FULTON ST.
FULTON ST.
JOHN BALL PARK
US 131
BUTTERWORTH ST.
WEALTHY ST.
WEALTHY ST.
I-196
GRAND RIVER
MARKET ST.
RR
GR WWTP
PLASTER CREEK

NORTH

FLOOD INUNDATION MAP

0 1,000 2,000 FEET

Legend

100-Year Flood Inundation Area

Source: Esri, Digita
CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid,

City of Grand Rapids
Kent County, Michigan

Grand River Flood Protection System

FIGURE NO. 6

PROJECT NO. G120330LMP

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fishbeck, thompson, carr & huber, inc.

engineers
scientists
architects
constructors

fteh

Tables

Table 4
Action Item Chart

Item No.	Address/Item	Location of Item	Description of Item	Critical Elevation (when problem occurs)		Action Required	Materials Needed (during 100-year event)	Equipment Needed (to deliver and onsite)	Responsible Department
				USGS Flood Stage (at Blue Bridge) 100-year = 25.46	NAVD 88 (at Location of Item)				
1	Storm Water Valve MH castings in Berm at WRRF	**East Side** - WRRF	Two 24" and two 12" storm sewers enter the WWTP from the CSX property to the south. The CSX property is below the the BFE. There are valves on these sewers in the grass embankment between the asphalt drive and perimeter fence. If these valves are open during an extreme flood the WRRF is susceptible to flooding.	19.9	602.0	Close all four valves.	None	2" Square valve key	Environmental Services Department
2	East Side Interceptor	**East Side** - Along Eastside of Grand River from MARB to Pearl Street	When the river rises the East Side Interceptor may become bouyant. The pipe is 12' wide and 11.25' tall and is cast-in-place concrete. The invert elevation at the Market Avenue Pump Station is approximately 584.0. The normal water level in the pipe is approximately 24".	12.0	594.5	Keep water level in East Side Interceptor no lower than 15 feet below the Grand River.	None	None	Environmental Services Department
3	240 Front Avenue	**West Side** - Floodwall between Letellier and Emperor Streets	4" core in floodwall for driveway drainage	21.0	604.8	Install 4" inflatable sewer plug; or place 30 sandbags behind the floodwall to plug the hole.	• 4" inflatable sewer plug = 1 • Sandbags = 30	Small air compressor	Environmental Services Department
4	355 Market Avenue (Chesapeake & Ohio Railroad)	**East Side** - RR Bridge between Wealthy and Goodrich Streets	The top of railroad ballast is slightly below the BFE.	24.5	608.6	Construct 50' of sandbag berm across railroad property and connect to the permanent flood control walls. Coordinate with CSX Transportation.	• Sandbags = 1,500 • Sand = 14 cyd	Flat bed delivery truck	Street Maintenance Department
5	242 Front Avenue (Chesapeake & Ohio Railroad)	**West Side** - RR Bridge between Emperor and Butterworth Streets	The top off railroad ballast is slightly below the BFE.	24.5	608.6	Construct 50' of sandbag berm across railroad property and connect to the permament flood control walls. Coordinate with CSX Transportation.	• Sandbags = 1,500 • Sand = 14 cyd	Flat bed delivery truck	Street Maintenance Department
6	Fulton/Monroe/Market Avenue Intersection	**East Side** - Fulton/Monroe/Market Avenue Intersection	This area is below the BFE and not connected to a stormwater pumping station. When the flap gates are closed during extreme flooding events the area is susceptible to flooding during rainfall events that occur during the flood.	23.5	607.6	Connect portable pumps to quick connect located in chamber outside the curbline at the northeast corner of the intersection and pump water from intersection. (Pump hose to fit Andrews #600B 6" male N.P.T. aluminum quick coupler)	• Sandbags = 3,000 • Sand = 28 cyd	• Portable trailer-mounted pumps • Flat bed delivery truck • Fork lift	• Traffic Safety • Environmental Services Department
7	Bond Avenue at Newberry Street	**East Side** - Bond Avenue at Newberry Street	This area is below the BFE and not connected to a stormwater pumping station. When the flap gates are closed during extreme flooding events the area is susceptible to flooding during rainfall events that occur during the flood.	24.0	612.7	Drain area with portable pumps.	• Sandbags = 3,000 • Sand = 28 cyd	Portable pumps	• Street Maintenance Department • Environmental Services Department
8	624 Front Avenue (Fish Ladder Park)	**West Side** - Front Avenue and 4th Street	The sidewalk from the parking lot to the Fishladder is not high enough for extreme flood events.	23.5	611.0	Erect closure by placing aluminum stop logs into guides cast in retaining walls on either side of the sidewalk.	Aluminum stop logs stored at Front Avenue Stormwater Pumping Station	Flat bed delivery truck	Environmental Services Department
9	678 Front Avenue	**West Side** - Floodwall 340' south of 6th Street	4" core in floodwall for riverwalk drainage	21.0	609.6	Install 4" inflatable sewer plug; or place 30 sandbags behind the floodwall to plug the hole.	• 4" inflatable sewer plug = 1 • Sandbags = 30	Small air compressor	Environmental Services Department
10	Myrtle Street from Grand River to Scribner Avenue	**West Side** - Myrtle Street from Grand River to Scribner Avenue	This area is below the BFE and not connected to a stormwater pumping station. When the 24" flap gate at Myrtle Street is closed during an extreme flood event this area is susceptible to shallow flooding during rainfall events that occur during the flood.	20.0	611.0	Drain area with portable pumps.	• Sandbags = 10,000 • Sand = 195 cyd	Portable pumps	Environmental Services Department

Appendix A

Plans for Training, Exercising, Updating and Posting EAP

Annual Training of Project Operators and Other Responsible Personnel

All divisions as determined by the City Incident Commander (see Watch and Warning Emergency Notification Flowcharts, Pages 1 and 2) are responsible for the training of operating and supervisory personnel to assure timely and adequate assessments of developing emergency situations and performance of their duties in the event of an emergency situation. Each individual is to be instructed as to what conditions constitute a project emergency and what specific responsibility they are to execute.

The City Incident Commander (City Manager) and the Kent County Emergency Management & Homeland Security Office are responsible for conducting annual refresher seminars, workshops, or meetings for this EAP.

Annual Review and Test of State of Readiness

At least once a year, the City Incident Commander (City Manager), City Engineer, Environmental Services Manager, Public Services Director, Water Systems Manager, and Kent County Emergency Management & Homeland Security Office, will meet and perform a test to simulate a levee/floodwall failure (Watch or (Warning). The test will be initiated when the City Engineer contacts the City Incident Commander (City Manager) and the Kent County Emergency Management & Homeland Security Office telephone numbers to advise that a test of the emergency alert system for a problem at the GRFPS is being conducted. Every participant in the EAP will execute their required actions as if it were a real emergency. When executing the drill, each person in the contact network should give their name and position and state that this is only a drill and repeat that this is only a drill. In no case shall the news media be notified.

Once everyone in the (Watch or Warning) networks has been contacted, the Kent County Emergency Management & Homeland Security Office will notify the City Incident Commander (City Manager) that all contacts have been made. The City Incident Commander (City Manager) then cancels the test and directs the City Engineer to notify the EAP plan participants of the completion of the test.

Each year, the test of the emergency contact network should be carried out at different times of the day and night and different months to observe the efficiency of the EAP under all situations.

After the drill, the City Incident Commander (City Manager) and Kent County Emergency Management & Homeland Security Office will determine if the test was successful. They will check names, titles, telephone numbers, radio logs, and any other information that is vital to the execution of the EAP. Any revisions to the emergency contact networks for a (Watch and Warning) condition will be made immediately after this review.

Posting

This EAP shall be filed in an area within each participant’s place of work where it is easily accessed and identified. During the annual test of the EAP, the City Incident Commander (City Manager) shall specifically request each participant to verify that they have been able to easily find their copy of the EAP.

Appendix B

Site Specific Concerns

Drain Pipe Backflow Prevention

There are 90 drain pipes that extend through the levee embankment and floodwall along the Grand River and Indian Mill Creek (see the Closure Evaluation Report for pipe locations). Every drain pipe has either a flap gate or a duckbill check valve on its outlet end or in manholes upstream of the river. In some cases, there are no flap gates or duckbill valves; however, manhole covers upstream of the outlet are bolted down to prevent flooding. In the event that a flap gate or duckbill valve is jammed open due to ice, debris, impact damage, or vandalism, the Environmental Services Department and Public Services Department must be prepared to shut-off these pipes at the inlet end. This could be accomplished by inserting an inflatable plug into the inlet. During a flood event where the outlet ends of the pipes are submerged, the Environmental Services Department and Public Services Department should monitor the level of water in these pipes to determine if it is rising in the pipes. If the water is rising, it may indicate that the flap gate on the outlet end of the pipe has not seated and the need to shut-off these pipes at the inlet end.

Appendix C

City Environmental Services Department Maintenance Equipment

Last Updated: December 2012

Item*	Number	Location**
Dump Truck, 1 Ton	6	Maintenance Facility
Dump Truck, 1 Ton	2	Wastewater Treatment Plant
Dump Truck, 40,000 – 60,000 GVWR	2	Maintenance Facility
Pickup Truck, Standard	2	Maintenance Facility
Pickup Truck, Standard	9	Wastewater Treatment Plant
Pickup Truck, 4x4	8	Maintenance Facility
Pickup Truck, 4x4	1	Wastewater Treatment Plant
Stake Truck, up to 20,000 GVWR	3	Maintenance Facility
Stake Truck, 20,000 to 30,000 GVWR	1	Wastewater Treatment Plant
Utility Truck, up to 15,000 GVWR	1	Wastewater Treatment Plant
Utility Truck, 15,000 to 30,000 GVWR	1	Maintenance Facility
Mini-Van	2	Maintenance Facility
Mini-Van	3	Wastewater Treatment Plant
Utility Van	4	Wastewater Treatment Plant
Backhoe, Heavy Duty	3	Maintenance Facility
Backhoe, Heavy Duty	1	Wastewater Treatment Plant
Crane, Large	1	Wastewater Treatment Plant
Salt Spreader	1	Wastewater Treatment Plant
Trailer	5	Maintenance Facility
Trailer	3	Wastewater Treatment Plant
Pumps, Portable	3	Wastewater Treatment Plant

* 1 Ton refers to the truck capacity while GVWR is the Gross Vehicle Weight Rating

** Maintenance facility is located at 1900 Oak Industrial Drive NE, Grand Rapids

Appendix D

Emergency Response Contractors

Last Updated: December 2012

Diversco Construction Co. 570 Market Avenue, SW Grand Rapids, MI 49503 Phone: 616.458.6379 *Contact:* Ryan Maas – 616.318.0830 Mark Robinson – 616.299.8469 *Services:* Road Reconstruction, Bridge Repairs, Sheet Pile Installation, Underground Utilities, Street Resurfacing, Site Grading, Sewer Pump Stations and Modifications, Dewatering, Gravel and Sand Processing	**Dykema Excavators, Inc.** 1730 – 3 Mile Road, NE Grand Rapids, MI 49505 Phone: 616.363.6895 *Contact:* Randy Dykema – 616.459.5800 or 616.862.4151 *Services:* Excavation, Site Grading, Underground Utilities
Georgetown Construction Co., Inc. 6601 Wilshere Drive Jenison, MI 49428 Phone: 616-669-6000 *Contact:* Jeff Hoffman – 891.8656 (Caledonia) *Services:* Housing Construction, General Contracting	**Kamminga & Roodvoets Inc.** 3435 Broadmoor Avenue, SE Grand Rapids, MI 49512-2899 Phone: 616.949.8000 *Contact:* Kurt Poll – 616.245.8175 *Services:* Excavation, Underground Utilities
Lodestar Construction Inc. 333 North Park Street, NW Grand Rapids, MI 49544 Phone: 616.785.7373 *Contact:* David Myers – 616.531.3836 Greg Bustraam – 616.457.5767 *Services:* Excavation, Underground Utilities	**Wyoming Excavators** 9580 – 5 Mile Road, NE Ada, MI 49301 Phone: 616.691.7368 Contact: Nate Post – 616.293.3924 *Services:* Excavation, Underground Utilities

Appendix E

Approval of the EAP

Acknowledgement of Receipt and Understanding

Two copies of this acknowledgement page are included in this copy of the GRFPS EAP. The addressee of this copy of the EAP shall sign and date as indicated below to acknowledge receipt. More importantly, the addressee signifies by their signature that they have read the EAP and understand their role in making the necessary emergency contacts and, if appropriate, mobilizing the necessary personnel and equipment to protect the public in the event of a levee embankment and/or drainage structure problem at the GRFPS.

One copy of this acknowledgement form, signed and dated by the appropriate person, shall be forwarded to the City Engineer and Public Works Department at the addresses shown below. The other signed and dated copy should remain in this copy of the EAP.

I, _____ acknowledge receipt of a copy of the Grand River flood protection

(print name)

system Emergency Action Plan. I further acknowledge that I have reviewed the plan and understand my role in the event of an emergency situation at the project.

_____ Date: _____

(signature)

Return one copy to:

City Engineer
4234 Remembrance Road, NW
Walker, MI 49534

Public Works Department
4234 Remembrance Road, NW
Walker, MI 49534

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(signature)

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4234 Remembrance Road, NW
Walker, MI 49534

Public Works Department
4234 Remembrance Road, NW
Walker, MI 49534

Grand River Flood Protection System
44 CFR 65.10 (c&d)
Emergency Action Plan

Prepared For:
City of Walker
Walker, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

fishbeck
Engineers | Architects | Scientists | Constructors

fishbeck
Engineers | Architects | Scientists | Constructors

1515 Arboretum Drive, SE
Grand Rapids, Michigan 49546

616.575.3824 | fishbeck.com

Grand River Flood Protection System
44 CFR 65.10 (c&d)
Emergency Action Plan

Prepared For:
City of Walker
Walker, Michigan

January 30, 2020
Project No. 120330LMP

Final

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List of Abbreviations/Acronyms

City	City of Walker, Michigan
EAP	Emergency Action Plan
GRFPS	Grand River Flood Protection System
NAVD	North American Vertical Return of 1988
NIMS	National Incident Management System
NWS	National Weather Service
OM&I	Operations, Maintenance & Inspection
USGS	U.S. Geological Survey

Statement of Purpose

The purpose of this Flood Protection Emergency Action Plan (EAP) is to minimize the hazard to life and property during a flood emergency event in the City of Walker, Michigan (City). The functionality of the City's response to any emergency situation is dictated by the National Incident Management System (NIMS) with an Incident Commander (City Manager) responsible for weighing the responsibility for each City department. This EAP is a subpart of this command structure. This Flood Protection EAP is specific to a flood emergency and should be coordinated with the overall emergency response provisions of the City's emergency action guidelines included in the City of Walker and Kent County Emergency Management Agreement dated May 3, 2019.

The City, which lies on the west bank of the Grand River and surrounds the portion of the City of Grand Rapids on the west bank of the river and also borders Alpine and Plainfield Townships (Kent County) to the north, the cities of Grandville and Wyoming (Kent County) to the south and Tallmadge Township (Ottawa County) to the west could be flooded to varying degrees depending on the water level in the Grand River and the nature of an unusual or emergency event. The flood protection measures constructed in the City are an extension of the City of Grand Rapids Grand River Flood Protection System (GRFPS) extending from the on/off ramps of US-131 to 4,530 feet north along US-131 as shown on Figure 4. Should the City experience an emergency event that exceeds the GRFPS level of protection, portions of the protected area could be inundated by flood waters. In addition to residential structures (including their contents) and public infrastructure (roadways, railroads, and utilities), industrial facilities, and commercial establishments could be damaged.

Communication of the emergency situation will be on cellular telephones with the Kent County 800 MHz Radio System as a backup. All City, County, and State officials will observe rules of jurisdiction and proper chains of command.

City departments are responsible for monitoring the situation during major floods, when a potentially hazardous condition is developing, and when levee and/or floodwall failure is imminent or has occurred. City departments will respond in accordance with this document. Refer to the Emergency Notification Chart Figures 1 and 2. It is the responsibility of every Flood Protection EAP participant to be fully aware of his/her duties and to execute those duties to the best of their ability.

System Description

The GRFPS in the City is part of Reach W1 of the larger City of Grand Rapids GRFPS and consists of a combination of two types of protective structures built along the banks of the Grand River. These protective structures may be generally classified as: 1) concrete flood walls atop embankments and 2) low earth levees/embankments constructed atop natural stream banks. The interior flood control system consists of one pump station (located in the City of Grand Rapids), the storm water collection system, and a series of floodwall backflow devices on outfalls that drain to the Grand River. Under non-flood conditions in the Grand River, storm water discharges directly to the river through outfall penetrations through embankments, natural stream banks and US-131. In the event that flood stages in the river are high enough to close the backflow devices on the storm water drain outlets, the storm water flow is diverted to the Indian Mill Creek Pump Station in the City of Grand Rapids.

The GRFPS for Reach W1 was designed to protect approximately 170 acres (119 acres in the City of Walker) on the right (west) bank of residential, commercial, institutional, and industrial properties from up to the 100-year flood. The project provides pumping capacity, stormwater interceptors, and gravity outfalls to discharge interior runoff during a rainfall event. Within the City, the GRFPS consists of 4,530 feet of natural ground and embankment between the Grand Rapids/Walker city boundary at the US Route 131 exit ramps north of Nason Street NW to the railroad tracks near the intersection of West River Drive and Lankamp Street. The location of the GRFPS in the City is shown in Figure 3. Although there are no storm water pump stations in the City, storm water

from the area protected by the GRFPS in the City is directed to the Indian Mill Creek Storm Water Pump Station in Grand Rapids. The Indian Mill Creek Storm Water Pump Station has 3 pumps with a discharge capacity of 4,500 gallons per minute (gpm) and is located along Indian Mill Creek upstream of the confluence with the Grand River at the west end of parking lot on the south side of Ann Street for the building at 400 Ann Street. The location of drainage pipes that penetrate the levee embankment and natural ground are shown in Figure 4.

Emergency Detection, Evaluation, and Classification

Definition of Terms

- *Warning*: The flood stage is 18-feet or above as measured at the U.S. Geological Survey (USGS) gage upstream of the Fulton Street Bridge ("Gauge 0" Datum: 585.25 NAVD88). Alternatively, the levee, floodwall, or drain pipe backflow prevention devices have failed or actual failure is in progress and immediate warnings to evacuate are required. A (Warning) condition is the primary focus of this EAP.
- *Watch*: The flood stage is 12-feet and predicted to continue rising ("Gauge 0" Datum: 585.25 NAVD88). Alternatively, a condition exists that could potentially develop into an unsafe condition, but the immediate safety of the levee and/or floodwall is not in jeopardy. The deficient condition should be monitored closely, and a licensed professional engineer familiar with levee and floodwall safety should be contacted to recommend remedial measures. Provisions for addressing deficient conditions are included in the Operations, Maintenance, and Inspection Manual.

Inspection

The levee, floodwall, embankment, retaining walls and backflow prevention devices should be inspected as required by the Operations, Maintenance, and Inspection Manual. The person(s) responsible for maintaining and/or inspecting the levee and floodwall should be familiar with this section.

High Water Levels

The City of Walker is subject to rising water levels depending on climatic and meteorological factors. There is an automatic water level recorder operated by the USGS along the west bank of the Grand River between the Fulton Street Bridge and the Blue Pedestrian Bridge in Grand Rapids (USGS Station No. 04119000) to determine the current state of the water levels.

Several water levels have been established to trigger specific actions by the City:

- USGS gauge water level = 12-feet (elevation 597.25-feet NAVD88) and rising: (Watch) Alert issued for City Departments and Public Works Department begins road closure installations starting with Turner Avenue.
- USGS gauge water level = 18-feet (elevation 603.25-feet NAVD88) and rising: City Incident Commander (City Manager) issues (Warning) Alert and Kent County Emergency Management & Homeland Security begins to set up Command Center at the Kent County Sheriff's Office
- USGS gauge water level = 21-feet (elevation 606.25-feet NAVD88): Command Center at Kent County Sheriff's Office fully operational

Regular "walk-by" inspections as performed by the Department of Public Works should occur daily when the Grand River is at a flood level sufficient to trigger the high water (Warning) Alert by the City Manager. Visual observations from inspections should be documented to establish current event baseline conditions, any developing conditions, or damage assessment.

Potential Levee Problems

Almost all levee failures can be directly related to seepage, piping, sediment loss, slope failure, settlement, or problems related to conduits through the levee embankment. Although the City's levees are relatively short in length, the problems inherent in levee design and construction still require vigilance. Each of these potential levee problems is discussed in the following paragraphs.

Seepage

Depending on the water depth and duration of a particular water depth in a stream, all levees normally experience a minor degree of seepage as water from the stream seeks paths of least resistance through the levee embankment and the levee foundations. However, excessive seepage or seepage that is visually different than previously observed can be indicative of major problems within the levee embankment and the levee foundations. Seepage must be controlled in both velocity and quantity. Along the GRFPS in the City, seepage is most likely to occur along the embankment opposite the embankment for southbound lanes of U.S. Route 131.

Indicators

- Appearance of wet spots or springs in the protected (dry) face of the earth embankment or in areas immediately adjacent to the toe of the embankment
- Areas that prematurely thaw, or where snow melts prematurely during the winter
- Areas of wetland-type vegetation (reeds, cattails, etc.) along the protected (dry) side toe of the levee embankment
- Boils, seepage, piping (fine-grained material being ejected in a stream of water out of a hole in the levee embankment forming a small cone of material), appearing on the protected (dry) face of the levee embankment or in the area adjacent to the protected (dry) side toe of the embankment
- Sinkholes or depressions occurring on the levee embankment or in the area adjacent to the toe of the embankment slope
- Landslides on the protected (dry) side face of the levee embankment. Note that shallow depth landslides are not always caused by seepage
- Depressions formed in either side of the levee embankment and the levee crest including unusual localized cracking of the road service atop the embankment. Depressions could also form along the paths of the buried drain pipes through the levee embankment
- The appearance of a persistent whirlpool (vortex) in the Grand River adjacent to the levee embankment during a high water event

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the Operations, Maintenance & Inspection (OM&I) Manual. Note that current river stage information can be obtained from the National Weather Service (NWS) Forecast Office, Grand Rapids, Michigan, Advanced Hydrologic Prediction Service at:

http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4

or the USGS Michigan Water Science Center at:

http://waterdata.usgs.gov/mi/nwis/sw

Piping of foundation and/or embankment material is normally indicated by a buildup of materials around the seepage area or a slope failure (e.g. boils, slumps, landslides, sinkholes). Catching some seepage water in a clear glass jar and looking through the water can often indicate particles in suspension during the initial stages of piping. If the seepage velocity is high, the water may just be cloudy or muddy and buildup of materials may be some distance from the actual seepage location. After the seepage is reported, the area should be photographed before any measures are taken to control the problem. Disturbance of any seepage indicator, such as the buildup of sediment around the seepage area, should be kept to a minimum. Any occurrence of a persistent (not dissipating and/or moving downstream) whirlpool in the Grand River adjacent to the levee and/or floodwall is an emergency (Warning) condition.

Temporary Controls (until more permanent repairs can be made)

- Changes in Seepage, Boils, and Whirlpools
  - Observe for various stream levels to determine the approximate elevation that initiates seepage and the location of the seepage source.
  - If the source of the seepage can be found or a suspected location identified, place a blanket of impervious material such as bentonite clay over the seepage source.
  - If the seepage is persistent, install a grout curtain inside the levee embankment or along the river face of the floodwall.
- Boils
  - Place a ring of sandbags or a large diameter pipe around the boil area to pond water above the ground surface at the boil location and reduce the velocity of the water emanating from the boil.
  - Never dump sand or similar material into a boil until an assessment of the sediment in the boil can be completed.
  - After an assessment of the sediment associated with the seep or boil, an overlay of an approved granular material may be selected as a control measure.
- Sinkholes, Settlement, and Depressions
  - The cause of any sinkholes, settlement, and depressions should be investigated by a qualified geotechnical engineering firm.
  - After documenting the location of sinkholes, settlement, or depressions, they should be filled with earth or rocks until more permanent measures can be taken to resolve the problem.
  - The option exists to perform a temporary control as recommended by a licensed professional engineer with expertise with flood control and safety and approved by the City Engineer.

Slope Failure

In general, slope failures occur gradually, and if detected in the early stages, measures can be taken to prevent total embankment failure. On the river (wet) levee and embankment slopes, failures may occur shortly after a rapid decrease in the river level following a protracted flood. On the protected (dry) levee slope, failures may occur after large rainfall events following a protracted period of hot, dry weather where the levee soils shrink and crack, allowing water to penetrate the surface instead of normally infiltrating. Slope failures can also occur in multiple areas and at different times, but are more likely during special operating or loading conditions or during extended periods of heavy rainfall. They may be initiated by excessive vibrations, seepage, earthquakes, or erosion. Massive slides can initiate catastrophic failure of a levee.

Indicators

- Slumping, sloughing, or sliding of soil material on either the river (wet) face or protected (dry) face of the levee or embankment.
- Cracking of the road pavement atop the levee or embankment
- Cracks in the levee or embankment. Transverse cracks appear across the levee or embankment and might indicate differential settlement within the embankment. Such cracks provide avenues for seepage water and piping could quickly develop. Longitudinal cracks run parallel to the levee or embankment and may signal the early stages of a slide or slump on either face of the embankment.
- Erosion of the river (wet) side or protected (dry) side of the levee or embankment caused by a rapid decrease in the river level following a protracted flood, rainfall, runoff, snow melt, river currents, wave action, lack of vegetation, foot-traffic, overtopping, or increased seepage through the levee or its foundation. Deep erosion gullies and levee waterline erosion can threaten the structural integrity of the embankment. Erosion along the base of the levee indicates potential deterioration of the foundation that could result in landslides or misalignment of the embankment.

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls (until more permanent repairs can be made)

- Slumps/Sloughs/Landslides/Erosion/Settlement
  - For slumps, sloughs, erosion, and settlement on the levee embankment, or at the toe of the embankment slope, fill the affected area with soil, rockfill, or sandbags until more permanent repairs can be made.
  - On the protected (dry) face of the levee embankment, cover the repaired area with plastic sheets or other erosion-resistant materials to prevent subsequent erosion during storms.
  - For landslides, stabilize the toe of the slide by weighting with soil, rock, or gravel. If necessary, fill materials should be placed at the top of the slide to restore freeboard after the toe is stabilized.
- Cracks
  - Fill non-leaking cracks in the levee embankment with soil, rocks, cement grout, or sandbags until more permanent repairs can be made.
  - Improve (line) the drainage path from the crack to prevent further erosion.
  - A leaking crack is an emergency (Warning) situation. The crack should be filled immediately with an available material including bentonite clay, soil, hay bales, sandbags, and rocks to stop or slow the flow of water until the stream level recedes and a permanent repair is made.
- Levee Overtopping
  - If it is apparent that the levee or embankment will be overtopped, this is an emergency (Warning) situation. The City Incident Commander and Kent County Emergency Management & Homeland Security Office should be notified to initiate evacuation procedures for the areas potentially affected by the coming flood.

Settlement

Settlement is the decrease in elevation of soil from its originally constructed elevation. To a certain degree, settlement of a levee embankment is normal and to be expected. Often settlement occurs because the soil was not fully compacted beneath a road surface atop a levee or embankment. Settlement is most likely to occur along the levee crest, adjacent to pipe outfalls, and at the interface between the levee embankment and natural ground. Settlement of the ground may also result from gypsum voids in the underlying bedrock. Settlement along the path of drain pipes through the levee, which could be an indication that material is being removed within the levee along the pipe, is most likely and an emergency (Warning) situation.

Indicators

- A noticeable slump in the levee embankment crest.
- Cracking of the road surface atop an embankment or levee
- Depression in the ground along the path of the drainage pipes.
- Depression at the interface between the levee embankment and natural ground.

Reporting

Reporting and documentation of potential levee and floodwall problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls (until more permanent repairs can be made)

- Sandbags
  - Install sandbags in accordance with the Operations, Maintenance and Inspection Manual.
- Areas where settlement has occurred that are not actively continuing to settle should be filled with clay-type soil to return the levee crest or face to the as-constructed elevation. The clay-type soil should be compacted to 95 percent or above of maximum dry density at 1 percentage point below to 3 percentage points above optimum moisture content based on the Standard Proctor Density Test (ASTM D 698-78).
- Settlement may constitute a (Warning) and the City Engineer should be notified.

Backflow Device Problem

The flap gates on the ends of the drainage pipes through the levee and embankment sections of the GRFPS are exposed to the flow in the Grand River and could be damaged or clogged by floating debris and ice impact.

Indicators

- Water flowing from storm sewer manholes and/or street stormwater inlets during high water conditions in the Grand River. This will typically be seen as water flowing down a street emanating from a manhole cover or catch basin; or ponding water at any location around a manhole cover or catch basin.

Reporting

Reporting and documentation of potential levee problems should be completed in accordance with the inspection forms included in Appendix 2 of the OM&I Manual.

Temporary Controls

- Drainage Pipes through Levee and Floodwall
  - If a flap gates is not operating properly, the inlet end of the pipe should be sealed using an inflatable plug. If this is not possible sandbags can be placed around all catch basin inlets and manhole covers below the projected high water elevation. Once the water level subsides in the Grand River, the flap gates should be unclogged, repaired, and/or replaced.

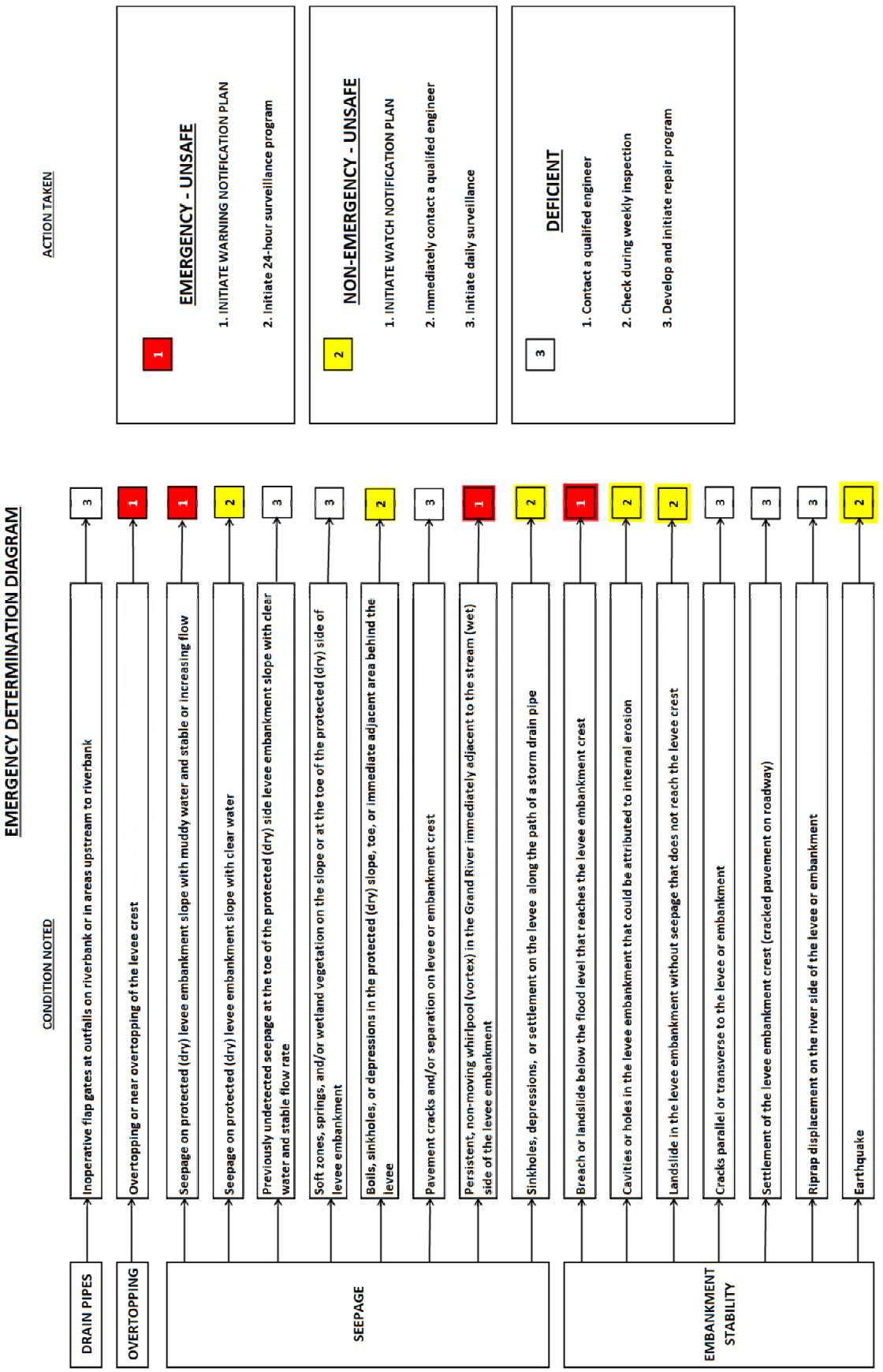
Additional Comments

The types of levee failures described above are often interrelated in a complex manner. For example, uncontrolled seepage may weaken the soil and lead to a slope failure. A slope failure may shorten the seepage path and lead to a piping failure. Minor defects such as cracks in the levee embankment may be the first visual sign of a major problem that could lead to failure of the structure. A licensed professional engineer experienced in levee design and construction should evaluate the seriousness of all deficiencies and recommend appropriate permanent remedial measures.

Whenever a potential emergency situation is reported, the City Engineer or his/her designee should immediately visit the area of concern at the GRFPS and evaluate the situation as described in the above paragraphs. If the situation is severe enough that there is any concern that there could be an uncontrolled release of water into the area protected by the GRFPS, the City Engineer shall initiate a levee failure (Warning) alert in accordance with the Emergency Notification Chart in Figures 1 and 2.

If upon visiting the potential problem area at the GRFPS, the City Engineer or his/her designee determines that the situation can be handled without danger of an uncontrolled release of water into the area protected by the GRFPS, the necessary work should be coordinated by the City Engineer with the asset management plan inspections, updates, and improvements.

Once a levee and/or floodwall problem progresses to the point that the levee and/or floodwall is failing, evacuation in the flood inundation zone, (see Inundation Map in Figure 5), may be necessary if emergency actions do not appear to be adequate to prevent flooding in the protected area.


EMERGENCY DETERMINATION DIAGRAM
CONDITION NOTED
ACTION TAKEN
DRAIN PIPES
OVERTOPPING
SEEPAGE
EMBANKMENT STABILITY
Inoperative flap gates at outfalls on riverbank or in areas upstream to riverbank
Overtopping or near overtopping of the levee crest
Seepage on protected (dry) levee embankment slope with muddy water and stable or increasing flow
Seepage on protected (dry) levee embankment slope with clear water
Previously undetected seepage at the toe of the protected (dry) side levee embankment slope with clear water and stable flow rate
Soft zones, springs, and/or wetland vegetation on the slope or at the toe of the protected (dry) side of levee embankment
Boils, sinkholes, or depressions in the protected (dry) slope, toe, or immediate adjacent area behind the levee
Pavement cracks and/or separation on levee or embankment crest
Persistent, non-moving whirlpool (vortex) in the Grand River immediately adjacent to the stream (wet) side of the levee embankment
Sinkholes, depressions, or settlement on the levee along the path of a storm drain pipe
Breach or landslide below the flood level that reaches the levee embankment crest
Cavities or holes in the levee embankment that could be attributed to internal erosion
Landslide in the levee embankment without seepage that does not reach the levee crest
Cracks parallel or transverse to the levee or embankment
Settlement of the levee embankment crest (cracked pavement on roadway)
Riprap displacement on the river side of the levee or embankment
Earthquake
1
2
3
EMERGENCY - UNSAFE
1. INITIATE WARNING NOTIFICATION PLAN
2. Initiate 24-hour surveillance program
NON-EMERGENCY - UNSAFE
1. INITIATE WATCH NOTIFICATION PLAN
2. Immediately contact a qualifed engineer
3. Initiate daily surveillance
DEFICIENT
1. Contact a qualifed engineer
2. Check during weekly inspection
3. Develop and initiate repair program

Emergency Action

Emergency Action by River Stage

As the Grand River rises in the City, various actions are required to protect areas of the City from inundation by flood waters. Table 1 provides a list of actions by river stage that need to be performed. Note that Table 1 should be reviewed annually to ensure that it is up to date and reflects any modification to the GRFPS.

Preparedness

Levee Owner

The City is responsible for levee inspections as outlined in the City Operations and Maintenance Manual. The City is also responsible for detecting emergency conditions and depending on the observed conditions, he/she is responsible for deciding the appropriate action under the NIMS Incident Commander and the appropriate Emergency Notification Chart in Figures 1 and 2 and in cooperation with the Engineering Department, Public Works Department, Police Department, and Fire Department.

If flood (Watch) non-emergency conditions are predicted based on local observations and consultation with the NWS in Grand Rapids, the City Engineer should contact the Public Works Department to prepare to monitor levee and embankment conditions along the Grand River. If the water level reaches the (Watch) non-emergency condition and is continuing to rise, or if notification from the City Incident Commander and/or Kent County Emergency Management & Homeland Security Office is received, the Public Works Department shall prepare to install the temporary flood control measures as described in Table 1. Personnel from the City Engineer's Office and Public Works Department should inspect the levee, embankment, drainage structures and backflow prevention devises daily to ensure that no problems are occurring that would trigger an emergency response. In the case that problems are detected, the problem area should be continuously monitored until the flood subsides and remedial measures can be implemented. After the flood subsides, the City Engineer's office should conduct an inspection of the levee, embankment, drainage structures and backflow prevention devices to determine if any damage has occurred that requires repair.

During a flood watch or warning situation, the City Incident Commander (City Manager) should stay in contact with the City of Grand Rapids Incident Commander (City Manager) to coordinate actions regarding the preparation and operation of the GRFPS including but not limited to the sharing of equipment and materials if needed.

During flooding of the Grand River, the curious public and news media can create a major obstacle to performance of necessary tasks; therefore, levee access control measures should be taken. In conjunction with any evacuation of residents in the area protected by the GRFPS, it will be necessary to provide easy access for equipment, supplies, and personnel involved in the effort to affect repairs. The City Engineer and Public Works Department should work closely with the City Incident Commander and Police and Fire Departments to prevent unauthorized access to the GRFPS and to facilitate movement of necessary equipment, supplies, and personnel to the levee and embankment.

Notification

In the event of a flood (Warning) emergency condition or problems with the GRFPS, it is the shared responsibility of the Walker City Engineer and Walker Public Works Director to notify the Walker Incident Commander (City Manager) and Kent County Emergency Management & Homeland Security Office and brief them on the situation. The Kent County Emergency Management & Homeland Security Office will prepare and deliver a message for public release based on the existing conditions and information provided by the Walker City Engineer and Walker Incident Commander (City Manager). Preparation of (Warning) emergency messages should begin as soon as their potential need is apparent so that they can be issued promptly upon declaration of a (Warning) emergency condition. When time is available for their preparation, the initial message should contain all pertinent information. However, in some cases a (Warning) emergency condition may be declared with little or no advance notice. The following sample messages provide models for the first announcement in such cases. Subsequent announcements should provide additional details.

Announcement of Levee Failure in Progress

Urgent, Urgent: The City has announced that a portion of the levee along the Grand River (has failed/is in imminent danger of failure).

Attempts to stabilize the levee are underway, but their success cannot be determined as of yet. Residents living in the following areas should evacuate to high ground immediately:

- Name of area (location and extent)
- Name of area (location and extent)
- Name of area (location and extent)

Additional information will be released as soon as possible.

Announcement of Flood Crest Above Flood Protection Level

Urgent, Urgent: The City has announced that the Grand River is expected to crest at elevation (insert elevation), which is (insert number of feet) above the top of the flood protection levees and floodwalls in the City.

Residents living in the following areas should evacuate to high ground immediately:

- Name of area (location and extent)
- Name of area (location and extent)
- Name of area (location and extent)

Additional information will be released as soon as possible.

The simplest functioning means of communications will be used to maintain communications with authorities and construction contractors retained to stabilize the levee and/or floodwall. Notification will normally be on the Kent County 800 MHz Radio System or by cellular telephones.

The NWS will also be a primary source through which emergency announcements are released to the news media.

National Weather Service (Grand Rapids, Michigan): 24-hour telephone number (616)949-0643

The following radio and television stations should be contacted if the NWS cannot be contacted. These stations are considered to have broadcast areas covering Walker.

TELEVISION STATIONS	
WXSP 120 College Avenue, SE Grand Rapids, MI 49503 (616) 456-1818 newsroom@woodtv.com	**WZZM** 645 3 Mile Road, NW Grand Rapids, MI 49544 (616) 785-1313 news@wzzm13.com
WXMI 3117 Plaza Drive, NE Grand Rapids, MI 49525 (616) 364-8722 news@fox17online.com	**WGVU/WGVK** 301 Fulton Street, NW Grand Rapids, MI 49504 (800) 442-2771
WZPX 2610 Horizon Drive, SE Grand Rapids, MI 49546 (616) 222-6443	**WOOD/WOTV** 120 College Avenue, SE Grand Rapids, MI 49503 (616) 456-8888 newsroom@woodtv.com
RADIO STATIONS - FM	
WTRV 50 Monroe Avenue, NW Grand Rapids, MI 49503 (616) 770-8200	**WBCT** 77 Monroe Center Street, NW Grand Rapids, MI 49503 (616) 242-0220
WHLT 50 Monroe Avenue, NW Grand Rapids, MI 49503 (616) 770-8957	**WTNR** 60 Monroe Center Street, NW Grand Rapids, MI 49503 (616) 774-9450
WFGR 50 Monroe Avenue, NW Grand Rapids, MI 49503 (616) 459-9889	**WOOD** 77 Monroe Center Street, NW Grand Rapids, MI 49503 (616) 774-2424 news@woodradio.com
WGRD 50 Monroe Avenue, NW Grand Rapids, MI 49503 (616) 770-8200	**WBLU** 161 Ottawa Avenue, NW Grand Rapids, MI 49503 (616) 458-9258
WCSG 1159 E. Beltline Avenue, NE Grand Rapids, MI 49525 (616) 942-1500	**WKLQ** 60 Monroe Center Street, NW Grand Rapids, MI 49503 (616) 774-9450

RADIO STATIONS - FM

WAYG
1159 E. Beltline Avenue, NE
Grand Rapids, MI 49525
(616) 974-3690

WBBL
60 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 459-1180

WLAV
60 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 456-5461

WFUR
399 Garfield Avenue, SW
Grand Rapids, MI 49504
(616) 451-9387

WGVU
301 Fulton Street, NW
Grand Rapids, MI 49504
(616) 331-6666

WHTS
60 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 451-0105

WPRR
3777 44th Street, NE
Grand Rapids, MI 49512
(616) 656-2619

WSNX
77 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 770-8104

WBFX
77 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 459-1919

RADIO STATIONS - AM

WMFN
2422 Burton Street, SE
Grand Rapids, MI 49546
(616) 451-0551

WTKG
77 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 456-1230

WNWZ
50 Monroe Avenue, NW, #500
Grand Rapids, MI 49503
(616) 451-4800

WJRW
60 Monroe Center Street, NW
Grand Rapids, MI 49503
(616) 456-1340

WDSS
3777 44th Street, SE
Grand Rapids, MI 49512
(616) 656-4052

Evacuations

The City Incident Commander, Kent County Emergency Management & Homeland Security Office, and Walker Police Department, are responsible for evacuation of the flood inundation area. The City Incident Commander and/or Kent County Emergency Management & Homeland Security Office will also contact the Kent County Sheriff and Michigan State Highway Patrol for area coordination, as needed. The City Engineer should not assume responsibility for evacuation but should coordinate with the appropriate officials.

Termination and Follow-Up

The City Engineer should monitor the emergency situation at the GRFPS and keep the City Incident Commander informed of developing conditions. The City Incident Commander and the Kent County Emergency Management & Homeland Security Office are responsible for terminating the (Watch) non-emergency condition or the (Warning) emergency condition for the area protected by the GRFPS.

Following the emergency situation, the City Engineer is responsible for performing a follow-up evaluation of this Flood Protection EAP with the participants involved in the emergency.

Flood Protection EAP Coordination

The City Engineer is responsible for the coordination of this Flood Protection Project EAP. The responsibility encompasses the following items:

- Revisions to the Flood Protection EAP.
- Coordination of Flood Protection EAP exercises in cooperation with the City Incident Commander and Kent County Emergency Management & Homeland Security Office and the City of Grand Rapids Incident Commander
- Establishment of Flood Protection EAP training seminars for the City Engineer's Office, Public Works Department, and City Incident Commander.
- Serving as the Flood Protection EAP contact for emergencies (Warning) and non-emergencies (Watch) related to the GRFPS. The City Engineer may delegate this responsibility to the Police Chief and/or Fire Chief as necessary to efficiently coordinate the emergency response.

Access to the GRFPS

The primary route of access to the GRFPS is from West River Drive, Turner Avenue, and U.S. Route 131.

Response During Periods of Adverse Weather

During periods of adverse weather, the City Engineer should be prepared to isolate and protect areas of potential levee repair from rainfall, ice, and snow. This includes stockpiling repair materials, including sandbags, sand, plastic sheets, gravel, and clay soil, and having a list of available contractors, equipment, and equipment operators, including portable lighting, generators, heavy-duty electric cords, and earth moving equipment (skid steers, backhoes, front end loaders, bulldozers, etc.).

Response During Periods of Darkness

For emergency situations that occur at night, the City Engineer and/or Public Works Department, shall provide lighting, either fixed or portable, for the GRFPS that is sufficient to illuminate the site. At least three or more portable generators, maintained in good working order, are to be provided for use in levee and/or drainage structure failure emergencies. The generators and associated electrical cords shall be capable of providing power to any emergency electrical equipment including emergency lighting and have an output capacity that meets or exceeds the power required by emergency equipment.

Alternate System of Communications

Cellular telephones are to be used as an alternate means of communications.

Emergency Supplies and Resources

For emergency use, the City Engineer and Public Works Department shall have the following materials and supplies available at their respective facilities with sufficient transport vehicles to ensure a timely response to an emergency situation:

- Flashlights to provide lighting where emergency lighting does not illuminate and for directing traffic
- Portable, petroleum-fueled generator(s)
- Extension cords (heavy duty) for use with the portable generators and emergency equipment including lights
- Fire extinguishers (preferably type ABC) for extinguishing any fire that may occur in the emergency equipment
- Portable electric floodlights
- Fill material to dump into any levee breach and to fill sandbags
- Sandbags
- Backhoe, trackhoe, front end loader, and/or skid steer for hauling and placing fill material
- Four-wheel drive vehicle and dump truck for hauling fill material and equipment
- One or more portable pumps with flexible hoses to assist in pumping water from the pump station wet wells in the event that one or more pumps become disabled
- Plastic sheets for temporary crack repair and for protecting eroded areas on the levee embankment
- Rope to assist emergency personnel
- Personal flotation devices
- First aid kit
- Traffic control cones and/or barriers

A list of available City equipment for emergency operations is included in Appendix C.

Emergency Contractors and Suppliers

The City should have sufficient personnel, equipment, and materials to respond to emergencies at the GRFPS. In the event that additional personnel and equipment is required at the GRFPS site, the City Engineer shall procure the required services on an emergency basis. A list of emergency response contractors is provided in Appendix D.

Figures

FIGURE 1 - NOTIFICATION FLOWCHART - WARNING (EMERGENCY)

Grand River Flood Protection System (Warning) Emergency Level Contact Network

Flood Stage 18 Feet or Higher or
Active Failure of Levee, Floodwall, or Drainage Structure During Flood
(uncontrolled flow into protected area)

Incident Commander
City Manager
Phone: **(616) 292-5954**

Kent County
Emergency Management &
Homeland Security
Phone: **911** or
(616) 632-6100

City Engineer
Phone: **(616) 292-5991**

City Departments

Public Works Director
Phone: (616) 262-1653

Police Chief
Phone: (616) 293-2918

Fire Chief
Phone: (616) 293-9308

Damage Assessment
Phone: (616) 916-6121

Mayor
Phone: (616) 334-4885

Environmental Programs
Coodinator
Phone: (248) 200-8815

State and Federal Government Agencies

National Weather Service
Grand Rapids
Phone: (616) 949-0643

MDOT Grand Region
Bridge Operations
Phone: (616) 451-4884

U.S. Army Corps of Engineers
Detroit District
Emergency Response
Phone: (313) 226-1323

FEMA-Region V
Regional Response
Coordination Center
Phone: (800) 273-0890

U.S. Geological Survey
Michigan Water Science Center
Phone:(517) 887-8903

Michigan Department of
Environmental Quality
Dam & Levee Safety
Phone: (517) 284-5567

Adjacent Levee Owner City of Grand Rapids

Grand Rapids Incident Commander
City Manager
Phone: (616) 456-3166

Grand Rapids
City Engineer
Phone: (616) 456-3060

Other Contacts

CSX Corporation
Bridge & Rail Emergencies
Phone: (800) 232-0144

Consumers Energy
Phone: (800) 477-5050

FIGURE 2 - NOTIFICATION FLOWCHART - WATCH (NON-EMERGENCY)

Grand River Flood Protection System (Watch) Non-Emergency Level Contact Network

River Stage 12 Feet and Rising but Less than 18 Feet or
Leak, Landslide, Crack, Erosion, Sinkhole, Settlement, Boil, etc.,That Does Not Immediatly Threaten the Integrity of the Flood Protection System

Incident Commander
City Manager
Phone: **(616) 292-5954**

Kent County
Emergency Management
& Homeland Security
Phone: **911** or
(616) 632-6100

City Engineer
Phone: **(616) 292-5991**

City Departments

- **Public Works Director**
  Phone: (616) 262-1653
- **Police Chief**
  Phone: (616) 293-2918
- **Fire Chief**
  Phone: (616) 293-9308
- **Mayor**
  Phone: (616) 334-4885

State and Federal Government Agencies

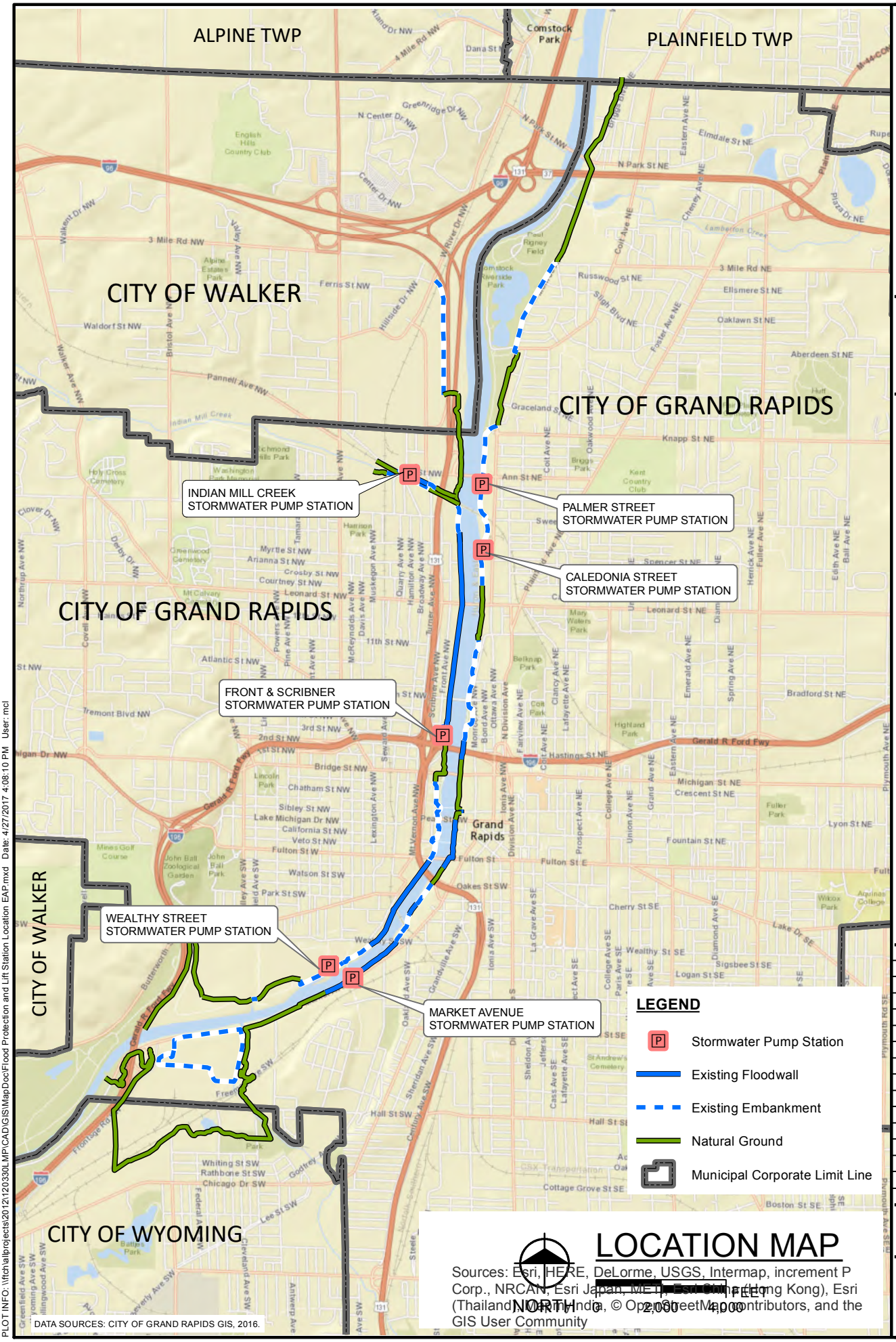
- **National Weather Service**
  Grand Rapids
  Phone: (616) 949-0643
- **MDOT Grand Region**
  Bridge Operations
  Phone: (616) 451-4884

Adjacent Levee Owner
City of Grand Rapids

- **Grand Rapids Incident Commander**
  City Manager
  Phone: (616) 456-3166
- **Grand Rapids**
  City Engineer
  Phone: (616) 456-3060

Other Contacts

- **CSX Corporation**
  Bridge & Rail Emergencies
  Phone: (800) 232-0144
- **Consumers Energy**
  Phone: (800) 477-5050



LOCATION MAP

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

DATA SOURCES: CITY OF GRAND RAPIDS GIS, 2016.

PLOT INFO: \\fchallprojects\2012\120330LMP\CAD\GIS\MapDoc\Flood Protection and Lift Station Location EAP.mxd Date: 4/27/2017 4:08:10 PM User: mcl

fishbeck

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 8.5"x11" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

Cities of Grand Rapids and Walker
Kent County, Michigan

Grand River Flood Protection System

PROJECT NO.
120330LMP

FIGURE NO.
3

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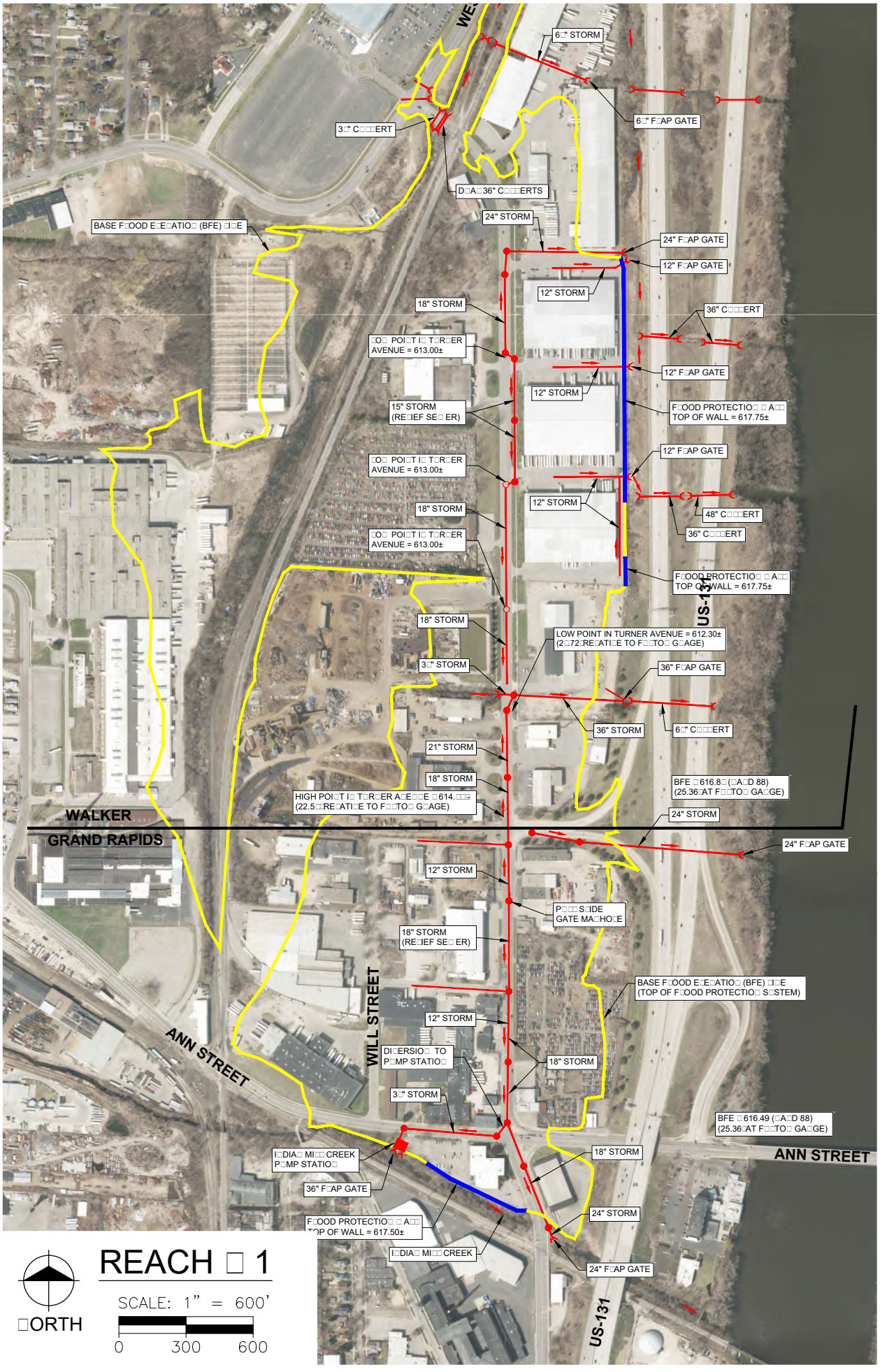

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engineers
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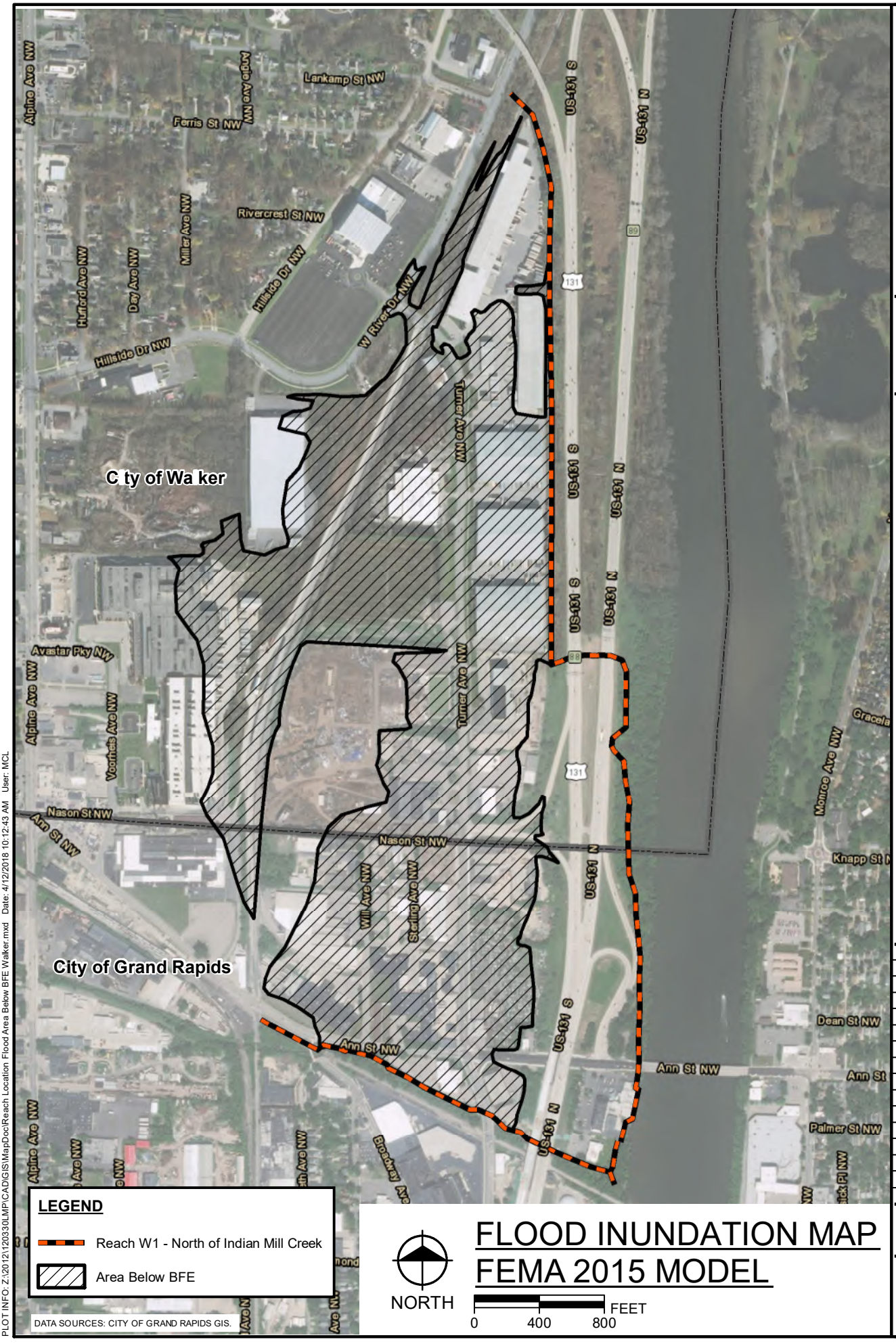
Cit□ o□Grand Ra□ids
Kent Count□, Michigan

FLOOD PROTECTION SYSTEM LAYOUT

PROJECT NO.
G12□33□

FIGURE NO.
4



LEGEND

- Reach W1 - North of Indian Mill Creek
- Area Below BFE

DATA SOURCES: CITY OF GRAND RAPIDS GIS.

NORTH

0 400 800 FEET

FLOOD INUNDATION MAP
FEMA 2015 MODEL

fishbeck

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 8.5"x11" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

Cities of Grand Rapids and Walker
Kent County, Michigan

Grand River Flood Protection System

PROJECT NO.
120330LMP

FIGURE NO.
5

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PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Reach Location Flood Area Below BFE Walker.mxd Date: 4/12/2018 10:12:43 AM User: MCL

Tables

Action Item Chart

Table 1
Action Item Chart

Item No.	Address/Item	Location of Item	Description of Item	Critical Elevation (when problem occurs)		Action Required	Materials Needed (during 100-year event)	Equipment Needed (to deliver and onsite)	Responsible Department
				USGS Flood Stage (at Grand Rapids gage) 100-year = 25.36'	NAVD 88 (at Location of Item)				
1	Road Closure	North Park Street west from West River Drive to Monroe Avenue	When the river rises, the street may become impassable	22.0	616.0	Barricade Road	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
2	Road Closure	Turner Avenue between West River Drive and Southbound U.S. Route 131 ramps	When the river rises, the street may become impassable	20.0	611.4	Barricade Road	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
3	Road Closure	Mill Creek Avenue between North Park Street and West River Drive	When the river rises, the street may become impassable	22.0	616.0	Barricade Road	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
4	Road Closure (outside the GRFPS)	Veterans Memorial Drive between Maynard Avenue and Butterworth Street	When the river rises, the street may become impassable	12.0	593.5	Barricade Road	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
5	Road Closure (outside the GRFPS)	Riverbend Drive between Butterworth Sreet and Veterans Memorial Drive	When the river rises, the street may become impassable	12.0	593.7	Barricade Road	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department

Appendix A

Plans for Training, Exercising, Updating and Posting EAP

Training of Project Operators and Other Responsible Personnel

All divisions as determined by the City Incident Commander (see Watch and Warning Emergency Notification Flowcharts, Pages 1 and 2) are responsible for the training of operating and supervisory personnel to assure timely and adequate assessments of developing emergency situations and performance of their duties in the event of an emergency situation. Each individual is to be instructed as to what conditions constitute a project emergency and what specific responsibility they are to execute.

The City Incident Commander (City Manager) and the Kent County Emergency Management & Homeland Security Office are responsible for conducting annual refresher seminars, workshops, or meetings for this Flood Protection EAP.

Review and Test of State of Readiness

At the occurrence of a change in the Walker City Incident Commander (City Manager) or Fire Chief, the City Incident Commander (City Manager), City Engineer, Public Works Director, Fire Chief, and Kent County Emergency Management & Homeland Security Office, will meet and perform a test to simulate a levee failure (Watch or (Warning). The test will be initiated when the City Engineer contacts the City Incident Commander (City Manager) and the Kent County Emergency Management & Homeland Security Office telephone numbers to advise that a test of the emergency alert system for a problem at the GRFPS is being conducted. Every participant in the Flood Protection EAP will execute their required actions as if it were a real emergency. When executing the drill, each person in the contact network should give their name and position and state that this is only a drill and repeat that this is only a drill. In no case shall the news media be notified.

Once everyone in the (Watch or Warning) networks has been contacted, the Kent County Emergency Management & Homeland Security Office will notify the City Incident Commander (City Manager) that all contacts have been made. The City Incident Commander (City Manager) then cancels the test and directs the City Engineer to notify the Flood Protection EAP plan participants of the completion of the test.

After the drill, the City Incident Commander (City Manager) and Kent County Emergency Management & Homeland Security Office will determine if the test was successful. They will check names, titles, telephone numbers, radio logs, and any other information that is vital to the execution of the EAP. Any revisions to the emergency contact networks for a (Watch and Warning) condition will be made immediately after this review.

Posting

This Flood Protection EAP shall be filed in an area within each participant's place of work where it is easily accessed and identified. During the annual test of the Flood Protection EAP, the City Incident Commander (City Manager) shall specifically request each participant to verify that they have been able to easily find their copy of the EAP.

Appendix B

Site Specific Concerns

Drain Pipe Backflow Prevention

There are 7 drain pipes that extend through the levee embankment and natural ground along the west side of US-131 and the Grand River (see Figure 4 for pipe locations). Every drain pipe has a flap gate on its outlet end. If a flap gate is jammed open due to ice, debris, impact damage, or vandalism, the Public Works Department must be prepared to shut-off these pipes at the inlet end. This could be accomplished by inserting an inflatable plug into the inlet or isolating the subject catch basin inlets and manhole covers with rings of sandbags. During a flood event where the outlet ends of the pipes are submerged, the Public Works Department should monitor the level of water in these pipes to determine if it is rising in the pipes. If the water is rising, it may indicate that the flap gate on the outlet end of the pipe has not seated and the need to shut-off these pipes at the inlet end.

Appendix C

Walker Public Works Department Maintenance Equipment

Last Updated March 2018

Item*	Number	Location**
1 Ton Truck Cab and Chassis	3	Walker Public Works
HD Road Truck	13	Walker Public Works
Pickup Truck	11	Walker Public Works
Front End Loader	1	Walker Public Works
Sewer Truck	1	Walker Public Works
Sweeper Truck	1	Walker Public Works
Trailer	11	Walker Public Works

* 1 Ton refers to the truck capacity while GVWR is the Gross Vehicle Weight Rating

** Walker Public Works is located at 4243 Remembrance Road, Walker, MI 49534

Appendix D

Emergency Response Contractors

Last Updated: December 2012

Diversco Construction Co. 570 Market Avenue, SW Grand Rapids, MI 49503 Phone: 616.458.6379 *Contact:* Ryan Maas – 616.318.0830 Mark Robinson – 616.299.8469 *Services:* Road Reconstruction, Bridge Repairs, Sheet Pile Installation, Underground Utilities, Street Resurfacing, Site Grading, Sewer Pump Stations and Modifications, Dewatering, Gravel and Sand Processing	**Dykema Excavators, Inc.** 1730 – 3 Mile Road, NE Grand Rapids, MI 49505 Phone: 616.363.6895 *Contact:* Randy Dykema – 616.459.5800 or 616.862.4151 *Services:* Excavation, Site Grading, Underground Utilities
Georgetown Construction Co., Inc. 6601 Wilshere Drive Jenison, MI 49428 Phone: 616-669-6000 *Contact:* Jeff Hoffman – 891.8656 (Caledonia) *Services:* Housing Construction, General Contracting	**Kamminga & Roodvoets Inc.** 3435 Broadmoor Avenue, SE Grand Rapids, MI 49512-2899 Phone: 616.949.8000 *Contact:* Kurt Poll – 616.245.8175 *Services:* Excavation, Underground Utilities
Lodestar Construction Inc. 333 North Park Street, NW Grand Rapids, MI 49544 Phone: 616.785.7373 *Contact:* David Myers – 616.531.3836 Greg Bustraam – 616.457.5767 *Services:* Excavation, Underground Utilities	**Wyoming Excavators** 9580 – 5 Mile Road, NE Ada, MI 49301 Phone: 616.691.7368 Contact: Nate Post – 616.293.3924 *Services:* Excavation, Underground Utilities

Appendix E

Turner Avenue Flood Control Procedure

Appendix E
Turner Avenue Flood Control Procedure

April 1, 2018, Revised January 2020
By: FTCH (JRP)

Reference USGS Stream Gage: 04119000 (NOAA GDRM4) Grand River at Grand Rapids, MI (GRR)
Location: West side of the Grand River just south of the Blue Bridge.
https://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4

At the Walker/Grand Rapids City Limits the 100-Year Flood Stage = 25.36' = 616.80 NAVD88

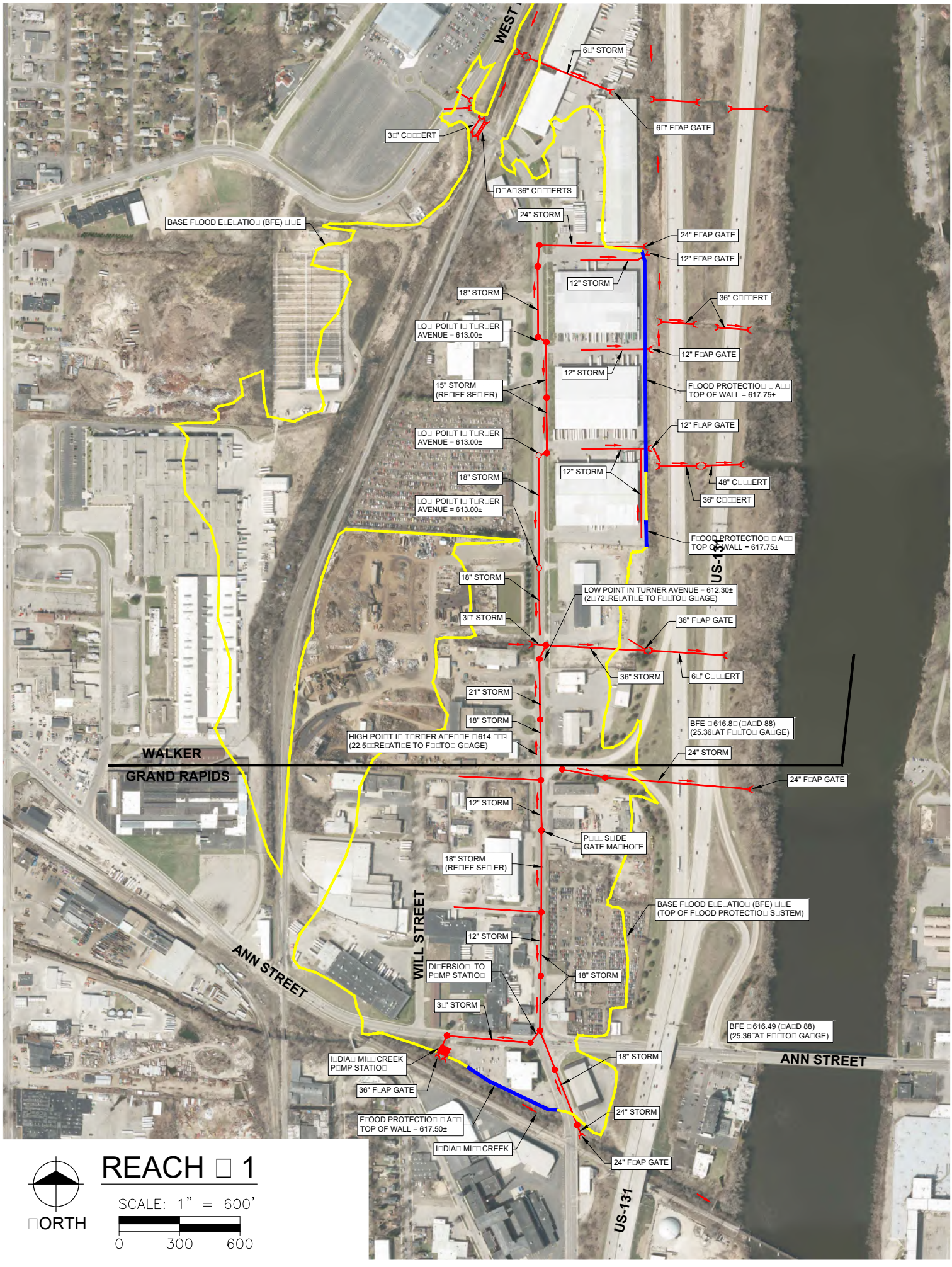
System Information

Flood Stage Information

- **Action Stage = 12.00' (603.44)**
  - Begin monitoring flood and weather forecasts; inspect flap gates.
- **Flood Stage = 18.00' (609.44)**
  - Begin preparing to close Turner Avenue.
  - For Reference: February 2017 Peak Stage = 20.67' (612.11)
- **Moderate Flood Stage = 21.00' (612.44)**
  - Turner Avenue begins to flood around catch basins 510' north of City Limits at 20.10' (611.54) *(flap gates should prevent this from happening)*
  - For Reference: April 2013 Peak Stage = 21.85' (613.29)
  - Turner Avenue flooding overflows south into the City of Grand Rapids at 22.51 (613.95) *(flap gates should prevent this from happening)*
- **Major Flood Stage = 23.00' (614.44)**
- **100-Year Flood Stage = 25.36' (616.80)(Based on 2017 FEMA Model)**
  - Levees are breached at approximately = 26.31' (617.75)
  - Major Flooding will occur.

Indian Mill Creek Storm Water Pump Station

- The Indian Mill Creek Storm Water Pump Station is located in the City of Grand Rapids. (See attached figure for location.) It serves both the City of Grand Rapids and the City of Walker.
- Interior ponding that might occur in Turner Avenue is conveyed to the pump station via a cross connection between the Grand Rapids and Walker storm water collection systems. (See attached figure)
- Should the collection system fail portions of Turner Avenue may flood up to 1 foot in depth prior to overflowing into the City of Grand Rapid overland. The flow would then entire the Grand Rapids collection system and be conveyed to the Mill Creek Storm Water Pump Station.



REACH □ 1

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SCALE: 1" = 600'

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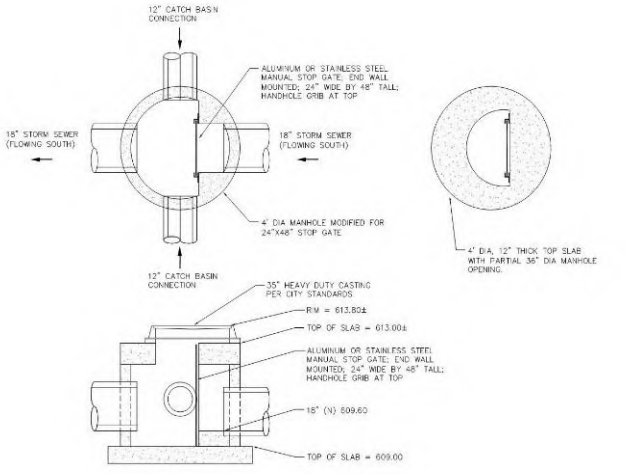
Overflow/Slide Gate Manhole

- 325’ south of Walker/Grand Rapids City Limits (See photo, detail and figure.)
- Rim Elevation = 613.80
- Invert of 18” Overflow Pipe to the South = 609.80

Gate Owner: City of Grand Rapids

Gate Operator: City of Walker is authorized to remove gate as deemed required to control Turner Avenue flooding.





Low Point in Turner Avenue

- 510’ north of City Limits (See photo and figure.)
- Centerline Elevation = 612.00
- Gutter Pan Elevation (west side) = 611.5 +/-
- Gutter Pan Elevation (east side) = 611.5 +/-



Other Low Points

- 980’ north of City Limits; Centerline Elevation = 613.00 (See attached figure.)
- 1,530’ north of City Limits; Centerline Elevation = 613.00 (See attached figure.)
- 2,130’ north of City Limits; Centerline Elevation = 613.10 (See attached figure.)

High Point in Turner Avenue

- At Walker/Grand Rapids City Limits (See attached figure.)
- Centerline Elevation = 614.50
- Gutter Pan Elevation (west side) = 613.95
- Above 613.95 water will flow into the City of Grand Rapids

Low Point in Walker Levee System

- 617.75 (See top of wall in picture below); equal to 26.31’ at Grand Rapids NOAA Gauge.
- Provides approximately 1 foot of freeboard above the 100-year flood elevation.



Operational Scenarios

Normal River Levels

No Rain to Moderately Heavy Rainfall Event

- Slide gate to remain in place separating City of Walker and City of Grand Rapids storm water collection systems.

Heavy Rainfall Event

- Monitor water levels in:
    - Catch basins or centerline manhole at the low point in Turner Avenue at 510' north of the City Limits.
    - Slide gate manhole at 325' south of the City Limits.
- The slide gate may be removed if the water level in the slide gate manhole is less than the water level in the catch basins and manhole at 510' north of the City Limits. The gutter pan elevation at the low catch basin is 611.5 +/-; the rim elevation of the slide gate manhole is 613.80.
- Reinstalled slide gate once any flooding in Turner Avenue has subsided and no further rain is forecasted.
- Continue to monitor water levels if additional rain is forecasted.

Action Stage (12') to Flood Stage (18')

No Rain to Moderately Heavy Rainfall Event

- Slide gate to remain in place separating City of Walker and City of Grand Rapids storm water collection systems.
- Monitor flap gates to ensure they close properly. See attached figure for flap gate locations.

Note: Even if backflow prevention fails water levels will get no higher than 609.50 in the Turner Avenue collection system. No street flooding will occur.

Heavy Rainfall Event

- Follow same procedure as for "Normal River Levels".
- Monitor flap gates to ensure they close properly. See attached figure for flap gate locations.

Stage 18' and 22.5'

Monitoring

- Monitor flap gates to ensure they have closed properly. See attached figure for flap gate locations.
- Monitor river level relative to water level in the Turner Avenue collection system. River water is leaking into the collection system, likely at one or more of the flap gates, in water levels are equal.
- If flooding occurs: Once elevation 613.95 or Stage 22.35' (if river water is entering the system) is reached flood waters will overflow the high point in Turner Avenue and flow overland into the City of Grand Rapids. Allow this to happen.

No Rain to Moderately Heavy Rainfall Event

- The slide gate does not need to be removed if river water is not leaking into the Turner Avenue collection system.
- Remove the slide gate if river water is leaking into the Turner Avenue collection system.
- Reinstalled slide gate once the risk of flooding in Turner Avenue has subsided.

Heavy Rainfall Event (Occurring or Forecasted)

- Remove slide gate regardless of whether or not river water is leaking into the Turner Avenue collection system.
- If flooding occurs: Once elevation 613.95 or Stage 22.35' (if river water is entering the system) is reached flood waters will overflow the high point in Turner Avenue and flow overland into the City of Grand Rapids. Allow this to happen.
- Street flood water will recede slowly once rainfall event has ended.
- Reinstalled slide gate after flooding in Turner Avenue has subsided.

Stage 22.5' to 26'

Same procedure as for previous scenario except if backflow prevention fails Turner Avenue will flood and overflow the high point into the City of Grand Rapids. Allow this to happen.

Stage 26' and Greater

Levee system will be breached. An area equal to or greater than the yellow boundary on the attached figure will flood. Follow previous scenario procedure.

Appendix

NOAA Flood Stage

Reference USGS Stream Gage: 04119000 (NOAA GDRM4) Grand River at Grand Rapids, MI (GRR)
Location: West side of the Grand River just south of the Blue Bridge.
https://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4

Datum Conversions

NAVD88 (pre 2009) = NGVD29 – 0.45'
NAVD88 (after 2009) = NAVD88 (pre 2009) – 0.13'

1982 FEMA Model

- Datum: 0.00' stage = 585.70 *(NGVD29)*
- 100-Year Flood Stage = 25.46' *(Based on 1982 FEMA Model)*
- 100-Year Flood Elevation = 611.16 *(NGVD29, 1982 FEMA Model)*
- 100-Year Flood Elevation = 610.58 *(NAVD88, 1982 FEMA Model)*

2017 FEMA Model

- Datum: 0.00' stage at USGS Stream Gage = 585.12 *(NAVD88)*
- 100-Year Flood Elevation = 610.48 *(2015 FEMA Model, NAVD88)*
- 100-Year Flood Stage = 25.36' *(Based on 2015 FEMA Model)*

City of Walker (at City Limits Line)

2017 FEMA Model

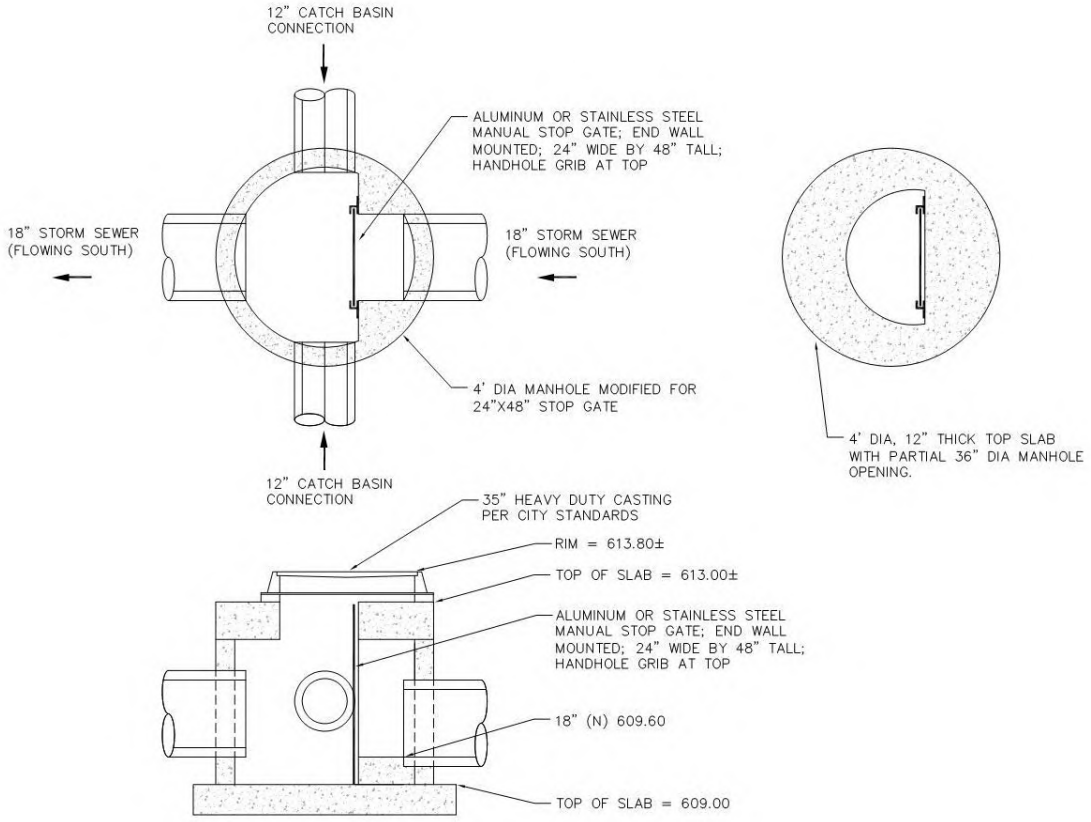
- 100-Year Flood Elevation at Walker/Grand Rapids City Limits = 616.80 = 25.36' (at USGS Stream Gage 04119000)
- Datum: 0.00' stage at Walker/Grand Rapids City Limits = 591.44

High Point in Turner Avenue (See attached figure.)

- At Walker/Grand Rapids City Limits (See attached figure.)
- Centerline Elevation = 614.50
- Gutter Pan Elevation (west side) = 613.95 +/- = 22.35' (at USGS Stream Gage 04119000)

Low Points in Turner Avenue (See attached figure.)

- 510' north of City Limits; Centerline Elevation = 612.00; Gutter Pan = 611.5 +/- = 20.06' (at USGS Stream Gage 04119000)
- 980' north of City Limits; Centerline Elevation = 613.00
- 1,530' north of City Limits; Centerline Elevation = 613.00
- 2,130' north of City Limits; Centerline Elevation = 613.10


12" CATCH BASIN CONNECTION
ALUMINUM OR STAINLESS STEEL MANUAL STOP GATE; END WALL MOUNTED; 24" WIDE BY 48" TALL; HANDHOLE GRIB AT TOP
18" STORM SEWER (FLOWING SOUTH)
18" STORM SEWER (FLOWING SOUTH)
4' DIA MANHOLE MODIFIED FOR 24"X48" STOP GATE
12" CATCH BASIN CONNECTION
4' DIA, 12" THICK TOP SLAB WITH PARTIAL 36" DIA MANHOLE OPENING.
35" HEAVY DUTY CASTING PER CITY STANDARDS
RIM = 613.80±
TOP OF SLAB = 613.00±
ALUMINUM OR STAINLESS STEEL MANUAL STOP GATE; END WALL MOUNTED; 24" WIDE BY 48" TALL; HANDHOLE GRIB AT TOP
18" (N) 609.60
TOP OF SLAB = 609.00

Appendix F

City of Walker and Kent County Emergency Management Agreement 3-27-19

CITY OF WALKER AND KENT COUNTY EMERGENCY MANAGEMENT AGREEMENT

3-27-19

I. Overview

This Emergency Management Agreement is between the City of Walker and Kent County.

The City of Walker is exercising its option to appoint the Kent County Emergency Management Coordinator as its coordinator, as provided for in Act 390, Section 9, as amended.

By this appointment, the City of Walker agrees to become part of the Kent County Emergency Management Program.

This agreement sets forth the emergency management relationship between the City of Walker and Kent County, and it is agreed both parties will act in accordance with this Agreement and with procedures set forth in the Kent County Emergency Operations Plan and the City of Walker Support Emergency Operations Plan.

II. Scope

This plan is a flexible document in which changes from the content of the plan may occur due to unique nature of emergencies. Each agency that has a supported role in this plan or its elements has developed Standard Operating Procedures (SOP) which provides systematic instructions for accomplishing assigned functions. In addition, to support emergency preparedness and response efforts, the local government also conducts other activities such as personnel training, participating in exercises, encouraging chronic disease prevention techniques; educating the public on awareness activities, and use of appropriate land use planning decisions for mitigation and prevention purposes. Through this plan, the City of Walker continues to implement the National Incident Management System, participating in efforts to provide an effective and efficient incident management operation.

III. Plan Maintenance and Implementation

The plan has been developed together with local community, and county officials to ensure consistency within the county emergency management program documents. The plan is required to be approved by Walker City Commission every year, or whenever the Mayor

changes. A copy of the updated plan is to be forwarded to the County Emergency Management Office. Upon approval, it will be implemented, tested through exercises in concurrence with County officials, and reviewed/updated to maintain currentness with the County Emergency Operations Plan.

This plan has been provided to all municipal agencies, elected officials, the county emergency management office and the MSP/EMHSD district coordinator.

A. MUNICIPAL RESPONSIBILITIES

The City of Walker agrees to be responsible for the following:

1. Appointment of Municipal Emergency Management Liaison

   A Municipal Emergency Management Liaison and one or two successors to this position will be appointment by the Mayor and/or City Manager of the City of Walker to assist the Kent County Emergency Management Coordinator in all matters pertaining to disaster prevention, mitigation, response, and recovery operations within the municipality.

   Maintain a Support Emergency Operations Plan that identifies emergency response procedures in relation to the Kent County Emergency Management Program. The Support Plan will be considered to be part of the County's Emergency Operations Plan and shall be maintained in accordance with the standards of currentness of the County's Emergency Operations Plan. The Support Plan shall contain the signature of the Mayor and City Clerk of the City of Walker and be forwarded to the County.

B. COUNTY RESPONSIBILITIES

Kent County agrees to be responsible for the following:

1. Coordinate all Emergency Management Functions

   The Kent County Emergency Management Coordinator is primarily responsible for coordinating all Emergency Management functions pertaining to disaster prevention, mitigation, response, and recovery operations within the County and municipalities that are part of the County Emergency Management Program. The Kent County Emergency Management Coordinator is responsible for all communications with the Michigan State Police, Emergency Management Division, which includes filing necessary paperwork required for funding, filing of flash reports, and developing assistance requests for the City of Walker. The Kent County Emergency Management Coordinator will continually work with the City of Walker Emergency Management Liaison when involved in emergency management activities that involve the municipality.

2. Development of Emergency Operations Plan; Support Plan Assistance

The Kent County Emergency Management Coordinator has the responsibility of developing the Kent County Emergency Operations Plan in accordance with Federal and State requirements. The Kent County Emergency Management Coordinator will assist the City of Walker Emergency Management Liaison with the development of the City of Walker Support Emergency Operations Plan to assure that it meets specified requirements and is compatible with the Kent County Emergency Operations Plan.

C. COUNTY/MUNICIPAL RESOURCES

If the City of Walker requests and receives emergency or disaster assistance from the County, in accordance with this Agreement, the County will absorb the costs. If the City of Walker provides resources to the County for emergency or disaster assistance in some other part of the County program area, the City of Walker will absorb the cost.

D. ANNUAL WORK AGREEMENT

Each year the Kent County Emergency Management Coordinator will develop an Annual Work Agreement. This Agreement will list, in priority order, Emergency Management Program items related to mitigation, preparedness, response and recovery that should be considered for that year, and shall be compatible with the annual County Work Agreement.

Gary Carey, Mayor
City of Walker

May 3, 2019
Date

Darrel Schmalzel, City Manager
City of Walker

5/7/19
Date

Sarah Bydalek, City Clerk
City of Walker

May 3, 2019
Date

Chairperson of the Kent County
Board of Commissioners

4/25/19
Date

Appendix G

Approval of the EAP

Acknowledgement of Receipt and Understanding

Two copies of this acknowledgement page are included in this copy of the GRFPS EAP. The addressee of this copy of the EAP shall sign and date as indicated below to acknowledge receipt. More importantly, the addressee signifies by their signature that they have read the EAP and understand their role in making the necessary emergency contacts and, if appropriate, mobilizing the necessary personnel and equipment to protect the public in the event of a levee embankment and/or drainage structure problem at the GRFPS.

One copy of this acknowledgement form, signed and dated by the appropriate person, shall be forwarded to the City Engineer and Public Works Department at the addresses shown below. The other signed and dated copy should remain in this copy of the EAP.

I, _____ acknowledge receipt of a copy of the Grand River flood protection

(print name)

system Emergency Action Plan. I further acknowledge that I have reviewed the plan and understand my role in the event of an emergency situation at the project.

_____ Date: _____

(signature)

Return one copy to:

City Engineer
4234 Remembrance Road, NW
Walker, MI 49534

Public Works Department
4234 Remembrance Road, NW
Walker, MI 49534

Acknowledgement of Receipt and Understanding

Two copies of this acknowledgement page are included in this copy of the GRFPS EAP. The addressee of this copy of the EAP shall sign and date as indicated below to acknowledge receipt. More importantly, the addressee signifies by their signature that they have read the EAP and understand their role in making the necessary emergency contacts and, if appropriate, mobilizing the necessary personnel and equipment to protect the public in the event of a levee embankment and/or drainage structure problem at the GRFPS.

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4234 Remembrance Road, NW
Walker, MI 49534

Public Works Department
4234 Remembrance Road, NW
Walker, MI 49534

Grand River Flood Protection System
44 CFR 65.10 (c&d)
Operations, Maintenance and Inspection Manual

Prepared For:
City of Grand Rapids
Grand Rapids, Michigan

Project No. 120330LMP
January 31, 2020, Revised July 16, 2020



FINAL

fishbeck
Engineers | Architects | Scientists | Constructors

fishbeck
Engineers | Architects | Scientists | Constructors

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Grand Rapids, Michigan 49546

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Final

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List of Abbreviations/Acronyms

BFE	Base Flood Elevation
City	City of Grand Rapids
EAP	Emergency Action Plan
EGLE	Michigan Department of Environment, Great Lakes, and Energy
GRFPS	Grand River Flood Protection System
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
NIMS	National Incident Management System
NREPA	Natural Resources and Environmental Protection Act
NWS	National Weather Service
OM&I	Operation, Maintenance & Inspection
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe

SCADA	Supervisory Control and Data Acquisition
SPS	Stormwater Pump Station
USGS	U.S. Geological Survey
WRRF	Water Resource Recovery Facility

Preface

The Grand River Flood Protection System (GRFPS) was constructed along the left and right banks of the Grand River to provide protection for the residents, commercial and institutional establishments, and industries of Grand Rapids, Michigan from the 100-year return interval flood. The flood protection system was constructed in segments and modified over a number of years making use of natural stream banks, floodwalls, levees, and road and railroad embankments.

This manual is compiled to assist City of Grand Rapids (City) officials in the operation, maintenance and inspection (OM&I) of the GRFPS including floodwalls, levees, stormwater pump stations (SPS), backflow prevention devices, and closure structures. The procedures described in this manual are generally for conditions in the Grand River when the stage, as measured by the U.S. Geological Survey (USGS) gage, upstream of the Fulton Street Bridge is less than 12 feet; however, this manual also provides guidance on flood preparatory measures that may be enacted when flood conditions are predicted to occur. For flood conditions where the stage is above 12 feet and predicted to rise to 18 feet or higher, refer to the GRFPS Emergency Action Plan (EAP).

The successful functioning of the GRFPS is not assured by the mere construction of an adequate system of levees, walls, gates, SPSs, etc. If the GRFPS is to function, it must be carefully maintained throughout normal river stage periods and properly operated during flood periods. Failure to do so can result in severe losses in property and life and may undermine the confidence of the citizens in their reliance on the system. The necessity for proper continuous maintenance cannot be too highly stressed. Considerable damage may be incurred through failure of a minor element of the system at flood times caused by neglect, deterioration, or damage that could have been prevented by proper maintenance. Proper maintenance and operation require that responsible local officials have a thorough understanding of the functions of the various units of the system and the knowledge of best methods of maintaining the system and operating it during flood emergencies. It is with this purpose in mind that this manual has been prepared for the guidance of those responsible for the maintenance and operation of the GRFPS.

Introduction

System Overview

The GRFPS is located along both banks of the Grand River in the City of Grand Rapids, Kent County, Michigan. A general plan of the protected area is shown on Figure 11. The GRFPS consists of a combination of protective structures built along the banks of the Grand River. These protective structures include concrete flood walls and low earth berms. The interior flood control system consists of six SPSs and the stormwater sewer system that drains to the Grand River, Indian Mill Creek, and Plaster Creek. Under non-flood conditions in the Grand River, stormwater discharges directly to the river through pipe penetrations through the floodwalls and storm drains installed in the natural stream banks. In the event that flood stages in the river are high enough to close the backflow devices on the stormwater drain outlets, the stormwater flow is diverted to the SPSs. The GRFPS was designed to protect approximately 1,420 acres on the right (west) bank and 195 acres on the left (east) bank of residential, commercial, institutional, and industrial properties within the City boundaries from the 100-year flood. The GRFPS also provides pumping capacities, stormwater interceptors, and gravity outfalls to discharge interior runoff during a rainfall event.

Construction History

A floodwall was constructed along the Grand River in Grand Rapids as early as 1899 to protect the City lighting plant and crematoria. Following the flood of record in March 1904, and another flood in June 1905, the City funded construction of flood walls including a wall that extended from a point 3/4 mile north of Leonard Street to the south end of Market Avenue on the east side of the river and from north of Leonard Street to the Wealthy Street Bridge on the west side. This construction occurred in the period 1907 through 1910. Over the years since then, a variety of floodwalls, earth berms, stormwater collection systems, SPSs, and backflow prevention measures have been constructed along both banks of the Grand River within the City limits. Recent floodwall improvements were made in the period 1998 to 2008, in accordance with the recommendations of the Grand River Floodwall Implementation Plan (1995).

Regulations

Floodplain management regulations are codified in the Code of the City, Title II—Utilities and Services, Chapter 32—City Stormwater Drainage System, Article 6. Floodplain Standards and Title V—Zoning and Planning, Chapter 61—Zoning Ordinance, Section 5.8.05 Flood Plain Overlay District (OD-FP).

Procedures

Purpose

The successful functioning of the GRFPS can be assured by following the procedures set forth in this manual. By doing so, all of the benefits and protection against floods for which the GRFPS were designed can be secured.

Proper OM&I require that responsible local officials have a thorough understanding of the functions of the various units of the flood protection system; the best methods of maintaining them during normal river stages; and of operating them during flood emergencies. It is with this purpose in mind that this manual has been prepared for the guidance of the City in the OM&I of the GRFPS. This manual assembles and correlates all the details essential for satisfactory OM&I of the flood protection system, so maximum flood protection may be available at all times during the service life of each component of the entire asset.

Duties of the Superintendent

The Superintendent of the flood protection system should be the City Environmental Services Department Manager and designated members of his/her support staff. The duties of the Superintendent should include the OM&I oversight, records keeping, and correspondence with the other City officials and departments. The Superintendent should have available the names, addresses, and telephone numbers of all key personnel, and a reasonable number of substitutes. The key personnel should have similar information on all of the persons that will be required for assistance in the discharge of their duties. These persons should include the following:

- An assistant to act in the Superintendent's place in cases of his/her absence or indisposition.
- Supervisors in sufficient number to lead maintenance, operation and inspection of the GRFPS. High qualities of leadership and responsibility are necessary for these positions.
- Persons knowledgeable in the manual operation of each SPS in the event that the Supervisory Control and Data Acquisition (SCADA) system becomes inoperable.

The Superintendent should ascertain that all of his key persons have read the portions of the OM&I Manual pertaining to their duties. He/she should also see that copies of the Stormwater Pump Station (SPS) operating instructions and drawings are posted in the operating room of each station, and that they are preserved in a legible condition.

The Superintendent should be responsible for the development of an organization capable of providing for the efficient OM&I of the GRFPS, and the necessary maintenance of the entire asset during normal stages of the river.

The provisions of this manual include general requirements that cover practically all types of local flood protection works. They are supplemented by technical data and instructions pertinent to the GRFPS which are necessary for its efficient OM&I.

OM&I Management

The general requirements for the OM&I management of the GRFPS are as follows:

- The structures and facilities should be continually maintained as necessary to obtain the maximum benefits.
- The Superintendent shall be responsible for the efficient OM&I of all the structures and facilities and for routine inspection and maintenance of the entire asset.
- A reserve supply of materials needed during a flood emergency should be kept on hand at all times.
- No encroachment or trespass which will adversely affect the efficient operation or maintenance of the GRFPS should be permitted upon the rights-of-way for the GRFPS.
- No improvement or construction shall be permitted within the limits of the GRFPS right-of-way, nor should any change be made in any feature of the GRFPS without prior determination by the City Engineer that such

improvement, construction, or alteration will not adversely affect the functioning of the GRFPS. Such improvements or alterations, as may be found to be desirable and permissible under the above determination, should be constructed in accordance with standard engineering practice. Record drawings or prints showing such improvements or alterations as finally constructed should be furnished to the City Engineer after completion of the work.

- At no time should the level of flood protection provided by the GRFPS during construction or any alterations, including excavation, of improvements that pass over, under, or through the GRFPS, be less than that provided for a 100-year flood (1% annual chance of occurrence). All temporary or permanent flood prevention measures made to the GRFPS to facilitate construction must be approved by the City Engineer.
- The City Engineer and the Superintendent or authorized representatives should have access at all times to all portions of the GRFPS.
- Maintenance measures or repairs which the City Engineer, the Superintendent, or their authorized representatives deem necessary, should be coordinated with the Asset Management Plans for the components of the GRFPS. The Asset Management Plans shall be used as the guides for ongoing maintenance and improvements to the GRFPS.

Permits for Use of Rights-of-Way

The rights-of-way for the GRFPS have been procured and protective works have been constructed thereon for the protection of life and property in times of flood. The Office of the City Engineer provides for the legitimate use of the rights-of-way in addition to crossing by gas lines, oil lines, and utilities, or other use of a similar nature.

A permit from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) may be required for construction along or modifications to the flood protection system under Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended. The routine OM&I of the GRFPS is the responsibility of the Environmental Services Department, and will be completed in accordance with this manual. The right-of-way for the GRFPS is issued, recorded, and maintained in document form by the Office of the City Engineer.

Adjacent Construction by Others

When owners of properties adjacent to the levees and/or floodwalls initiate new construction, particularly if it involves deep excavation, the City Engineer should be notified and take such action as may be necessary to assure that there is no encroachment on right-of-way, that adequate shoring is used to prevent disturbing flood protection foundations, and that the work insofar as possible is performed outside of flood periods.

River Stage Prediction

It is the responsibility of the City Engineer to keep advised of predicted river stages. This information will enable the City Engineer to make all the necessary preparations required for the operation and erection of those features of the system for the protection of the areas against high river stages in advance of their occurrence.

The river stages referred to herein correspond to automated gage readings taken at the USGS Station 04119000, Grand River at Grand Rapids, Michigan. The gage station is located at latitude 42˚ 57’ 52”, longitude 85˚ 40’ 35” referenced to North American Datum of 1927, in NE 1/4 Section 25, Township 7 N, Range 12 W, Kent County, Michigan, on the right (west) river bank, 500-feet upstream from the Fulton Street bridge in Grand Rapids and 1.7 miles upstream from Plaster Creek. The datum for the gage is 585.70-feet National Geodetic Vertical Datum of 1929 (NGVD 29) (elevation 585.25-feet North American Vertical Datum of 1988 [NAVD 88]). Current river stage information can be obtained from the National Weather Service (NWS) Forecast Office, Grand Rapids, Michigan, Advanced Hydrologic Prediction Service at: http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4 or the USGS Michigan Water Science Center at: http://waterdata.usgs.gov/mi/nwis/sw

The predicted stages are available for up to five days in advance. This is sufficient time to allow the City Engineer to make all necessary emergency preparations and conduct such operations as may be required for various river stages as described in this manual and the National Incident Management System (NIMS). It should be kept in mind that the predicted stage is only an approximation and may possibly range higher.

Procedure at Various River Stages

Appendix 4 lists the operations to be performed at various river stages.

The actual time of mobilization of the various personnel will be dependent upon the rate of rise of the Grand River (see "Grand River – Rate of Rise – Closure Operation" in Emergency Closure Structures), the various functions to be performed, the condition of the flood protection system, the time required to erect sandbag and other closures, and other pertinent requirements of the Special Operation & Maintenance During High Water Periods section of this manual.

Reference Drawings

A list of reference drawings including record drawings is included in Appendix 1. The station references used in this manual are referenced to a survey baseline along the centerline of the Grand River that begins at Station (Sta.) 2003+05.20, at the right lane edge of pavement on the east bound lanes of the Interstate 196 (I-196) bridge. The survey baseline station numbers increase in the upstream direction.

Elevations

The GRFPS was constructed at different times under different construction contracts. Therefore, different vertical datum were used throughout the history of construction. To the extent possible, this manual attempts to identify the elevation datum for all elevations used in its paragraphs. The user of this manual should be careful to discern which vertical datum is being used when comparing to published flood elevations. The conversion between elevations using the NAVD 88 and those using NGVD 29 is given by:

NAVD 88 = NGVD 29 – 0.4495 feet

Safety

The Superintendent should provide a health and safety plan in accordance with the Occupational Safety and Health Administration law and regulations for all personnel involved in the maintenance of the GRFPS. The Superintendent and maintenance personnel should familiarize themselves with the safety procedures and implement them during routine maintenance and flood operations. Safety precautions should be complied with as follows:

- Personnel should remain alert to the possibility of hazardous gases at the structures, primarily at the pumping stations, manholes, and junction chambers, and take appropriate safety measures when inspecting, maintaining, or operating the structures. Sewer gases and pungent vapors may accumulate in the pump chambers. Power ventilation should be accomplished before any attempt is made to enter the pump chambers.
- Two persons should always be present during maintenance, inspection, or operation of all drainage structures. The buddy system should be used to provide necessary help and assistance to each other in the event an accident occurs. At no time should one person be allowed to enter the pump chamber area without an assistant standing by on the operating floor. A lockout/tagout procedure shall be required.
- Since a potential drowning hazard exists during flood emergencies, emergency response teams from the City's Fire Department with appropriate personnel and equipment shall respond accordingly.

Inspections

Annual inspections of the GRFPS will be completed by the Office of the City Engineer, or their consultants, in accordance with the Asset Management program. The Environmental Services Department will also conduct routine inspections of the GRFPS during the course of the year. Repair and maintenance of the GRFPS should be coordinated with the scheduled Asset Management improvements when possible. Other maintenance activities that should be completed as soon as possible are completed in cooperation with the City Engineer.

Earth Embankments (LEVEES)

Earth Embankment Maintenance

The pertinent requirements for maintenance of the earth embankments are as follows:

The Environmental Services Department shall provide at all times such maintenance as may be required to insure serviceability of the earth embankments in time of flood. Measures should be taken to promote the growth of sod, exterminate or remove burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable, measures should be taken to retard bank erosion by placement of riprap stone or by planting suitable plants on areas riverward of the levees. Inspection of the earth embankment should be completed by the Environmental Services Department to insure the above maintenance measures are being effectively carried out and to be certain that:

- No unusual settlement, sloughing, or material loss of grade or earth embankment cross section has taken place.
- No caving has occurred on either the land side or the river side of the earth embankment which might affect the stability of the earth embankment section.
- No seepage, saturated areas, or sand boils are occurring.
- Toe drainage systems are in good working condition and that such facilities are not becoming clogged.
- Drains through the earth embankments and backflow gates on said drains are in good working condition.
- No revetment work or riprap has been displaced, washed out, or removed.
- No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod.
- Access roads to and on the earth embankments are being properly maintained.
- Crown of the earth embankment is shaped to drain readily and roadway, if any, is well shaped and maintained.
- There is no unauthorized vehicular traffic on the earth embankment.
- Encroachments are not being made on the earth embankment right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Burrowing Animals

Burrowing animals (muskrats and groundhogs) create seepage paths in earth embankments. Burrowing animals should be removed from the earth embankment and the burrows filled with a mud-pack prepared by adding water to a 90 percent soil and 10 percent cement mixture until a slurry or thin cement consistency is attained. After filling the burrow with the mud pack mixture, the burrow entrance should be filled with dry earth and seeded.

Drift

Drift (river-borne debris) should be removed from the earth embankment and other grassed areas on the right-of-way at the end of each winter flood season before the new growth of grass starts in the spring, and after each flood occurring during the growing season.

Gullies, Holes, and Washes

Gullies, holes, and washes in the levee, slopes, and berms should be repaired using compacted clay soils in an approved manner.

Earth Embankments Crest Depressions

Gaps occurring where trail or road crossings have been worn down or where the earth embankment may be below grade should be remedied. It is advisable to run levels occasionally to determine whether depressions have occurred in the top of the earth embankment. The profile of the top of the earth embankment should be maintained to the elevations shown on the construction plans.

Spare Cover Vegetation

All areas deficient in sod should be reseeded or resodded.

Seeding

When new permanent seeding is necessary to obtain cover for bare areas, it is recommended that such work be done in the late summer, between July 15 and September 15, or in the spring between April 10 and June 5. Temporary seeding can be performed up to a month before or a month after the above dates, respectively; however, temporary seeding must be followed-up with permanent seeding during the appropriate season.

Sodding

Where sodding is considered the most favorable method of reestablishing a good stand of grass on the earth embankment, it should be performed in advance of the flood season to ensure knitting of the transplanted sod with the prepared base. Sodding should preferably be done between May 1 and October 20, if irrigation can be provided as needed. Sod should not be laid between June 10 and September 10 without irrigation.

Grass Mowing

Grass should be mowed as necessary to help maintain a good stand of grass.

Earth Embankment (Levee) Inspection

Sample check list forms for use in performing inspections of earth embankments (levees) are enclosed as Appendix 2.

Earth Embankment (Levee) Operation

When the Grand River flood stage exceeds 12 feet at the USGS gauge station, the earth embankment should be patrolled daily, or more frequently as conditions warrant, to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

- There are no indications of slides or sloughs developing.
- Wave wash or scouring action is not occurring.
- No low reaches of earth embankment exist that may be overtopped.
- No other conditions exist which might endanger the structure as determined by the City Engineer.

Earth Embankment Damage Due to High Water:

If it is found that sand boils, scouring, or other hazardous conditions are occurring, immediate steps should be taken to control the situation and repair or correct any damage. In the face of such dangerous conditions due to high water, the provisions of the NIMS and city-wide Asset Management Plan shall be implemented. Suggested methods of operations for combating such flood conditions are given in the Special Operation & Maintenance During High Water Periods section of this manual.

Sand Boils and Seepage Areas:

When sand boils or other seepage areas are observed which are of small magnitude, posing no major threat to structure safety, and therefore are not economically feasible to repair, their locations should be recorded for future action in conjunction with Asset Management improvements.

Flood Walls

Flood Wall Maintenance

The City Engineer, in accordance with the GRFPS Asset Management Plans, should provide such maintenance strategies as may be required to ensure a continued high level of serviceability of the entire asset in time of flood conditions. Measures should be taken to repair concrete cracks, spalls, and cavities; prevent leakage through concrete joints, remove trees and brush at the base of the flood walls and in joints, cracks, or cavities in the concrete; remove drift deposits at the base of the wall; remove materials deposited or stored along the inside surface of the wall; and repair damage caused by erosion, floating ice and debris impact, or other forces. Where practicable, measures should be taken to retard bank erosion at the base of the flood wall by placement of riprap stone or by planting suitable plants on areas riverward of the flood wall.

Annual inspections should be made by the Office of the City Engineer in accordance with the flood protection system Asset Management Plans. The Superintendent shall also visually observe the GRFPS on a periodic basis and review with the City Engineer if repairs are necessary to maintain operational soundness of the floodwalls. The visual observations shall verify that the above maintenance measures are being effectively carried out and, be certain that:

- All joints contain water stops or a mastic compound for the full height of the wall to prevent leakage during a flood.
- Cracks, spalling, chips, and cavities in the wall concrete and caps are not extensive or deep enough to endanger the stability of the wall.
- Flood wall monoliths are aligned.
- Flood wall monoliths have not settled.
- Flood wall caps are intact and not providing a gap for flood waters to overflow.
- No appurtenances are attached to the river side of the wall that could overstress the wall concrete and reinforcement or catch debris during a flood.
- No animal burrows are present along the river-side toe of the wall that may provide a seepage path under the wall.
- Any sand boil locations are monitored and controlled during a flood and promptly addressed after the flood waters recede.
- No seepage, saturated area, and/or boils are occurring.
- No undue settlement has occurred which affects the stability of the wall or its water tightness.
- No trees exist, the roots of which might extend under the wall, and offer accelerated seepage paths.
- There are no encroachments upon the right-of-way, which might endanger the structure or hinder its functioning in time of flood.

Care is being exercised to prevent accumulation of debris adjacent to walls.

No bank caving conditions exist riverward of the wall which might endanger its stability.

Toe drainage systems are in good working condition and not becoming clogged.

Sample inspection check list forms for use in making inspections of the flood walls are shown as Appendix 2.

Flood Wall Repairs

Repairs to floodwalls or other concrete structures should be completed in conjunction with the Asset Management Plan improvements, when possible, with approval of the City Engineer. Repairs that require immediate attention should be completed through cooperation between the Supervisor and the City Engineer.

Adjacent Land Maintenance

Maintenance of the land area adjacent to the flood walls should comply with Part III of this manual.

Flood Wall Operation

Daily inspection (or more frequently if conditions warrant) of the floodwalls, by the office of the City Engineer, should be maintained during flood warning (Emergency) conditions (stage > 18 feet), to locate possible leakage at monolith joints or seepage underneath the wall. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures should be taken to protect the concrete and construction joints. Immediate steps should be taken to correct any condition with endangers the stability of the wall.

Adjacent Land Damage Due to High Water

If it is found that seepage, saturated areas, sand boils, bank caving, or other situations detrimental to wall stability are occurring during flood watch (Non-Emergency) or warning (Emergency) conditions (stage > 12 feet), emergency repairs as described in Appendix 3 of this manual should be employed immediately.

Drainage Structures

Maintenance

Under the classification of drainage structures include: culverts, seepage and toe drainage systems, manholes, storm sewers, SPS discharge lines that pass through, under, or over the levee and floodwalls, and flap and sluice gates. The various backflow prevention measures on the pipe penetrations through the GRFPS with outfalls below the Base Flood Elevation (BFE) are described in detail in the Closure Analysis Report.

Adequate measures should be taken to ensure that inlet and outlet channels are kept open and that trash, or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures should be examined, lubricated, and operated annually. Periodic inspections should be made by the Superintendent to be certain that:

- Pipes, gates, operating mechanisms, riprap, and headwalls are in good conditions.
- Inlet and outlet channels are open.
- Care is being exercised to prevent the accumulation of trash and debris near the structures, and that no fires are being built near bituminous coated pipes.
- Erosion is not occurring adjacent to the structure which might endanger its water tightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections, unless it can be delayed to be included with future Asset Management improvement projects.

Sluice Gates: Sluice gates are located in the SPSs and in several storm and combined sewer gate chambers. These gates should be trial operated, serviced, and lubricated annually. The gate slides and stems should be well greased. Sluice gate cranks for manual operation are kept in the nearest SPS.

Flap Gates and Duckbill Gates: Flap gates are installed on the ends of the discharge lines of the pumping units in the following SPSs:

- Market Avenue SPS (River Station 2074+00)
- Wealthy Street SPS (River Station 2068+00)
- Front Avenue & Scribner Avenue SPS (River Station 2155+00)
- Indian Mill Creek SPS (Indian Mill Creek River Station 16+50 above confluence with Grand River)
- Caledonia Street SPS (River Station 2214+50)
- Palmer Street SPS (River Station 2235+00)

In addition, there are flap gates or duckbill gates on the outlets of the storm drains and in manholes at the locations listed in Tables 1A, 1B, and 1C. Note that all of the gates in the following tables are flap gates unless otherwise noted.

Table 1A - East Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
2093+00	11	2217563	15" RCP	Traffic Safety Dept. parking lot, 509 Wealthy Street, SW
2096+00	12-B	2084100	12" DIP	In 2 manholes in parking lot for 301 Market Avenue, SW, between building and railroad track and in 4 manholes in street in front of 301 Market Avenue, SW
2099+00	12-A	2217566	12" DIP	Floodwall at 301 Market Avenue, SW, upstream of railroad bridge
2101+00	15	2083781	42" RCP	Flap gate in upstream manhole in Public Service Center Yard; extended from Bartlett Street, SW
2101+00	16	2217571	18" STL	Catch basins in Public Service Center Yard on Market Street; extended from Bartlett Street, SW
2107+50	20-A	2217580	15" VCP	In first upstream manhole on pipe extending from Williams Street, SW (Public Services Center Yard)
2118+00	23	2217592	8" RCP	Concrete head wall at river south of Fulton Street
2120+00	29	2083787	12" DIP and 24" DIP	In 4 manholes (12" DIP) at intersection of Market Avenue, NW, and Fulton Street and 1 manhole (24" DIP) at intersection of Ottawa Avenue, SW, and Fulton Street
2128+00	31	2217600	6'x6' Cast in Place	Louis Street, NW, (16" & 24" flap gates in upstream manholes)
2129+50	32-A	2217602	12" DIP	Flap gate located in manhole in the lower parking area between Louis Street, NW, and Pearl Street, NW
2131+00	33	2036200	12" RCP	Pearl Street, NW
2132+50	34	2217606	6" STL	Amway Grand Plaza Drain
2133+00	35	2217607	10" STL	Amway Grand Plaza Drain
2133+50	36	2217608	10" STL	Amway Grand Plaza Drain
2134+00	37	2217609	18" RCP	Lyon Street, NW
2134+50	38	2217610	12" STL	DeVos Place Convention Center just north of Lyon Street, NW
2137+00	39	2217612	12" RCP	DeVos Place Convention Center
2137+50	40	2217613	12" RCP	DeVos Place Convention Center
2138+50	41-A	2217613	16" RCP	DeVos Place Convention Center
2139+00	42	2217613	15" RCP	DeVos Place Convention Center
2140+00	42-A	2217613	16" RCP	DeVos Place Convention Center
2145+00	47-A	2084173	96" RCP	Michigan Street (flap gates in upstream manholes to protect basement of Federal Building)
2156+50	49	2084106	30" STL	End of pipe extended from Trowbridge Street, NW
2159+00	49-A	2083788	36" DIP	In manhole on south side of 6th Street, NW, just east of 6th Street Bridge

Table 1A - East Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
2160+50	49-B	2217623	36” RCP	4th Street Dam; ties into Outfall 49-A; flap gate in manhole
2167+00	49-C	_____	36” DIP	In manhole at 6th Street west of Monroe Avenue
2174+00	53	2084102	42” RCP	Extended from Mason Street, NW; flap gate in upstream manhole
2181+00	53-A	2084103	36” RCP	Extended from Walbridge Street, NW; flap gate in upstream manhole
2190+00	54	2084065	10’x9’ Brick	10” flap gate on north side of drain at Ionia Avenue, NW
2197+50	54-A	2084228	15” RCP	Leonard Street, NW
2203+50	55	2084124	48” RCP	At river on the south side of 1305 Monroe Avenue, NW; and in junction chamber at Monroe Avenue, NW
2207+50	55-A	2217627	24” STL	In upstream manhole fed by parking lot drains behind 1345 Monroe Avenue, NW
2211+50	55-B	2217628	30” RCP	Backwash line for water storage tank at 1401 Monroe Avenue, NW; flap gates in 2 upstream manholes
2214+50	56-B	2084181	36” DIP	Flap gate in upstream manhole
2227+00	57	2217632	18” RCP	At river behind 1615 Monroe Avenue, NW (Baker Furniture Building)
2231+00	59	2217634	18” RCP	At river behind 1661 Monroe Avenue, NW (Baker Furniture Building)
2233+00	60	2217635	18” RCP	At river behind 1799 Monroe Avenue, NW (Baker Furniture Building)
2235+00	61	2083795	36" RCP	South of Ann Street at Palmer Street SPS
2238+00	63	2217637	8” STL	End of pipe from catch basin for gas station at 1801 Monroe Avenue, NW
2242+00	64	2083794	24" RCP	400' north of Ann Street in upstream manhole east of berm
2243+50	64-A	2217638	12” RCP	End of pipe extended from Burr Oak Street, NW
2245+50	64-B	2217639	12” RCP	At headwall along river adjacent to Marine Corps Reserve Center parking lot on north side of 1863 Monroe Avenue, NW
2246+50	64-C	2217640	12” RCP	At headwall along river adjacent to Marine Corps Reserve Center parking lot on north side of 1863 Monroe Avenue, NW (extension of Elmwood Street, NW)
2247+00	65	2083793	54” RCP	End of pipe extended from Elmwood Street, NW
2251+00	66-A	2200647	12” RCP	Upstream manhole in pipe extended from Knapp Street, NW
2277+00	70	2084049	72” RCP	At river in Riverside Park extending from Guild Street, NW

Table 1A - East Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location

Pipe Material Key

Brick = brick masonry
CIP = cast iron pipe
CMP = corrugated metal pipe
CONC = concrete
DIP = ductile iron pipe
HDPE = high density polyethylene
PVC = polyvinyl chloride
RCB = reinforced concrete box
RCP = reinforced concrete pipe
STL = steel
VCP = vitrified clay pipe

Table 1B - West Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
2022+00	72-E	2217654	48” CMP	On end of pipe at drainage ditch on west side of Butterworth Landfill near I-96
2022+00	72-F	2217655	21” CMP	On end of pipe at drainage ditch on west side of Butterworth Landfill near I-96
2041+00	72	2217649	48” CMP	2 flap gates on end of pipes at end of westside ditch just upstream of confluence with river
2041+00	72-A	2217650	96”x84” RCB	At upstream end of westside ditch, south of intersection of Wealthy Street, SW, and Garfield Avenue, SW
2041+00	72-B	2217651	30” CMP	At westside ditch just southwest of intersection of Wealthy Street, SW, and Garfield Avenue, SW
2041+00	72-C	2217652	48” CMP	At westside ditch in Butterworth Landfill
2068+00	72-H	2083776	12” DIP	Duckbill gate at Wealthy Street SPS outfall structure
2078+50	72-I	2217656	15” HDPE	At river behind 700 Wealthy Street, SW
2082+00	72-J	2217657	24” HDPE	At river behind 700 Wealthy Street, SW
2090+00	83	2217701	8” STL	In manhole in sidewalk at north end of 322 Front Avenue, SW
2099+00	84	2217706	10” PVC	On floodwall upstream of railroad bridge adjacent to south parking lot for 210 Front Avenue, SW
2100+50	86	2217708	10” PVC	On floodwall adjacent to north parking lot for 210 Front Avenue, SW
2119+00	96	2083786	30” RCP	At river just north of Fulton Street bridge
2136+00	103	2084096	30” RCP	At river upstream of pedestrian bridge to Ford Museum
2162+50	109	2217738	12” RCP	In upstream manhole behind floodwall in parking lot for 634 Front Avenue, NW
2180+00	112	2084165	42” STL	In upstream manhole behind floodwall; extension of pipe from 10th Street, NW

Table 1B - West Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
2198+50	117	2084232	36" RCP	In upstream manhole behind floodwall in south parking lot for 265 Leonard Street, NW
2201+00	118	2217760	8" RCP	In upstream manhole behind floodwall in parking area north of 265 Leonard Street, NW
2203+00	119	*	10" RCP	On floodwall behind MDOT building at 1240 Front Avenue, NW
2205+50	120	2217761	15" RCP	In upstream manhole behind floodwall behind building at 1250 Front Avenue, NW
2207+00	121-A	2217762	4" STL	In upstream manhole behind floodwall behind building at 1300 Front Avenue, NW
2208+50	122	2217767	10" CIP	In upstream manhole behind floodwall behind building at 1336 Front Avenue, NW
2211+00	124	2084075	24" RCP	In upstream manhole behind floodwall at Myrtle Street, NW
2213+50	125	2217768	8" DIP	On floodwall behind MDOT West Michigan Transportation Operations Center, 1420 Front Avenue, NW
2215+50	127-A	2217772	8" STL	On floodwall behind building at 1440 Front Avenue, NW
2217+00	128	2217773	12" DIP	On floodwall behind building at 1450 Front Avenue, NW
2222+50	131	2217777	15" RCP	At river from pipe in work yard on north side of Kent County Public Service Center at 1500 Scribner Avenue, NW
2223+00	132	2217778	24" CMP	At river from pipe in work yard on north side of Kent County Public Service Center at 1500 Scribner Avenue, NW
2224+50	133	2217779	15" RCP	At river from pipe in work yard on north side of Kent County Public Service Center at 1500 Scribner Avenue, NW
2226+00	133-A	2217780	12" DIP	At river from pipe in northeast corner of work yard on north side of Kent County Public Service Center at 1500 Scribner Avenue, NW
2250+50	135-A	2217784	24" RCP	At riverside toe of embankment for U.S. Route 131 north of Ann Street, NW
2257+00	135-B1	2084177	36" RCP	At riverside toe of embankment for U.S. Route 131 and at head of channel draining to river north of Ann Street, NW
2268+00	135-C1	*	12" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of and between 2204 Turner Avenue, NW and 2280 Turner Avenue, NW

Table 1B - West Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
2273+00	135-C2	*	12" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of and between 2280 Turner Avenue, NW and 2356 Turner Avenue, NW
2277+00	135-C3	*	12" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of south end of building at 2400 Turner Avenue, NW
2277+00	135-C4	*	24" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of south end of building at 2400 Turner Avenue, NW
2285+00	135-F	2312878	60" RCP	At head of drainage ditch at north end of building at 2400 Turner Avenue, NW and behind building at 2474 Turner Avenue, NW

Pipe Material Key
Brick = brick masonry
CIP = cast iron pipe
CMP = corrugated metal pipe
DIP = ductile iron pipe
HDPE = high density polyethylene PVC = polyvinyl chloride
RCB = reinforced concrete box
RCP = reinforced concrete pipe
STL = steel
VCP = vitrified clay pipe

There are currently no Facility ID numbers for these outfalls in the City GIS.

Table 1C - Indian Mill Creek				
River Station**	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
9+50	136-A	2084235	24" RCP	In manhole behind 330 Ann Street, NW
11+90	136	2217792	12" DIP	Duck bill gate in manhole in parking lot behind 400 Ann Street, NW
16+50	137-A	2084179	36" RCP	At creek on SPS discharge pipe
16+70	137-B	2084178	36" RCP	At creek on SPS bypass pipe
18+00	138	2084003	30" RCP	In upstream manhole in Broadway Avenue, NW near intersection with Hamilton Avenue, NW

Pipe Material Key
Brick = brick masonry
CIP = cast iron pipe
CMP = corrugated metal pipe
DIP = ductile iron pipe
HDPE = high density polyethylene
PVC = polyvinyl chloride
RCB = reinforced concrete box
RCP = reinforced concrete pipe
STL = steel
VCP = vitrified clay pipe

**River stations measured in the upstream direction from the confluence with the Grand River.

The flap gates should be operated, serviced, and lubricated annually to be certain that they swing freely and do not bind. Clear all debris that prevents full closing of the flap gate. Caution: In order to prevent possible damage, do not allow the flaps to slam against their seats.

Inspection

Drainage structures should be inspected annually. Sample inspection check list forms are provided in Appendix 2.

Operation

Whenever a flood stage exceeding 18 feet as measured at the USGS Station 04119000, Grand River at Grand Rapids, Michigan, is predicted by the NWS Forecast Office, Advanced Hydrologic Prediction Service (see Permits for Use of Rights-of-Way section), all gates should be inspected before water reaches the invert of the pipe and any object which might prevent closure of the gate should be removed. Manually operated gates and valves should be closed as necessary to prevent inflow of flood water. All drainage structures in earth embankments (levees) should be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps should be taken to correct any adverse condition.

Sluice and Flap Gate Operation Caution

Observe cautions for opening and closing the sluice gates and operating the flap gates as directed in the maintenance instructions.

Flap Gate and Duckbill Gate Operation

The flap gates and duckbill gates should be inspected in order that objects that would prevent the gate from seating properly or sealing may be removed. The flap gates and duckbill gates should be closely monitored until it is definitely determined that they are securely closed and that no more debris will pass through their outlets. Water will pass through a flap gate and a duckbill gate outlet as long as the landside water surface is above the riverside water surface. Until both surfaces are above the crown of the pipe, floating debris and trash will attempt to pass through the drainage structure and can possibly keep the gate from seating properly when the water on the riverside reaches an elevation above that on the landside.

Emergency Closure Structures

Maintenance

Three small pipe penetrations, one sidewalk penetration, and one railroad penetration through the flood wall are not protected from the base flood elevation by the permanent GRFPS. Emergency temporary closures consist of either sewer plugs or prefabricated metal closures. Each closure, including storage and hauling information, is listed in the table in Appendix 4. The City of Grand Rapids Environmental Service Department is responsible for the storage, maintenance, inspection and installation of all closure devices.

The sewer plugs and other closures should be inspected annually to be certain that:

- Proper closure can be made promptly when necessary (no obstructions are found in the area where the closure would be installed that would obstruct installation).
- Sufficient materials are on hand for the erection of other closures (e.g. sandbags, lumber, wire, etc.) and that the location of such materials will be readily accessible in times of emergency.
- Closures are in good condition.
- Sewer plugs are clean and free of leaks, bulges, cracks, or other damage that would prevent proper installation.

Inspection

The closures and sewer plugs should be inspected annually. Sample inspection check list forms are provided in Appendix 2. The forms contain an inventory of materials necessary for the complete erection and operation of the closures. All materials should be checked against the check list to ascertain their presence at the City storage location. It is advisable to check the material storage areas immediately before impending high water to see that no materials are missing. Any irregularities observed during inspections should be noted and immediate measures taken to correct them.

Operation

The closing of flow paths for flood waters should be started in sufficient time to permit full closure before flood waters flow into the protected areas. The order of operations to close flood paths is provided in the table in Appendix 4. The sewer plugs and other closures will be inspected frequently during flood periods to ascertain that no undue leaking is occurring and that drains provided to care for ordinary leakage are functioning properly.

Closures and Sewer Plugs

The sewer plugs and other closures should be made as instructed in the Special Operation & Maintenance During High Water Periods section of this manual. The installation of sewer plugs requires experienced crews with portable air compressors and pneumatic hoses.

Grand River - Rate of Rise - Closure Operation

It is imperative that ample time be allowed to install the sewer plugs and other closures before the water reaches the predicted flood elevation. It is the responsibility of the Superintendent to keep advised of predicted river stages and of possible additional local rainfall. This information will enable the Superintendent to make all the necessary preparations required for the erection of those features of the system for the protection of the area against high river stages in advance of their occurrence. River stage predictions for the Grand River and forecasts of local rainfall are issued by the NWS, Advanced Hydrologic Prediction Service, NOAA, Grand Rapids Michigan, at the internet web site: http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4

With this information, it will be possible to perform such operations as may be required for various stages. The predicted stages are usually available five days in advance. This is sufficient time to allow the Superintendent to make all necessary emergency preparations. Due consideration must be given to the rate of rise of the river. Table 2 contains Rates of Rise in feet per hour for various gage readings up to flood crest of major flood experiences. By comparing a predicted flood with records of past floods (Table 2), it is possible to estimate and use as a guide Rates of Rise to be expected at various gage readings over the period required to effect closure. There are many factors determining the Rates of Rise, and the City Engineer shall be consulted in understanding the predictability of the Grand River and the Rates of Rise that may be anticipated. The period required to erect each closure must also consider the possible delays because of inexperienced help and other delays.

Table 2 - Grand River - Rates of Rise in Feet Per Hour, Grand Rapids, Michigan

Gage Readings (Zero of Gage = 585.7 feet)	April 2013 Flood	Mar. 1985 Flood	May 2004 Flood	Oct. 1986 Flood	April 1960 Flood
12[(1)]					
	0.13	0.24	0.09	0.03	0.12
13					
	0.08	0.22	0.07	0.05	0.10
14					
	0.08	0.26	0.07	0.04	0.13
15					
	0.10	0.17	0.07	0.05	0.12
16					
	0.05	0.32	0.06	0.06	0.10
17					
	0.01	0.28	0.06	0.05	0.10
18					
	0.09	0.14	0.05	0.03	0.09
19					
	0.07	0.24	0.06	0.05	0.03
20					
	0.04	---	---	---	---
21					
	0.03	---	---	---	---
22					

Table 2 - Grand River - Rates of Rise in Feet Per Hour, Grand Rapids, Michigan					
Gage Readings (Zero of Gage = 585.7 feet)	April 2013 Flood	Mar. 1985 Flood	May 2004 Flood	Oct. 1986 Flood	April 1960 Flood
Crest Stage	21.85	19.64	19.54	19.25	19.25
NOTES:					
(1) Action stage - River is bank full upstream and downstream of floodwalls in downtown Grand Rapids.					

Clean Up

Upon final recession of flood waters, the closures should be disassembled. All closures should be inspected, repaired or replaced, as required, and restored to appropriate storage locations. Sewer plugs should be deflated, removed from the pipes, and inspected for damage and leaks. All damaged and unsalvageable materials should be removed and disposed.

Stormwater Pump Stations

General

There are six flood pumping stations that pump stormwater that cannot flow by gravity to the Grand River or Indian Creek from the area protected by the earth embankments (levees) and floodwalls during an extreme flood. All the SPSs are inoperative when the Grand River and Indian Creek are not at flood stage. The pumping stations are placed into operation when water levels in the receiving waters are above normal to the point where pumping is required. When these conditions are reached, float-operated switches and/or transducers in each SPS initiate pump operation. Individual control panel lights for each pump are located in the SPS control centers to alert City personnel that pumps are operating and to identify possible operation problems.

This section of the manual is intended as a guide for the personnel responsible for inspection, operation, and preventative maintenance of SPS equipment. It outlines basic maintenance procedures that are in facilities of this nature in order to guide the operating personnel in systematically detecting and correcting potential defects before they develop into major failures. This section of the manual is not intended to take the place of the manufacturer's instructions on maintenance, but is a compilation of general procedures advocated by manufacturers and based upon experience. Although some manufacturers' instruction books have been furnished to the local operating agency, the Superintendent should procure and maintain for reference a manufacturer's instruction file on all equipment installed. In cases of variance within the manufacturer's instructions, the manufacturer's instructions should be followed.

Basic Equipment Care

Preventive maintenance is the systematic inspection and servicing of equipment required to assure that it remains ready to be placed into service when needed. It includes proper care, use, operation, inspection of equipment, cleaning, and lubrication. The following sections describe the basic operations making up preventive maintenance.

Inspection, Tests, and Maintenance

SPSs should be inspected by the Superintendent annually to ensure that all equipment is functioning properly so that it can be placed into operation when needed. At regularly scheduled intervals, measures should be implemented to provide for cleaning buildings and equipment, repainting as necessary, lubricating equipment as recommended by the equipment manufacturer's OM&I Manual, and verifying the operability of flash lights or lanterns for emergency lighting. Telephone service should be maintained at the SPSs to ensure that communications with the Superintendent and maintenance personnel can be maintained should the pumps require manual operation. All equipment, including switch gear, transformers, motors, pumps, valves, and gates should be trial operated at least annually. Pumps should be "bumped" on an every-other-week basis. A record should be kept showing the results of such tests.

All the SPSs receive primary electrical power from the Consumers Energy Company electrical grid. For the Wealthy Street and Front Avenue & Scribner Avenue SPSs, there are two primary electrical power lines providing power to each SPS control building. At each of these SPSs, the switch gear should be manually operated annually to isolate one of the power lines to ensure the uninterrupted flow of power to the pump controls from the other power line and then this procedure should be reversed to isolate the other power line.

The Market Avenue, Caledonia Street, Palmer Street, and Indian Mill Creek SPSs have receptacles on the outside of the SPS building to connect with mobile auxiliary power units for supplemental power. A mobile auxiliary power unit should be connected to each of the SPSs annually, started, and allowed to run for sufficient time as may be necessary to ensure their serviceability in time of emergency.

Regular inspections, tests, and maintenance of the SPSs should be accomplished as directed herein to provide a reasonable indication of the readiness of the pumping facilities for uninterrupted operation, to detect and correct mechanical and electrical defects or conditions which prevent efficient operation, and to reduce the possibility of failure of vital electrical and mechanical equipment during critical flood periods. The thoroughness and care with which the inspector performs his work has a direct effect on the readiness of the stations and can be a significant factor in reducing malfunctions and equipment failures during times of flooding. Inspections and repairs should be entrusted only to competent personnel familiar with the manufacturer's instructions in both the function and adjustment of the various devices. Operating personnel for the City should be present during any tests conducted by inspector(s). The inspector should have a general understanding of the electrical and mechanical characteristics of the equipment being inspected, and sufficient information concerning its correct operating performance to enable them to know whether adjustments and repairs are necessary. The inspector should have access to or obtain such instruction books (manufacturer's and other publications) pertaining to the equipment requiring inspection, as may be necessary for the satisfactory performance of their duties. In order to facilitate thorough inspection of the SPSs, the check lists in Appendix 2 should be used. It should be noted that the best method of maintaining mechanical and electrical equipment is trial operation and testing of the equipment at frequent intervals. It is recommended that electrical and mechanical equipment other than pumps and motors be operated in the "test position," as described by the manufacturer, as frequently as necessary so that all moving parts will operate freely at all times. Operation in the "test position" does not require operation of the motors. Any equipment removed from the station for repair or replacement should be returned or replaced as soon as practicable and should be trial operated after reinstallation. Repairs requiring removal of equipment from the station should be made during off-flood seasons whenever practical.

Manufacturer's Instructions

The general instructions cover normal operation and maintenance of the pumping equipment. The operator should also be familiar with the equipment manufacturers' drawings, literature, and instructions when detailed information may be required for OM&I (see Appendix 1). In case of major operating difficulties or repairs on a particular item of equipment, the manufacturers should be consulted.

SPS Structures

The SPS structures should be properly maintained. All doors and all metal and wood parts should be adequately protected with paint to prevent corrosion. All hardware should be well oiled or greased for ease of movement and to prevent corrosion. Any cracks or leaks that may develop in the walls, roof, or floor, allowing water to leak or seep into the structure, should be sealed with a waterproofing material. The lighting system should be maintained in good working order and all defective lamps should be replaced promptly. The stations should be kept locked when not in use and should be made inaccessible to trespassers at all times. The stations should be kept free of fire hazards.

Keys

City personnel under the direction of the Superintendent have the necessary keys for SPS access. A second set of keys is also kept at the City Water Resource Recovery Facility (WRRF).

Access Roads

The roads leading to the SPS structures from City streets should be maintained in good condition at all times. Drainage and surface repairs should receive immediate attention when conditions requiring remedial measures arise. This will ensure access to heavy rolling equipment at any time and under all weather conditions.

Trash Rack, Bar Screens, and Sluice Gates

All trash racks, bar screens, and sluice gates should be inspected annually and/or after the associated SPS has been in operation. All of the SPS trash racks are permanently mounted and require manual cleaning.

Automatic Flap Gates

The outlet ends of the pump discharge pipes in SPSs are equipped with automatic flap gates located either in the discharge well (Market Avenue, Front Avenue & Scribner Avenue, Indian Mill Creek, Caledonia Street, Palmer Street), or mounted on a headwall at the outfall structure (Wealthy Street). These gates should be maintained and operated as instructed in Appendix 1 of this manual.

Electrical Power Supply

All electrical equipment, including power lines, transformers, generators, all component parts of the power supply, the switchgear, circuit breakers, automatic controls, cutouts, insulators, switches, meters, etc., should be checked during annual inspections to assure that these facilities are in satisfactory operating condition and ready for service. The depth monitoring equipment is described below.

The power lines and appurtenances are the primary source of power for the SPSs and therefore, should be maintained in the best possible conditions to guard against failure of power supply during flood periods. The transformers, circuit breakers, and other component parts of the switchgear, should be maintained and serviced as prescribed by the manufacturer. Switchgear should be kept in operating condition, including cleaning, by competent maintenance personnel. Equipment should be adjusted or serviced only by skilled mechanics. All electrical equipment, particularly the switchgear, should be kept as dry as possible. It is recommended that arrangements be made with the power company for the inspection of the electrical equipment, power lines, and transformers, and that the date pertaining to the inspection of these items should be added to the inspection report.

Pumps and Motors

Pumps and motors should be maintained and serviced in accordance with the instructions furnished by the manufacturer. These instruction manuals and other pertinent information were furnished at the time of the pump installations, and copies should be kept in the Superintendent's office as well as at each respective SPS. The pumps and motors should be trial operated and parts inspected as outlined under the operating instructions in the section of the manufacturer's manual.

Motors and pumps of different sizes have their own characteristic operating sound when in operation under various conditions. An operator will eventually become accustomed to this sound and should immediately investigate any noticeable change from this normal sound. Cleanliness can increase the efficiency and life of equipment. Moisture, dirt, dust, cobwebs, bugs, or oil causes deterioration and corrosion of mechanical and electrical equipment. Unnecessary oil on surfaces always collects dirt. Cleaning and painting is an important element in preventive maintenance to keep equipment in operation.

Adjustment or replacement of defective parts is a requirement of every preventive maintenance schedule. All the pumps in the SPSs are submersible units with sealed motor and pump assemblies. Disassembling equipment at regularly scheduled intervals by a factory representative, or a mechanic experienced with the equipment being checked, may be necessary for complete inspection.

Testing for proper operation is important. Testing procedures provided by the pump manufacturer(s) may show that equipment is out of adjustment and not capable of full efficient performance. Problems may then be discovered and corrected before a breakdown results.

All the pumps in the SPSs are submersible units with sealed lubrications systems. The manufacturer's recommendations regarding detection of seal leaks, oil spills, and other lubrication problems, should be carefully followed. All lubrication problems should be promptly addressed to reduce the time that an individual pump is out of service.

Heat

Conditions which cause excessive heat in operating equipment must be eliminated. The pump/motor control panels have high temperature warning lights for the bearings and motor windings.

Wet Well Depth Sensing Equipment

Pressure transducers and/or float switches are mounted in the SPS wet wells to sense the depth of water in the wells. The sensors trigger automatic operation of the pumps at the stations as follows in Tables 3A through 3F (note: local river stage refers to the stage at the USGS gage "Grand River at Grand Rapids, Michigan").

Table 3A - Market Avenue SPS
Water Elevation to Initiate Operation

Elevation	Local River Stage	Action (as needed for local drainage)
593.67	10.78	Start Pump No. 1
593.67	10.78	Start Pump No. 2
593.67	10.78	Start Pump No. 3
593.67	10.78	Start Pump No. 4

Table 3B - Wealthy Street SPS
Water Elevation to Initiate Operation

Elevation	Local River Stage	Action (as needed for local drainage)
590.45	8.08	Start Pump No. 1
590.45	8.08	Start Pump No. 2
590.45	8.08	Start Pump No. 3
590.45	8.08	Start Pump No. 4
590.45	8.08	Start Pump No. 5
590.45	8.08	Start Pump No. 6
590.45	8.08	Start Pump No. 7
590.45	8.08	Start Pump No. 8
590.45	8.08	Start Pump No. 9
590.45	8.08	Start Pump No. 10

Table 3C - Front Avenue & Scribner Avenue SPS
Water Elevation to Initiate Operation

Elevation	Local River Stage	Action (as needed for local drainage)
602.00	12.89	Start Pump No. 1
602.00	12.89	Start Pump No. 2
602.00	12.89	Start Pump No. 3
602.00	12.89	Start Pump No. 4
602.00	12.89	Start Pump No. 5
602.00	12.89	Start Pump No. 6

Table 3D - Indian Mill Creek SPS Water Elevation to Initiate Operation		
Elevation	Local River Stage	Action (as needed for local drainage)
610.75	15.71	Start Pump No. 1
610.75	15.71	Start Pump No. 2
610.75	15.71	Start Pump No. 3

Table 3E - Caledonia Street SPS Water Elevation to Initiate Operation		
Elevation	Local River Stage	Action (as needed for local drainage)
610.75	16.97	Start Pump No. 1
610.75	16.97	Start Pump No. 2
610.75	16.97	Start Pump No. 3

Table 3F - Palmer Street SPS Water Elevation to Initiate Operation		
Elevation	Local River Stage	Action (as needed for local drainage)
609.25	12.55	Start Pump No. 1
609.25	12.55	Start Pump No. 2
609.25	12.55	Start Pump No. 3

Repairs

Replacements or repairs of the equipment described herein, as determined by the inspections and tests, should be made by trained personnel in a timely manner. In taking remedial measures during periods of imminent flood, repairmen should bear in mind that use of the station may be required at any time, and therefore, repairs or replacements should be accomplished with the utmost speed without sacrificing quality of workmanship. In addition, contingency plans should be in place in case an SPS needs to be placed into operation before the repairs can be completed.

Trial Tests

Each item of pumping equipment should be trial operated as required herein. Manufacturer's instructions should be followed in testing pumps and equipment. Pumps should only be "bumped" for short periods (less than 15 seconds), rather than running dry. It is suggested that, in these trials, the motors be run consecutively and not concurrently. Procedures for operation during testing will be essentially similar to those described herein for regular station operation. During these trial runs, the inspector should be aware of indications that will give warning of impending failure of equipment.

Inspection and Trial Operation

SPSs should be inspected at least annually and more frequently during off-flood seasons. In addition, all equipment, including switchgear, transformers, motors, pumps, valves, and gates should be trial operated and checked annually. A schedule should be developed by the Superintendent to assure that these inspections take place on the prescribed intervals required. Manufacturer's recommendations for the equipment that should be inspected and the required frequency of inspections, as described in the equipment OM&I Manuals, should be followed. Sample check list and log forms for use in making inspections and trial operations of SPSs and equipment can be found in Appendix 2. The check list forms contain an inventory of tools and spare parts necessary for the operation and maintenance of the stations. Missing parts and tools should be replaced as quickly as possible. Any irregularities or damage should be noted and addressed in a timely manner. A report of any damage noted should be made promptly to the Superintendent.

Records Keeping - Records

Preventive maintenance programs are effective only if careful, accurate, and complete records are kept of all work done. The Superintendent cannot ensure that all personnel are carrying out their individual responsibilities and that all equipment is being properly inspected and maintained, unless careful documentation is maintained.

Inspection Records

The check list forms contained in Appendix 2 of this manual have been prepared with due reference to past experiences on similar projects. In order to maintain an effective preventive maintenance program, a record system should be maintained by the City covering inspection and service for each piece of equipment, as described. These scheduled inspections and inspection records should be maintained in a computer database and contain the following information as a minimum: 1) equipment and description; 2) the various parts of the equipment to be inspected; 3) work to be done (lubrication, adjustment, operation, cleaning, etc.); 4) normal frequency of inspection; and 5) date or dates when the inspections should be made. In addition, it should record: 1) date of actual service; 2) part of the equipment on which the maintenance has been performed; 3) person who performed the work; and 4) type of repairs required.

Operation

At least one SPS operator familiar with the City SPSs should be on duty at the SPS control center WRRF, whenever it appears that pumping operations will be required and remain on duty during the entire period of operation. They should be familiar with the equipment manufacturer's instructions and drawings and with the "Operating Instructions" for each station. The equipment should be monitored for operations in accordance with the "Operating Instructions" and care should be exercised that no overheating, undue vibration, or noise is occurring. Immediately upon final recession of flood waters, the pumping station should be thoroughly cleaned, wet wells flushed, and equipment thoroughly inspected, oiled, and greased. A record or log of SPS operation should be kept for each station, a copy of which should be furnished to the Superintendent following each flood.

Power Failure

Power failures during an emergency can be a cause of considerable damage to areas dependent on SPSs for protection. With this in mind, the City has several portable emergency power generators that can be hauled to the Market Avenue, Indian Mill Creek, Caledonia Street, and Palmer Street SPSs to provide auxiliary power. In order to prevent or minimize damage, the Superintendent should prepare a list of actions in their order of importance, to be followed in case of sudden power interruption that includes the transfer of power source to the generators. This list should be posted prominently in each station

Operation Diagrams

An SPS operation diagram for each SPS should be mounted in a frame and placed in the applicable SPS where it will be readily available. The operation diagram comprises a diagrammatic layout of equipment, description of control equipment, operating instructions, and a list of spare parts and tools required for ordinary maintenance. (Note: tools and spare parts should not be removed for use elsewhere.) The flood stage at which each SPS should be placed in operation is shown on the pump station operation diagram and on the location map.

Operation Log

The SPS operator at the operations center WRRF should keep a complete log of operations for the entire period over which SPS operations are carried out, i.e., from the time of notification that a stormwater pump has turned on until the last stormwater pump ceases operation. The log of operation should include river gage and water level readings at one-hour intervals, a record of all operational and maintenance duties performed, and the exact time of automatic (or manual) starting and stopping for each pump. At times when more than one pump is operating, the river gage and water level readings should be recorded at 15-minute intervals.

Grand River – Rate of Rise – SPS Operation

Sufficient time should be allotted to prepare the SPSs for operation when pumping may be required. It is the responsibility of the Superintendent to keep advised on predicted river stages and of possible additional rainfall, either locally or in areas tributary to the Grand River upstream of the City. This information will enable the Superintendent to make the necessary preparations for the operation of those features of the system for the protection of the area against high river stages in advance of their occurrence. River stage predictions for the Grand River and forecasts of local rainfall are issued by the NWS at Grand Rapids, Michigan, for specific periods. It is suggested that the Superintendent monitor available data from the NOAA Advanced Weather Service Advanced Hydrologic Prediction Service in order to monitor current river levels as well as predicted river levels:

(http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4)

With this information, it will be possible to perform such operations as may be required to keep the SPSs ready for a flood event. The predicted stages are usually available from three to five days in advance. This is sufficient time to allow the Superintendent to make the necessary emergency preparations. Emergency action shall be in coordination with the City's NIMS and Emergency Management Operations organization structure for a flood emergency. The time period required to prepare the SPSs must also allow for the current state of readiness of each of the stations as well as the availability of experienced personnel. It is advisable to prepare the SPSs at least 24 hours in advance of any anticipated operation in order that sufficient time will be available for any required minor repairs. The SPSs should be inspected, trial operated, and made ready for operation at the river stage shown in Table 4.

Table 4 - Order of SPS Preparation

SPS	Local River Stage
Market Avenue	9.78
Wealthy Street	7.08
Front Avenue & Scribner Avenue	11.89
Indian Mill Creek	14.71
Caledonia Street	15.97
Palmer Street	11.55

The flood stage at which the SPS sluice gates should be operated for the diversion of the stormwater for pump ejection is shown on the operation diagram for each station. This operation is based upon stormwater runoff behind the protection works coincidental with high water. If there is no appreciable amount of stormwater runoff during a rapidly rising river, then the sluice gates may be placed in position for SPS operation when the rising river reaches the sluice gate seat elevation in the discharge well. The Superintendent should not conclude that pump operation will not be required. Pumping may be required at any time when the river stage exceeds minimum sump elevation and storm runoff is imminent.

Electric Service

Electricity for the SPSs is furnished by Consumers Energy. The point of contact for this utility is as follows:

Consumers Energy (a subsidiary of CMS Energy)

Principal Office

CMS Energy

One Energy Plaza

Jackson, MI 49201

Non-Emergency Calls: 1-800-477-5050
Emergency Calls: 1-800-477-5050
Email: businesscenter@consumersenergy.com

Pump Operation Precautions

The pumps should not be operated unnecessarily, when the water surface in the sump is below the minimum sump elevation shown on the operation diagrams and above the bottom of the suction bowl. Exceptions may be made during periods when the pumping equipment is being tested in expectation of high water and then only for short-periods of time. The continued operation of the pumps when the impellers are submerged but with the water surface below minimum design sump elevation, may result in excessive vibration and also cavitation of the pump impellers and bowls. Minimum design sump elevation for the SPSs are as follows:

Table 5 - SPS Minimum Sump Elevations

SPS	Minimum Sump Elevation
Market Avenue	587.67
Wealthy Street	589.45
Front Avenue & Scribner Avenue	600.90
Indian Mill Creek	609.67
Caledonia Street	609.67
Palmer Street	608.17

Unless the water surface is above minimum sump elevation, pump tests during routine inspections should be made when the water surface is below the bottom of the suction bell.

Lubrication

Submersible pumps are installed in all the SPSs. These pumps have sealed bearing and motor lubrication systems and do not require external lubrication. Leakage of water into the sealed lubrication system of any pump will set off warning indicators for the pump at the control center WRRF.

Manual Control

Before starting any pump during testing and/or maintenance, be sure that no one is in the discharge well or outfall structure. The pumps are operated from the panels or master control centers at each SPS.

Automatic Control

All the SPSs operate utilizing automatic control of the pumps. Automatic operation is controlled through pressure transducers and/or float switches that sense the depth of water in the wet wells. Each of the pumps in each SPS can be operated manually from the control panel or master control center located at the SPS.

In the event of failure of the automatic controls, the pumps should be controlled manually, and the pump manufacturer should be promptly contacted for repair. Allow a minimum of a 10 second interval between the starting of pump motors within an SPS.

Protective Devices

The motors for all the pumps in all of the SPSs are protected by under voltage relays which close automatically when the voltage returns to normal. Overload and short circuit protection is also provided. The protection is obtained by thermal overload relays and instantaneous overcurrent relays. The following relays are built into the breaker and reset automatically.

- Under-voltage relay
- Overload relay (Thermal overload - motor winding temperature and motor bearing temperature)
- Short-circuit relay (Overcurrent)
- Moisture sensor relay

If the station is on manual control when a breaker trips, the motor can be started again by pushing the reset button on the control panel or master control center.

Electrical Difficulties

It is suggested that in cases of a short circuit or other electrical difficulties arising during emergencies, the aid of Consumers Energy can be enlisted in an effort to locate and correct the cause (see contact information above).

Closing-down SPSs - Inspections

Immediately upon final recession of flood waters, switches, valves, and sluice gates should be restored to their normal settings. The SPSs should then be thoroughly cleaned, pump house sumps flushed, and equipment thoroughly inspected, oiled, and greased. After any flood stage in excess of 12 feet, as measured at the USGS Station 04119000, Grand River at Grand Rapids, Michigan, and at periodic inspections, all parts of the pumps should be checked thoroughly. The pump bowls should be inspected for cracks, pitting, or other damage. The impellers should be checked for damage, pitting, looseness on the shaft, etc. A log of SPS operation, a sample of which is included as Appendix 3, should be furnished to the Superintendent following each flood. It is advisable that a log of operations be filled in for all trial operations of SPSs, to be certain that all inspections and operations are carried out and that a complete record of operations is available for future reference.

Preventive Maintenance

Spare Parts - Availability

In order to be assured of operation of the station equipment when required, it is necessary to carry a stock of certain spare parts, or know where such parts may be obtained quickly as well as the time required to procure them. The Superintendent should obtain a parts list with their order number from the manufacturer so that any part may be obtained in an emergency without harmful delay.

Parts that are kept on-hand should be documented in an inventory system that is maintained in a manner that will allow the Superintendent to assure that sufficient supplies are available. The inventory will serve to remind the Superintendent when ordering additional parts is necessary. The spare parts list on the SPS inspection forms in Appendix 2 should be revised, as necessary, to accurately represent the parts that are on-hand at each SPS.

Care of Structures General

SPSs and applicable structures, such as gate wells, walls, etc., require periodic inspection. SPS sumps that contain seepage should be emptied for such inspections. Masonry structures should be checked for spalling, porosity, cracks, and breaks in expansion joint seals. Wood structural appurtenances should be checked for rot or warping.

Masonry Structures

No large masonry repair job should be undertaken without prior approval of the Superintendent or the City Engineer.

Spalling

When concrete spalling is allowed to continue, progressively greater damage is caused to the structure by the allowance of additional water and increased freeze/thaw action. It should, therefore, be repaired as follows:

- Repair concrete surfaces with appropriate repair and patch materials which permit carrying the patch to a feather edge where necessary. Follow the manufacturer's recommendations for the repair work closely, paying particular attention to surface preparation recommendations.
- Keep concrete from spalling by sealing the surface with appropriate sealer, suitable for contact with water.

Cracks

Cracks in concrete surfaces also lead to serious damage, especially when structures are exposed to heavy freezing. Therefore, it is important that all cracks be repaired immediately when found. Cracks may readily be repaired with appropriate non-shrink repair grouts. The source of the cracks should also be investigated to determine if building settlement, vibration, earthquakes, or unanticipated equipment loads are the root cause, which may require additional structural remediation measures.

Coating of Metals

Periodic painting is required of the parts of SPSs, equipment/materials storage buildings, closure materials, and other structures that require this type of protection in order to protect metal parts from corrosive action of water and other elements. Frequency of painting varies depending on type of coating used, method of application, and conditions of wear. Coat metal surfaces before corrosion becomes so severe that equipment is damaged. Prepare metal surfaces by abrasive blasting or by the method recommended by the coatings manufacturer. Follow the recommendations that pertain to atmospheric conditions during the coatings work, such as humidity and both ambient air and surface temperatures.

Only specially prepared coatings should be used on damp surfaces that will be encountered in the protection works. Corrosion-preventive compounds may be used in moist or wet places and in gate wells where normal coatings would not last. Again, refer to manufacturer's recommendations to determine the proper use of the coatings product.

Care of Valves and Gates

Valves and gates contain moving parts that must be exercised periodically and lubricated to ensure proper operation and to prevent potential corrosion. Excess corrosion could prevent operation of the gate.

Automatic Flap Gates

Automatic flap gates are installed on SPS discharge and SPS bypass stormwater discharge lines that are subject to submergence from river flood waters. The smaller size gates, 12-inches or under, are generally of cast iron and the larger gates are of cast steel. These gates require very little attention other than cleaning and lubrication.

At regular intervals, the hinged parts should be lubricated with grease. Some hinges are provided with fittings, or with openings, whereby they may be lubricated by use of a grease gun. In other cases, it may be necessary to unbolt the pins and remove the links in order to apply grease to the bushings. Disassemble only one side at a time and provide a stable support for the flap while the pins are removed.

- Annually, and more often if necessary, clean all the parts with a wire brush, to remove all dirt and scale.

- Wire-brush the bearing surfaces of the flap and seat and check for continuous contact. If flaps and seat rings do not line up properly, check bushings or hinge pins for excess wear and replace if necessary.
- Paint all steel parts with the proper type of corrosion-resistant paint.

Sluice Gates

Sluice gates are installed at SPSs and on storm sewer lines where manual control of flow is desirable. Their principle of closure is somewhat similar to that of the gate valve. Flood conditions may not require the operation of the sluice gates as frequently as may be necessary to keep them in good working order. These gates should be operated at regular intervals through their complete range of travel or, if flow conditions make this impractical, as close to complete closure as is possible. The stem screws are generally of bronze but steel stems have been installed in some instances. Precautions must be taken that the latter type is kept coated with grease to prevent corrosion. Corrosion may affect the threads so that closure of the gate can be accomplished only with great difficulty. During a flood emergency, considerable damage may result if the gate closure cannot be completed in time.

- Annually clean all the parts with a wire brush removing all dirt and scale. Clean the wedges and the slides thoroughly. Paint all the steel parts with a suitable corrosion-resistant paint.
- Remove all hardened grease and replace it with proper grade and type grease. Examine the grease box in two-speed floor stands especially for hardened grease and repack when necessary. Grease the slides and wedges of the gates thoroughly to facilitate ease of operation. Use non-hardening grease.
- Check and adjust the wedges so that, when the gate is in a closed position, each wedge will apply uniform pressure against the gate and cause the gate to bear against all points on the gate seat. Proper wedge adjustment must be particularly provided for sluice gates installed for unseating pressures.

Lubrication

Lubrication is an important part of preventive maintenance. The types of equipment and the conditions under which they operate make proper and regular lubrication practices extremely important. Proper lubrication prevents metal-to-metal contact, eliminates wear, and reduces corrosion. Improper lubrication causes damage to wearing surfaces, increases maintenance costs and power consumption, and results in power failure. Always keep machinery, including valves, wiped clean of oil. Investigate and correct oil leaks. Oil should be changed whenever there is any sign of contamination, stickiness or gumming. Most of the pumping equipment in the SPSs does not require lubrication other than that performed as a part of a regular inspection by the equipment manufacturer(s).

Lubrication instructions given herein include recommended types and intervals for certain equipment. However, these are to be considered only as guides and may require modification. The manufacturer's instructions, or the manufacturer, should be consulted and the advice of oil companies sought to determine the types of lubricants to be used on all equipment. Lubricated mechanisms generate heat which reduces the viscosity of the lubricant. Knowledge of temperatures to be encountered is necessary to enable the oil companies to correctly determine whether the proper grades of lubricants are being used. The maximum temperatures at the points of lubrication should be determined with the aid of a thermometer when the equipment has been operated under load for any length of time.

Condensation

It may seem proper that as long as the correct amount of oil or grease is in a bearing, and no noise or heat is noticeable, that the machine would operate indefinitely. This, however, is not true as the SPSs are usually damp and condensation is present. Should the lubricating film break down, the presence of moisture could lead to corrosion of the metal surface.

Lubricant Deterioration

The principal deteriorating elements in lubricants are dirt, water, oxidation, and excessive heat. If these are controlled, lubricant deterioration between lubrication periods is less likely. Guard against dust, grit, and abrasives getting into containers used for storing lubricants. Wipe spouts and lips clean before using container; wipe fittings clean before filling with lubricant.

Pumping Equipment

The pumps installed in the six SPSs are all vertical submersible type. Their reliability during flood events is of major importance. Pumping equipment operates with little trouble if it receives proper preventive care. The City contracts out most of the annual pump maintenance. The matter of keeping necessary records and following the rules pointed out above, with reference to motors, are just as applicable to pumps. Manuals for each SPS that include troubleshooting procedures, can be found in each of the SPSs. The operator should familiarize themselves with these manuals prior to a flood event that requires SPS operation.

Pump and Motor Alignment

The submersible pumps used at all SPSs have the pump and motor within the sealed pump casing. Check the alignment of the pump and motor when bearing or motor warning lights are lit on the pump control panel or when excessive vibration occurs. If misalignment should recur frequently, the pump manufacturer's representative should be contacted for service and the pump taken off line until service is performed.

Bowls, Water Passage, and Impellers

Look for pitting, wear and corrosion on bowls, water passages, and impellers. Corrosive water affects performance and dependability of the pump. If pitting occurs only in the lower sections of the pump (bowl and impeller), cavitation may be taking place. Cavitation may result from operating the pump when the level of the water in the sump is too low. Cavitation causes severe pitting and a characteristic spongy appearance in the metal. It generally affects the entrance portion of the impeller, though it may also occur in the casing. Pumps may be operated for dry test runs when the sump water is below the intake of the suction ball.

Power Consumption

An indication of either electrical or mechanical difficulties may be determined by comparing ammeter and voltmeter readings for each motor during no load test runs with past records for similar conditions. A noticeable increase in the ammeter reading with a normal voltage indicates an undesirable condition, which should be traced. Under full load, the current demand should not exceed that shown on the data plate of the motor. A check may be made on the pump and motor unit operating efficiency, when no ammeter is in the line to the motor. Watt-hour meters are installed at all stations for recording the electrical energy consumed in operating the station. When electrical energy is being used in the station, the horizontal disc in the meter rotates. The speed with which it rotates is dependent on the amount of current being consumed. Some specific number of revolutions for two minutes should be counted and the nearest even figure (such as 50, 60, or 75, etc.) be adopted. All switches drawing electrical energy through the meter, except the pump unit being tested, should be in the open position when making such a test. The figure adopted should then be timed to the nearest second. All future readings can then be compared with past records by checking the time for this same number of revolutions under no load (or identical) conditions. Any appreciable variation in the time will indicate some difficulty in the motor or pump and should be investigated.

Disassembling and Inspecting Pump

The pump and motor for all of the submersible pumps are sealed units. The frequency of completely disassembling the pump for a thorough inspection will be dependent on local conditions and manufacturer's recommendations. It is cautioned that such inspections should not be deferred for long periods, as costly breakdowns may result at a most critical time. These inspections should only be made by a manufacturer authorized service technician.

Pump Lubrication

The lubrication system for the pumps in all SPSs is sealed within the submersible pump casing. The lubricant should be replaced during normal servicing by the manufacturer authorized service technician.

Pump Bearings

All of the SPSs have submersible pumps with sealed motors and bearings. The lubricants in these sealed units must be changed on occasion as instructed in the manufacturer's OM&I Manual. Bearing temperatures should be checked if there is any indication that they are overheating or are not running smoothly. After a pump has been in operation long enough for the bearings to be at normal temperatures, the control panel should be regularly checked to see if any bearing or motor winding temperature warning light is on. Should the bearing or motor winding temperature warning light on the control panel turn on for any pump, the operating conditions should be investigated in consultation with the pump manufacturer. An overheated pump should be shut down and an alternate pump turned on.

The lubrication of bearings is of the utmost importance in the efficient operation of any pump or motor, regardless of the size. The lubrication of bearings should follow the manufacturer's recommendations regarding inspection, pump removal and disassembly, cleaning of bearings and motor, proper type and grade of oil, lubrication of bearings, installation and inspection of seals, pump reassembly and installation. It may be necessary to retain the services of the manufacturer or a qualified pump servicing company to perform lubrication of the submersible pumps.

Electrical System

Where electrical equipment is to be handled or where contact is possible during inspection, the equipment must be de-energized and effectively grounded. A grounding harness should be applied where applicable.

Switchgear Equipment

A test check and inspection should be made of switchgear equipment at all regular inspections. A thorough general check and inspection should be made at least once every year. Switchgear equipment includes all component parts of the switchboard itself and all auxiliary equipment. This equipment consists of switchboard panels, instruments and meters, control and transfer switches, indicating lamps, test blocks, wiring and insulation, bus bars, draw-out devices, switches, relays, circuit breakers, and lighting transformers. Circuit breakers and transformers are discussed elsewhere in this section.

- The switchboard and component parts should be cleaned regularly. This should be done preferably with a vacuum cleaner having an insulated nozzle. Check the general condition of all parts. See that all covers are in place and in good condition, that there are no broken parts and no loose or missing screws and nuts. Metal-enclosed switchgear should be opened at intervals and all internal parts inspected for surface cleanliness. Any accumulated dust should be removed and all insulators carefully cleaned. These precautions are especially necessary if the equipment is located where metallic dust, cement dust, fine powder dust, salt spray, or acid fumes are present.

- Instruments and motors should be examined to see that all are in good condition, are registering properly, and have no broken or cracked glass, or damaged cases. Voltmeters, ammeters, and watt-hour meters should be tested and calibrated if necessary.
- The operation and control and instrument transfer switches should be checked, and the contacts of all switches inspected. Damaged parts should be repaired or replaced. The inspection should also include the operation of the controlled device.
- All indicating lamps should be examined and weak or burned out lamps replaced. The operation test of controlled devices should include checking of the proper indication by the lamps of the "open position" (green light) and "closed position" (red light).
- Test blocks should be examined to see that the contacts are in good condition and that there are no loose connections.
- Bus bars and connections should be examined. If they appear to be overheating, the cause of overheating should be found and corrected. If due to poor or loose connections (loose bolts and nuts in the bolted joints), these should be tightened. Where joints are badly overheated, it may be advisable to dismount them, clean the surfaces and reassemble them, making sure that all nuts are properly tightened. Should oxidation reoccur at an electrical joint after having been cleaned of oxide formation, it is advisable to cover such parts with a protective coating of a non-corrective lubricant (Vaseline, sloughing compound, or the like). "Cup" grease or other grease which hardens on exposure to air, should not be used.

Motors

The pump motors are all sealed within the casings of the submersible pumps. The pump motors should be maintained as recommended by the pump manufacturer's OM&I Manual. Only manufacturer authorized service technicians should perform maintenance on the pump motors.

If warning lights are lit for any of the following conditions on the individual pump control panel, the pump should be shut down and a manufacturer authorized service technician called to determine the cause of the problem and the maintenance required.

Market Avenue SPS Warning Lights

- High Motor Winding Temperature (each pump and sump pump)
- Pump Seal Leak (each pump and sump pump)
- Wet Well Level High

Wealthy Street SPS Warning Lights

- Trouble (each pump, sump pump, and flow channel pump)
- Low Wet Well Level
- High Water Alarm

Front Avenue & Scribner Avenue SPS Warning Lights

- Trouble (each pump and sump pump)
- Low Wet Well Level
- High Water Alarm
- High River Level

Indian Mill Creek, Caledonia Street, and Palmer Street SPSs Warning Lights

- Temp/Seal Failure (each pump and sump pump)
- Wet Well Level Alarm

The pump should not be returned to service until the cause of the problem is diagnosed and corrected. A regular system of inspection will tend to make motor operation more reliable. In order to facilitate locating the cause of forced shut-downs of pump motors, it is advisable to keep records of all troubles and cures of chronic cases. The most dependable motor service with a longer period of motor life can be provided by adhering to the following rules: (1) keep a regular inspection schedule; (2) know the condition of the apparatus at all times; (3) correct any indication of weakness before the motor fails; (4) motor repairs should be made only by a competent technician.

Lighting System

Maintenance of the SPS interior and exterior lighting systems in good condition is an important factor in preventing accidents. Lighting reflectors should be kept clean and lamps replaced when burned out. All wiring should be maintained free of conditions conductive to damage or faulty operation of the system.

SPS Power Transformers

As compared with most electric apparatus, transformers require relatively little attention. The extent of the inspection and maintenance required is governed by the importance of instantaneously available and continuous service, operating conditions, such as ambient temperature, unusually dirty atmosphere, and heavy fogs. In flood protection project installations, availability of immediate and continuous service is of utmost importance and a greater degree of attention is justified than would ordinarily be given where life and property were not endangered by a power failure. It is suggested that Consumers Energy be engaged to make all inspections on the SPS power transformers, other than visual, and to perform all maintenance work on them as well as on the fused disconnect switches. Transformers mounted in the open and exposed to the atmosphere are provided with weatherproof casings.

Control Panel and Lighting Transformers - Dry-Type

Dry-type transformers are generally used for the control panel and lighting circuits and are located inside the SPSs. If dust is found on a transformer, blow off with clean, dry, compressed air. A dust coating acts as an insulator and prevents the transformer from cooling properly. Do not block air circulation around any transformer.

Fused Disconnect Switches

Fused disconnect switches are installed on the incoming power transmission lines at the transformers and are used to protect the transformers from excessive overload. They are of the knife-switch variety and carry cartridge-type fuses. The disconnect switches are used to open the live lines when the SPS is out of operation; otherwise current will be consumed by the transformers. The disconnect switches should only be operated when the switches in the SPS are in the open position. These switches require very little maintenance. They should be inspected during the time that Consumers Energy inspects the transformers. Inspection consists of examining the contacts, insulators, mountings, and operating mechanism.

The contact surfaces should be cleaned when necessary. This may be done by opening and closing the switch several times in succession. If required, and with full care being taken to keep the amount of metal removed to a minimum, the contact surfaces may be rubbed very lightly with very fine sandpaper. Removing too much metal results in poor contact and overheating. The condition of contact can be checked by attempting to insert a 0.002-inch feeler gage between the blade and the contact at all accessible joints. If the gage can be inserted, adjustment should be made. In replacing fuses, use the size and type that will furnish adequate protection for the transformer. Be sure that the surfaces of insulators are clean.

Circuit Breakers, Knife Switches, Fuses, Insulators, and Relays

Circuit breakers, knife switches, fuses, insulators, and relays perform the purpose of protecting the SPS electrical equipment and pump motors. Circuit breakers are intended to open a circuit, thus stopping the flow of current, should the current exceed a predetermined rate through these safety devices. Knife switches manually open a circuit to de-energize equipment for repair, testing, or maintenance.

Circuit breakers, knife switches, fuses, insulators, and relays must be given proper care and maintenance. Quite often trouble is forestalled by tightening a wire or switch, replacing spring cotter pins, readjusting and cleaning contacts, keeping latches free of corrosion, etc., when regular periodic inspections are made. The frequency of complete inspection depends a great deal on ambient conditions, but, in general, a complete inspection should be made at least once a year, preferably just before the flood season. An inspection should always be made immediately when it is determined that the circuit breaker has been opened by a severe short circuit. Inspections should only be made by a qualified electrician.

Lightning Arresters

Low-resistance arresters to grounds have been installed on equipment where necessary to secure effective protection from lighting or voltage surges. Annual inspections should include the following:

- Check for loose line and ground connections. Be sure all electrical connections are clean and tight and make good electrical contact.
- Examine housing for chipping, shattering, cracks, or other damage, and for loose bolts on assembly or mounting hardware.
- Make sure ground connections are continuous and securely fastened to grounding rods.
- To prevent external flashovers, maintain some clearance between line terminal and grounded structures, hardware, line conductors, vegetation, etc., as between line conductors on the original installation. Keep external surfaces of arresters clean to prevent flashovers, especially where circuits carry 5,000 volts or more.

Bushings and Insulators

Bushings at transformer installations ordinarily require little, if any, attention. Maintenance is ordinarily limited to cleaning. The frequency of this operation depends on the prevalence of cement or metallic dust, salt spray, or acid fumes in the atmosphere.

- The same measures should be taken for the porcelain sections of the bushings and insulators as for the lightning arresters. Dirt deposits under moist conditions tend to form a conductive coating and should be cleaned off to prevent flashover. Check visually for cracked or broken porcelain. The porcelain transformer bushings should be tested with special testing equipment similar to that used by Consumers Energy.
- Clean bushings and insulators as required by local conditions. This operation should be performed by Consumers Energy on hot lines.

Grounds

Ground resistance to all equipment should be tested occasionally. See that transformer tank, outdoor switchgear housing, operating levers, lightning arresters, and metal fencing (around ground level substation) are properly connected to grounds. Ground resistance should not exceed 15 ohms for driven grounds. Test for accidental grounds on ungrounded equipment. Grounds can best be tested with equipment similar to that used by Consumers Energy.

Cable and Wire

Periodic inspection of cable and wire is the best method of preventing failure. Such inspections should be made for poor thermal conditions and potential danger spots. Exterior wiring should be noted for tension between anchor points which might be off-standard. Wires which are too slack or too tight should be adjusted to proper tension. If cables appear to be carrying excessive temperature, determine the cable temperature by attaching a suitable thermometer to the cable surface. Check with Consumers Energy for proper temperature for cable size and amperage load. Overheating can be caused by overloads or the presence of external sources of heat and will dry and harden the insulation. This in turn either increases the dielectric losses or produces cracks in the insulation and thus hastens ultimate failure. Oil on rubber insulated cables will cause swelling and softening of rubber.

Trees near overhead lines are a potential source of trouble because they may break and blow across wires during a storm. The limbs may break wires or cause a short circuit. To avoid these type of power interruptions, trees should be trimmed as necessary. For limbs less than 3-inches in diameter, allow at least 8-feet of overhang clearance, at least 4-feet of side clearance, and at least 3-feet of underneath clearance. Perform heavy pruning and heading the back of old trees in late fall or during winter when trees are dormant. Trim new growth soon after the spring growing period.

Poles and Appurtenances

Poles require very little maintenance which is generally limited to replacement when they show signs of rotting. Poles, cross arms, pins, bolts, braces, guys, anchors, and insulators should be inspected and repaired/replaced by Consumers Energy.

Depth Sending Pressure Transducers

The operation of pumps is automatically triggered by the water depth in the wet wells of each SPS. This level is monitored by pressure transducers that are connected to the Wet Well Level Transducer Panels inside each SPS. The pumps are placed in operation based on the readings on the Wet Well Level Transducer Panel. This equipment should be inspected and checked to insure the readings are accurate. The transducer should be cleaned periodically. Accumulation of grease, oil, or debris can result in inaccurate readings.

Mobile Pumps

General

All low areas, in all reaches, are served by storm water collection systems discharging directly to the Grand River. Where needed stormwater pump stations exist to keep interior flooding to a depth of less than 12-inches on average during extreme events. Isolated short duration ponding, averaging less than 12-inches in depth, may occur in some areas during extreme rainfall events. These areas (streets) are listed later in this report. If necessary, the City will close these streets to traffic until the water has receded or pump the water from the streets. Provided in Table 6 is a list of mobile pumps that the City has available to address shallow ponding.

Table 6 – Mobile Pumps Available to Localized Flooding

Equipment Description	Quantity on Hand	Max. Discharge per Pump* (cfs)
4" Gorman-Rupp Trash Pump	1	1.58
6" Gorman-Rupp Trash Pump	2	3.45
4" Godwin Trash Pump	1	1.96
6" Godwin Trash Pump	1	4.41
6" Godwin High Head Trash Pump	1	4.51
6" Flygt Submersible Sewage Pump	1	5.35

*Assumes static lift = 10 feet.

The pumps are all stored and maintained at the WRRF.

Maintenance and Inspection

Each mobile pump trailer should be inspected annually to confirm full tire inflation, operating tail and turn signal lights, an operational trailer hitch, and overall condition of the trailer frame. Any problems with the pump trailer should be corrected immediately.

The pump engine oil should be changed annually and the used-oil recycled. The pumps should be lubricated in accordance with manufacturer's recommendations. At least 2 times a year, each pump should be tested to confirm successful motor startup, pump self-priming, and smooth operation. For the pump tests, the pumps should draw water from and discharge it back to the Grand River. Any problems with pump operation should be resolved immediately in accordance with manufacturer's recommendations.

Operation

When the river stage at the USGS gage (station no. 0419000) reaches 21 feet and the flood stage hydrograph shown on the National Weather Service (NWS) *Advanced Hydrologic Prediction Service* internet web site (found at http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4) predicts a continuing rise in the flood stage, the mobile pumps shall be moved from their storage location at the WRRF and staged throughout the City as shown in Table 7.

Table 7 Mobile Pump Staging Locations
Parking Lot, southwest corner of Monroe Avenue and Sixth Street intersection
Fulton & Market Parking Lot, southwest corner of Market Avenue and Fulton Street intersection
Southwest parking lot at DeltaPlex Arena on West River Drive NE at Turner Avenue intersection in Walker (coordinate with Walker City Manager)
Kent County Road Commission work yard on Scribner Avenue

When the water depth at each local flood location approaches 9 inches and rising, the mobile pump staged nearby should be moved to the flood location, local traffic should be diverted if necessary, and the pump set-up to begin pumping. The water would be pumped directly to the river or to an adjacent storm water drainage system capable of handling the increased discharge. Pumping should continue until it is clear to the pump operator that water levels in the flooded area are decreasing and will not rise when the pump is turned off. Once the pumping ceases, the mobile pump should be returned to the WRRF for cleaning and storage.

Miscellaneous Facilities

Maintenance

Miscellaneous structures and facilities constructed as a part of the protective works and other structures and facilities which function as a part of, or affect the efficient functioning of the protective works, should be periodically inspected by the Superintendent and appropriate maintenance measures taken. Areas used for ponding in connection with SPSs, or for temporary storage of interior runoff during flood periods, should not be allowed to become filled with silt, debris, or dumped material.

Under the classification of miscellaneous facilities are the ponding areas utilized for storage of large runoff quantities, submerged storage tanks that could float as a result of high groundwater levels, and structures that could be flooded including:

- WRRF underground storage tanks
- Market Avenue SPS discharge control sluice gates (2 gates)
- Garfield Avenue at Westside Ditch discharge control sluice gate (1 gate)
- WWRF primary effluent retention basin
- WRRF stormwater and sanitary sewer valves in manholes in earth dike
- West end of Elmdale Street at river
- Intersection of Crosby Street, NW, and Turner Avenue, NW
- Eastside interceptor sanitary sewer along east bank of river
- Stormwater junction chamber in grassed cloverleaf area, approximately 30-feet west of the west curb line of Market Avenue, south of U.S. Route 131 north bound exit ramp (east bank of river)
- Intersection of Crosby Street, NW, and Scribner Avenue, NW
- Elmdale Street sanitary lift station
- Southeast interceptor sanitary sewer outflow chamber sluice gate at Market Avenue Bridge (1 gate)
- Fulton Street /Monroe Street, NW/Market Avenue, SW, intersection
- Wealthy Street SPS
- Intersection of Jenette Avenue, NW, and Sylvia Street, NW
- Intersection of Tenth Street, NW, and Front Avenue, NW
- Myrtle Street, NW, extension at Scribner Avenue, NW
- City Market Avenue property
- Riverfront building low-level windows
- Forslund Building basement
- Convention Center underground parking garage
- Convention Center entrance doors

Ponding Areas

The ponding areas used for temporary storage of interior runoff will ordinarily require little attention during flood periods other than the taking of usual precautions to block roads that might be cut off in extreme cases. Storm drain inlets should be kept clear of debris so that water will drain when the Grand River water level recedes. Water should be pumped from the following intersections to the river using portable pumps, if necessary:

- Intersection of Tenth Street, NW, and Front Avenue, NW
- Myrtle Street, NW, extension at Scribner Avenue, NW
- Wealthy Street, SW, and Market Avenue, SW
- Market Avenue, SW, between U.S. Route 131 and Fulton Street

- Fulton Street between the parking lot on the southwest corner of the Fulton Street/Market Avenue intersection and Ottawa Avenue, SW
- Campeau Avenue, NW, between the walkway leading to the Blue Pedestrian Bridge and Pearl Street, NW
- Monroe Avenue, NW, between Frank Street, NW, and the railroad crossing south of Sweet Street, NW
- Monroe Avenue, NW, at the intersection of Palmer Street, NW

WRRF Submerged Storage Tanks and Primary Effluent Retention Pond

Underground storage tanks and the bottom of the primary effluent retention pond at the WRRF could float if they are not partially filled during a flood event that causes the groundwater levels to rise. The groundwater level around the tanks and primary effluent retention pond should be checked at regular intervals during a flood event. As needed, the tanks should be filled with water to prevent tank floating. The primary effluent retention pond should be filled to the same level as the Grand River (refer to the WRRF O&M Manual for guidance).

SPS Flooding

The Wealthy Street SPS and the Elmdale Street sanitary pump station are subject to overland flooding during large flood events. At the Wealthy Street SPS, sandbags should be placed around the perimeter of the control building to protect electrical equipment. At the Elmdale Lift Station, flood water levels could exceed the top of the wet well elevation. In this case, the lift station pumps should be turned off. Homes with floor drains that flow to the lift station will be flooded when the top of the wet well elevation is exceeded by the flood elevation.

Sanitary Sewers

The Eastside Interceptor sanitary sewer could float when the Grand River rises to flood stage. Operations of the Market Avenue Pump Station and Market Avenue Retention Basin should be adjusted as necessary to maintain a water level in the sewer no lower than 15-feet below the Grand River level.

Operation

Miscellaneous facilities should be operated to prevent or reduce flooding during periods of high water. Those facilities constructed (or utilized) as a part of the protective works should not be used for purposes other than flood protection without approval of the Superintendent.

Special O&M During High Water Periods

General

This section of the manual is supplementary in nature and describes standard practices that have been used to advantage on levees and floodwalls during high-water emergencies. Most of the methods described herein have been developed during years of experience with the various problems that arise during periods of high water, but they are not intended to restrict the Superintendent, or others concerned, to a rigid set of rules for every possible circumstance. In all cases, the Superintendent should follow standard engineering practices in meeting emergency situations.

Earth Embankment (Levee) and Floodwall System

The earth embankment and floodwall system may be subjected to certain dangers during flood periods from current, ice, debris, or wave action. These dangers diminish with the degree of maintenance that the earth embankment system receives during normal river stages. Properly constructed earth embankments (levees) and floodwalls, if adequately maintained, should withstand any major flood. However, certain unexpected conditions that arise during floods and threaten the earth embankment (levee) system may be met with assurance if prompt action is taken and proper methods of treatment are used. Measures to cope with sand boils, seepage, sloughs, wave wash, ice impact or jams, scour, and possible overtopping of neglected low spots in the earth embankments (levees) and floodwalls, are described herein. Prompt and adequate maintenance will result in minimizing the necessity for such measures during high water periods.

Preparedness

It will be noted in the following paragraphs that various materials and equipment are required to combat such unforeseen conditions as may arise during a flood emergency. It is imperative to know in advance just where such materials and equipment may be secured in emergencies, even though such emergencies may never arise. A definite plan should be prepared by the Superintendent that will enable him to foresee just what materials he will need, where they may be obtained in time for use, what manpower and transportation will be needed, what routes will be open at particular river stages, etc. This information will be particularly vital as the possibility of earth embankment (levee) and/or floodwall overtopping is approached. Such a plan, once formed, must be checked prior to each flood season since the sources of material supply could very likely change during the year. The essential element in a flood emergency is time, therefore local interests should give early attention to the preparation of a list of sources from which the necessary labor, lumber, hardware, sandbags, suitable earth for sacking, equipment, etc., can readily be secured to cover any contingency. Such items should be provided as rapidly as is possible when the need arises.

Materials

For all practical purposes, the materials of consequence used during flood emergencies are:

- Sandbags
- Lumber (rough, common pine)
- Sacked or loose earth
- Plastic tarps/sheets
- Wire (No. 9) and nails

A reserve supply of emergency materials should be kept on hand or be immediately available through arrangements with local suppliers or manufacturers. The principal consideration in obtaining lumber and other materials for emergency construction is their availability. Stored materials subject to damage or deterioration should be checked, and damaged portions replaced, before the start of each high water season.

Sacked Earth or Loose Earth

Sacks filled with earth can be used in almost every phase of emergency high water work. It may best be used when the point of placement is readily accessible by truck. It is advisable to use sacked earth under other conditions. Sacks should be filled about two-thirds full, with the material shaken down into the sack loosely (never tamped). Sacks need not be tied or sewn together at the top if used for capping or on the land side of the earth embankment (levee). Earth-filled sacks used for wave wash, or as weights, should be filled and the ends tied. Sand should be used only if earth is not available, or if the time element is an important factor as in the distance required for hauling. In some cases, it may be better to fill sacks elsewhere and haul them to the site.

Sandbags

The term "sandbags" as used in flood emergency construction might to be considered a misnomer in that the bags are ordinarily filled with earth. Sand is used only when they are used as weights or when earth availability is a problem. An adequate initial supply of sandbags should be maintained to make all necessary sandbag closures. Bags must be checked annually to detect any deterioration. They should be stored in a dry location where there is free passage of air around them to prevent spontaneous combustion. Any bags that are damp, wet, or oily, should not be returned to storage with the main supply. Sacks used for sandbags are mildew treated burlap or ultraviolet light-resistant polypropylene. When they are two-thirds full, they hold about one-third cubic foot of earth. Any type and suitable size sack can be used if burlap or polypropylene is not available.

Earth

The most suitable type of earth to be used for flood emergency construction is a silty loam or a silty clay loam; however, almost any available soil can be used with plastic tarps/sheets to provide a water proof barrier or liner.

Preliminary Preparations

The City should have a trained organization of Supervisors, who may readily be assembled by the Superintendent immediately upon receipt of information that a Grand River flood stage > 12' is forecast. Each Supervisor should have charge of a definite section of levee, floodwall, or structures that may be endangered, or the operation of which is essential during high water. This organization should be capable of quick expansion so that each Supervisor will have sufficient personnel to carry out his function. As his/her initial activity, each supervisor should go over his/her entire sector, and part of adjacent sectors, making a detailed inspection, particularly with reference to the following matters:

- Sector limits; ascertain that the dividing line between sectors is plainly determined and, if necessary, marked
- Condition of earth embankments (levees) and floodwalls and recent repairs
- Condition of drainage structures
- Transportation facilities; roads, rail, and traffic/rail control signals
- Material supply; quantity, location, and condition
- Communications; locate and inspect all available telephones in the sector that may be needed

Initial Work

After initial inspection, the Supervisor should perform the following work immediately where required. To accomplish such work he/she should have organized labor and obtained the supplies and equipment as may be necessary.

- Where new earth embankment (levee) construction has been performed on the riverside of earth embankment (levee), preparation should be made in advance to combat wave wash by facing with sandbags.
- Inspect all flap gates and sluice gates, before the seats are submerged, to ascertain that they are clear of obstructions and will seat properly.

- Ascertain that all roads to and along the earth embankments (levees) and floodwalls are in good condition. The Superintendent should obtain the assistance of the local road forces to have all necessary roads put in usable condition. The Superintendent should be informed at all times of all roads in the vicinity that are closed for repair. An up-to-date route layout should be available at all times showing routes over which any and all types and weights of equipment can be sent to any point in the protection system.
- Locate necessary tools and materials (sacks, sandbags, lumber, lights, etc.), and distribute and store them at points where active maintenance is anticipated.
- Check and obtain repair of all telephones necessary for operation; obtain lists of all team forces, bus, automobile, and truck transportation that can be made available.
- Make thorough arrangements with reliable citizens of the community for supply, transportation, subsistence, and shelter for the necessary labor.
- Investigate all drainage ditches on the landside of the earth embankments (levees) and floodwalls and open these drains when obstructions exist.
- Remove all explosives of any kind from the vicinity of the earth embankments (levees) and floodwalls.

Methods of Treatment – General

After the above preliminary organizations and precautions have been completed, the various methods of combating possible flood emergencies are ready to be employed. Temporary treatment of emergency situations is described in the following paragraphs.

Seepage - Earth Embankments (Levees)

Seepage emerging from the slope, or at the landside toe of an earth (levee) embankment, can cause sloughing of the slope or even lead to piping (internal erosion) of fine sand or silt material. In many cases, high water stages do not act against the earth embankment (levee) long enough for this to happen, but the possibility of the combination of high water and a period of heavy precipitation may bring this about. In order to prevent sloughing where the slope is deeply saturated, small V-shaped drains should be cut in the landside slope to remove the seepage water. If the earth embankment (levee) should become saturated over a relatively large area, it may become necessary to take the measures outlined below to prevent sloughing.

Slope Drainage - Earth Embankments (Levees)

Drainage of the slope should be provided at all places on the landside of the earth embankment (levee) where seepage appears. The drains should be V-shaped, no deeper than necessary, and never more than 6-inches deep. The sod should not be cut unnecessarily. In all instances, drains should be cut straight down the earth embankment (levee) slope. Where possible near the toe of the slope, the small drains should be Y'd together and lead into large drains which lead to ponding areas or SPSs.

Sloughing - Earth Embankments (Levees)

Sloughing is the slipping, or flowing out of position, or the landside slope of an earth embankment (levee), due to being saturated through seepage to the point where that part of the earth embankment (levee) becomes unstable. Reaches in the earth embankment (levee), where the material is of such nature that prolonged high stages may cause sloughing, should be thoroughly drained as described above. After this operation, a single layer of willow brush, if obtainable, or any small trees or limbs, should be laid up and down the slope, butts upward and tops downward, and weighted with earth-fill sacks. If the slope begins to slough down, a log or heavy timber should be laid on top of the willows at the toe of the material sloughed off and fastened to long stakes which have been driven several feet into the ground. A buttress of earth filled sacks should then be built at the toe and extended up the slope. The buttress at the toe should be built in the shape of a small berm. Sandbags or weights

should not be placed more than two-thirds of the distance from the toe of the material sloughed off to the bottom of the slough. See Figure 2.

Sand Boils - Earth Embankments (Levees) and Floodwalls

A sand boil is a definite stream of seepage water issuing from the earth, usually near the landside toe of an earth embankment (levee) or floodwall. The source of this water is usually from pervious materials underlying the earth embankment (levee) or floodwall. Sand boils are serious in any location and should be watched closely, especially when within 100-feet of the earth embankment (levee) toe or floodwall. A sand boil which discharges clear water in a small steady flow, is ordinarily not a serious threat to the safety of the earth embankment (levee) or floodwall, and need not be ringed. However, if the flow increases or carries a substantial load of sand and silt, corrective action should be taken immediately to prevent possible earth embankment (levee) or floodwall failure. A neglected sand boil may gradually undermine an earth embankment (levee) or floodwall and cause failure by subsidence of the levee.

The accepted method of treating a sand boil is to construct a water tight ring of sand bags around the boil, high enough to create a head of water within the ring sufficient to reduce the velocity of flow. See Figure 3. The ring should not be built to a height which stops the flow of water completely. The sacks are filled about two-thirds full of earth, and are laid flat in a ring around the boil with the joints staggered, each layer being placed in alternate directions. The sacks should be lapped at least one-third. The ends are left untied, and are lapped under the sacks. Each complete layer should be tramped or tamped into place after placement. The base width of the ring should be not less than one and one-half times, and preferably twice, the contemplated height. A drain is provided by omitting one bag in the top layer, or by constructing a V-shaped drain of two boards or a piece of sheet metal inserted near the top of the ring.

If ground weakness is indicated close to the sand boil, it is well to include the weak ground within the ring, thereby avoiding the possibility of a breakthrough later. Several sand boils within a relatively small radius should be enclosed as a group in a sub-levee or single sack ring. Sand boils at the toe of the levee or floodwall are sacked in the same manner as those away from the earth embankment (levee) or floodwall, and in the case of an earth embankment (levee), using the earth embankment (levee) slope as one side of the closure.

Sandbags, Cotton Bagging, or Plastic Sheeting

Sections of cotton bagging or plastic sheeting should be placed over the washed areas as shown on Figure 4. If the washed area is considerable, or protection is desired to a predicted higher stage, the bagging may be cut into lengths and laid up and down the slope to cover the area. The strips should be lapped with the current to prevent lifting. See Figure 5. Bagging must be thoroughly weighted down with stone or sandbags to be effective. In using this method, stakes should be driven through the bagging approximately 6-feet apart below the water surface and at the top of protection, to be sure that the bagging is being held in place. As an alternative, sacked earth material may be used as a means to fill small washed areas or holes. The sacks should be placed close together beginning about 2-feet under the water surface. Each succeeding row of sacks should overlap the preceding row like shingles on a roof. The joints should be staggered. All holes should be filled with sufficient sacked earth to meet the original grade line. All sacks should be tamped into place so that wave action will not readily wash them away.

Log Boom

If sacking for the prevention of washes caused by floating ice cannot be placed or used effectively, it is desirable to make a log boom of any available large timbers to deflect ice from the embankment. The logs should be fastened together with steel staples and coil chain, or heavy wire, with a distance of about 12-inches between end faces. The staples at each end of the log should be driven on a line parallel to the axis of the log, and should be allowed to protrude sufficiently to permit enough room for rotation of the logs. Wire or chain should be

passed or wrapped around the logs as staples may pull out. The boom should be strung along the levee slope and anchored about 15-feet out from the water's edge by means of logs or timbers, spaced not more than 50-feet apart, tied to stakes near the shore line. See Figure 6. The booms should also be anchored to the slope approximately every 200-feet, or as conditions may require, with cables placed at angles of about 45 degrees. Additional stakes can be driven up the levee slope in anticipation of a rising river, and the anchor logs and cable ties adjusted as required. This method of protection is particularly effective against ice flows.

Scour

Current scour, or erosion of the riverside slope of the levee or along the floodwall footing, is caused by abnormally high current velocities. Conditions which cause scouring may be detected by the appearance of eddies and general turbulence of the water. Immediate steps should be taken to protect the levee when current scour appears.

Overtopping - Earth Embankment (Levee)

Overtopping, or the flow of water over the earth embankment (levee) crown, is a serious threat to the stability of the earth embankment (levee). The danger from overtopping and the necessity for preventive action cannot be over-emphasized. It is very difficult, if not impossible, to close a breach in an earth embankment (levee) after the substantial amount of material has been washed out. The various methods of increasing the height of the earth embankment (levee) to prevent overtopping are described in the following paragraphs. The required height of topping can best be determined by running a line of levels and setting grade stakes, so that a topping grade parallel to a predicted high water profile can be established. A freeboard of about 2-feet above predicted high water is sufficient for determining height of topping.

Sandbag Topping

This method of raising levees may be used when the required additional height is less than 3-feet. It is constructed of layers of earth filled sacks, which form a small berm on the crown of the levee, as shown on Figure 7. The top layer should be at least 3-feet wide and the side slopes should be about 1 on 1, or not less than required to provide a base width sufficient to prevent failure. In no case should the base width be less than three times the height. The landside slopes should be about 1 on 2-1/2 when the topping is placed on a smooth surface, such as concrete or asphalt instead of earth.

The earth levee crown is prepared by stripping the sod to the required width and to within 1-foot of the riverside edge. The surface is then scarified by plowing furrows, or by similar means to a depth of at least 2-inches. A trench should be dug to accommodate a row of sandbags parallel to the axis of the levee. These steps are very important as they provide a good bond between the topping and the levee surface. The sacks are filled two-thirds full of earth, and should be well tramped or tamped into place. They are laid in alternate directions, those in the bottom layer being lengthwise of the levee, the next layer crosswise, etc. Gravel-filled sacks should be placed on the riverside slope of the topping if wave action becomes more severe than anticipated.

Lumber and Sack Topping

This is one of the most common emergency methods of raising low reaches in levees, especially when the height required is less than 3-feet. It is constructed as shown on Figure 8, and consists of a board fence erected on the levee crown about one foot from the riverside edge; backed with sacked earth or earth fill, placed on a surface stripped of sod, and scarified as described in "Sandbag Topping" in Section 9.4. A row of 2 x 4-inch x 6-foot stakes is driven in as straight a line as practicable, to a minimum penetration of 2-feet, 6-inches. The stakes are spaced at 6-foot intervals for boards 12-feet long. A trench for a row of sandbags is dug adjacent to the landward edges of the stakes, with the riverside edge of the bottom being made as level as possible, in order to provide a secure and even seat for the bottom boards of the fence.

The bottom 1 x 12-inch x 12-foot boards are placed firmly on edge, end to end in the trench, and nailed to the stakes. The required additional rows of boards are nailed to the stakes with joints staggered. The fence should be braced as required, with 2 x 4-inch x 10-foot back braces nailed to 2 x 4-inch x 2-foot stakes as shown on Figure 8.

The bottom edge of the fence should be sealed with well-tamped earth fill on the riverside face. The landside backing is usually composed of earth-filled sacks, filled and laid as described in "Sacked Earth or Loose Earth" in Section 9.2 and "Sandbag Topping" in Section 9.4. In some instances, it may be more practical to use tamped earth fill or sack material should be nailed to the landside face of the fence.

Caving Banks and Slides - Temporary Protection - Earth Embankments (Levees)

Caving banks and slides can cause considerable damage and create hazardous conditions which should be remedied immediately upon discovery. Slides, as distinguished from sloughs, are characterized by the shearing of a mass of the embankment on a slip plane. Slides are brought about generally by undercutting due to current scour over a period-of-time. This action is particularly dangerous if the undercutting reaches the base of the earth embankment (levee) proper, which may result in earth embankment (levee) failure. These conditions should be noted and brought to the attention of the Superintendent. As a temporary remedial measure against active caving of river banks, a rock filled crib as illustrated on Figure 1 is very effective when properly placed. This will serve to alleviate bank or levee damage until permanent corrective measures can be taken.

Cribs are usually 14 x 14-feet in plan by 10 to 14-inches in inside depth. The cribs are constructed of a double thickness of 1 x 4-inch x 14-foot lumber, equivalent to 2 x 4-inch pieces, lapped "rail fence" fashion at all corners and intersections. They are divided into four compartments of about equal areas by two perpendicular cross walls constructed in the same manner as the side walls. The floors and covers are built up of double 1 x 4-inch boards spaced about 9-inches center-to-center. Under the floor, and perpendicular to the direction of the floor boards, are five equally spaced pairs of 1 x 4-inch boards about 3-feet center-to-center. On top of the cover, perpendicular to the direction of the cover boards, are three pairs of top boards, one over each of the side walls and one over the central division wall. The compartments are filled with rock before covering. Each wall intersection of the fabricated crib is securely fastened by a loop of No. 9 wire.

Excessive and Pronounced Floodwall Seepage

The possibility that excessive and pronounced seepage may develop in a flood wall section during its life cannot be discounted. It may be due to rodent holes, new basement construction nearby, utility changes, or other unforeseen circumstances. Excessive seepage connected with a wall section is considered more serious than similar seepage at levee sections. It is, therefore, highly desirable that a specific program of patrol and observation of concrete wall sections be established during flood periods. Adequate supplies of emergency treatment materials that may be required for corrective measures should be available. The following measures or combinations may be used in an emergency. (See Figure 9 for illustrations.)

- Stop leakage through joints or small flow channels on riverside of wall by means of cinders, coal dust, sawdust, or other similar materials.
- Where flow entry holes are too large for the treatment outlined above, sink a plastic, canvas, or similar barrier over the hole and place backfill thereon until flow is retarded.
- Place pervious fill (sand and sandbags) over the base area landside of the seepage to restrict flow and to provide additional stability. A blanket of pervious material (bank run gravel or similar material) not less than one foot thick may be placed over the ground surface and confined by sandbags, the height and width as required for stability of the wall. Boil areas beyond the wall limits should be ringed with sandbags as described for levee seepage control.
- Place heavy fill of sandbags over both landside and riverside area of base to weight down wall and restrict movement where it appears that movement may develop.

Flood Wall Extension

The methods for raising concrete walls in emergencies are shown on Figure 10. The wall treatment is similar to the lumber and sack topping for levees described above, in that a board box is built and filled with loose earth, well tamped into place.

Appendix 1

Grand Rapids Flood Protective System
Plan of General Improvements

LIST OF AS-BUILT/CONSTRUCTION DRAWINGS FOR FLOOD PROTECTION WORKS GRAND RAPIDS, MICHIGAN

(All drawings prepared by City of Grand Rapids unless otherwise noted)

Floodwalls/Levees/Outfalls

FEMA Reach E0 – East Bank, Just North of Kapp St. to North City Boundary

GPF No.	No. of Sheets.	Title
---	1	City of Grand Rapids – Mich., Sketch for Flood Prevention Plans (Ann St. to Graceland St.) (1934)
---	8	Michigan State Highway Department – Plans for Proposed Bridges, Michigan Project I 196-5(23)-76, Muskegon – Grand Rapids Road (1960)
4397	9	City of Grand Rapids, Public Works Services, Construction of Riverside Trail, East Side Phase 1, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Bruce A. VanderWeele, P.C. and OCBa, Sheets 00 to 08 (2000)
5269	4	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 01, 02, 06 and 07 (2014)

FEMA Reach E1 – East Bank, Leonard St. to Just North of Knapp St.

GPF No.	No. of Sheets.	Title
1895	1	Grand Rapids – Mich., Filtration Plant – Contract No. 1, Clear Water Conduit – Intake & Drain, Plan & Profile of Intake Conduit, Sheet 5 of 7 (1910)
---	1	City of Grand Rapids – Mich., Sketch for Flood Prevention Plans (Ann St. to Graceland St.) (1934)
4311	13	City of Grand Rapids, Public Works Services, Grand River Floodwall Improvements, Contract No. 6, Storm Water Pump Stations (Caledonia Street and Palmer Street), MDEQ Permit 99-09-0070, prepared by Fishbeck, Thompson, Carr & Huber, Inc. (1994)
4235	5	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 01, 06, 07, 12 and 16 (1998)
4311	10	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Water Pump Stations, Contract 6, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 01, 02, 03, 04, 05, 06, 07, 09, 10 and 11 (1999)

4397	4	City of Grand Rapids, Public Works Services, Construction of Riverside Trail, East Side Phase 1, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Bruce A. VanderWeele, P.C. and OCBa, Sheets 00, 01, 02 and 08 (2000)
4595	5	City of Grand Rapids, Public Works Services, Grand River Floodwalls & Embankments – Contract No. 7, Reconstruction of Monroe Avenue and Public Easement (NW) from Ann St. to Parade Dr., prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 01, 08, 09, 10 and 17 (2002)
5269	4	City of Grand Rapids, Design Development Enterprise and Services, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 02, 05, 07 and 14 (2014)

FEMA Reach E2 – East Bank, I-196 to Leonard St.

GPF No.	No. of Sheets.	Title
---	20	U.S. Post Office Department, U.S. Post Office Grand Rapids, Michigan, prepared by J & G Daverman Co., Sheets 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20 and 21 (1960)
---	11	Michigan State Highway Department – Plans of Proposed Bridges, Michigan Project I-96-1(15) 75, Grand Rapids – Spur Road (1962)
---	13	Michigan State Highway Department, I96 W.B. Crossing Scribner Ave. (Reloc.), Grand River and Monroe Ave. in the City of Grand Rapids, Sheets 13, 100, 102, 103, 109, 110, 117, 123, 124, 125, 126, 127 and 128 (1962)
---	7	State of Michigan, Department of State Highways and Transportation – Plans of Proposed Bridge, Michigan Project M2001 (042), Control Section Mu41014, Job Number 02785A, US-31, Kent County, City of Grand Rapids, Sheets 1, 2, 5, 6, 7, 8 and 9 (1978)
4210	7	City of Grand Rapids, Department of Public Services, Division of Engineering, Canal Street Park Construction, prepared by M.C. Smith Associates and Architectural Group, Inc., Sheets 1, 8, 9, 10, 12, 13 and 14 (1997)
4177	8	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, East Side Relief Sewer, Contract 3, prepared by Fishbeck, Thompson, Carr & Huber, Inc. (1997)
---	8	City of Grand Rapids, Department of Public Services, Division of Engineering, Grand River Walkway from Michigan Street to Sixth Street Bridge Park, Grand Rapids, Michigan, prepared by ProgressAE (1998)

4233	3	City of Grand Rapids, Grand River Floodwall Improvements, Contract 1, Floodwalls Restoration, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2 and 4 (1998)
4235	4	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 12, 15 and 16 (1998)
4482	28	City of Grand Rapids, Public Works Services and Parks and Recreation Department, Renovation of Sixth Street Bridge Park, prepared by ProgressiveAE (2001)
5269	6	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 4, 7, 10 and 11 (2014)
5426	4	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 1, 2, 16 and 17 (2016)

FEMA Reach E3 – East Bank, US Route 131 to Gillett Pedestrian Bridge

GPF No.	No. of Sheets.	Title
---	8	City of Grand Rapids, Dock Line – Wall from N. Line of Pier to N. Bridge Line (1901)
---	2	City of Grand Rapids, Plan for Retaining Wall across East Bridge Street near the East Line of the Right of Way of the Grand Rapids Ludington and Northwestern Railroad (1902)
---	8	Flood Protection Plans for Dock Line Wall and Embankment from North Line Market to P.M.R.R. on East Bank (1908)
---	2	Flood Protection Plans for East Side from Fulton St. to Power Dam (1909)
---	1	Forsland Building Drainage Update (1914)
---	5	Plans for Concrete Arch Bridge over Grand River near Lyon Street, Grand Rapids, Mich. for the Michigan Railway Co. prepared by the Michigan Railway Engineering Co., Sheets 13, 14, 15, 16 and 17 (1914)
2427	3	City of Grand Rapids, Flood Protection Plan for East Dock Line Wall along Civic Auditorium from North Line Market to P.M.R.R. on East Bank (1934)

---	2	City of Grand Rapids, Flood Protection Plan for East Dock Line Wall From Bridge St.to 606 Ft. South (1934)
---	1	City of Grand Rapids, Flood Protection Walls for Windows in Rear of Hopson Bldg. No. 29 Campau Ave. (1935)
---	1	City of Grand Rapids, Plan for Flood Protection along East Bank of River from 30 Ft. North of Fulton St. to 345 Ft. North (1935)
---	1	City of Grand Rapids, Flood Prevention Plans at Weiss Service Bldg. along East Dock Line (1935)
---	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Flood Wall on East Side of Grand River from 169.7' to 233.7' S. of Michigan St. (1953)
---	15	State of Michigan, Department of State Highways and Transportation – Plans of Proposed Bridge Reconstruction, Michigan Project M2001 (012), State Project No. Mu41081, Job Number 02786A, Fulton Street (M-45), Kent County, City of Grand Rapids, Sheets 1,3, 5, 10, 11, 12, 13, 16, 19, 22, 23, 24, 37, 38 and 39 (1976)
---	1	Boundary & Topographic Survey of the Eastbank Project prepared for United Development Corporation by Moore & Bruggink (1988)
---	43	Eastbank Waterfront Towers, Grand Rapids, Michigan, prepared by Greiner, Inc. Great Lakes et al. (1988)
---	1	Grand Rapids Riverwalk, Grand Rapids, Michigan, Site Plan, Dwg. No. 1, prepared by Michael Singer and Sasaki Associates, Inc. (Radisson Water Sculpture), Sheet 1 (1990)
---	1	Grand Rapids Riverwalk, Phase III, Grand Rapids, Michigan, Irrigation North prepared by Sasaki Associates (Radisson Water Sculpture), Sheet L3.1 (1992)
4235	3	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 3 and 12 (1998)
---	20	J.W. Marriot Hotel, Grand Rapids, Michigan, Bid Addendum #1 – Floodwall (2005)
---	1	Forslund Building Parking Area, Grand Rapids, Michigan, prepared by JDH Structural Engineering, Sheet S1.3 (2013), including update (2014)
5269	6	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 3, 7, 9 and 18 (2014)

5426	4	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheet 18 (2016)
16	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Survey of Bissell Property (undated)

FEMA Reach E4 – East Bank, Downstream Extent of Floodwall to US Route 131

GPF No.	No. of Sheets.	Title
---	1	City of Grand Rapids, Market Ave. South of Wealthy Ave. For Sewer Right-of-Way (1907)
---	8	City of Grand Rapids, Flood Protection Plans for Dock Line Wall and Embankment from North Line Market to P.M.R.R. on East Bank (1908)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 121+90 to Sta. 137, Sheet 4 (1909)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 137 to Sta. 153 (1909)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Market St. to Sta. 22 Rathbun Place (1910)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 150 to Sta. 169 (1910)
803	5	City of Grand Rapids, Contract 2, East Side Trunk Sewer, Sheets 1, 2, 3, 4 and 5 (1911)
---	1	City of Grand Rapids, Michigan, Department of Public Service, Office of Sanitary Engineer, Outfall Conduit and Outlet Structure, Contract V-7, Sheet 54 (1930)
---	1	City of Grand Rapids, Map Showing Proposed Flood Protection on East Side South of Wealthy Ave. (1938)
---	1	City of Grand Rapids, Revised Plan of Partials No. 1 and 2 from East Side Sewage Pumping Station to 3000 Ft. Southwesterly from Ken-O-Sha Creek Bridge of the Plan for the Improvement of Grand River & Grand River Blv'd. from East Side Sewage Pumping Sta. to Trunk Line Hi-Way M-114 (1938)
---	1	Grand Rapids, Michigan, Sewage Treatment Plant, Outfall Sewer Plan, Profile and Details, Contract 3, prepared by Drury, McNamee and Porter, Sheet 18 (1954)
---	22	Michigan State Highway Department – Plans of Proposed Bridge, Michigan Project I-96-1(20) 72, Holland - Grand Rapids Road, Kent County, Walker Township (1962)

4235	2	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1 and 2 (1998)
4327	1	City of Grand Rapids, Public Works Services, Engineering Department, Various Projects of the WWTP, Repairs to Outfall at the Grand River, Proposed Site Plan, Sections, and Notes, prepared by McNamee Porter & Seeley, Inc., Sheet 2 (1999)
4982	11	City of Grand Rapids, Public Works Services, Engineering Department, Construction of Market Avenue Stormwater Pump Station, prepared by Fishbeck, Thompson, Carr & Huber, Inc. (2008)
5269	5	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 3, 4 and 7 (2014)
5426	4	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 1, 2, 4, 13 and 14 (2016)

FEMA Reach E5 – East Bank, Ring Levee Around WRRF

GPF No.	No. of Sheets.	Title
4243	5	Grand River Floodwall Improvements, Contract No. 8, Plaster Creek Stream Bank Stabilization from the CSX Railroad to the Grand River, prepared by Fishbeck, Thompson, Carr & Huber, Inc. (1998)
4234	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, West Side Improvements (WWTP Access Road), Contract No. 4, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheet 6 (1998)
4235	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheet 14 (1998)
4755	3	Grand River Floodwall and Embankments, Contract No. 11, Site Work at the Wastewater Treatment Plant, prepared by Fishbeck, Thompson, Carr & Huber, Inc. (2004)
5319	21	City of Grand Rapids, Design, Development and Enterprise Services, Engineering Department, Improvements to Berms at the Wastewater Treatment Plant, prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc. (2014)

FEMA Reach W1 – West Bank, Indian Mill Creek to West River Drive (Walker)

GPF No.	No. of Sheets.	Title
---	8	Michigan State Highway Department – Plans for Proposed Bridges, Michigan Project I 196-5(23)-76, Muskegon – Grand Rapids Road (1960)
1262	3	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Reconstruction of Turner Avenue from I-296 Ramp to 400' South of Ann Street and from I-296 Ramp to 750' North, Sheet 5, 7, and 9 (1971)
4235	4	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 8, 11 and 12 (1998)
4311	10	City of Grand Rapids, Public Works Services, Grand River Floodwall Improvements, Contract No. 6, Storm Water Pump Stations (Indian Mill Creek), MDEQ Permit 99-09-0070, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 3, 4, 5, 6, 7, 8, 11 and 12 (1994)
---	6	Michigan Department of Transportation, NB US-131 Sta. 976+00 to Sta. 988+00, Job No. 56887A, prepared by URS (2006)
---	14	Michigan Department of Transportation, NB US-131/I-296, City of Grand Rapids, Kent County, NB US-131 Over Indian Mill Creek and GR Eastern RR, prepared by URS (2012)
5269	7	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 5, 7, 12, 13 and 15 (2014)
5426	4	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 1, 2, 11 and 12 (2016)

FEMA Reach W2 – West Bank, I-196 to Indian Mill Creek

GPF No.	No. of Sheets.	Title
---	1	City of Grand Rapids, West Bank Profile from 2800' Downstream of Fulton St. to Upstream City Limits (1904)
---	1	City of Grand Rapids, General Design for Dock Line Walls Approved and Adopted by the Board of Public Works (Fulton St. to 11th St.) (1892, revised 1905)
---	1	City of Grand Rapids, Flood Protection Plans for (West) Dock Line Wall from Station 35+00 to Station 42+62.6 (1907)

---	1	City of Grand Rapids, Flood Protection Plans for (West) Dock Line Wall from 50 FT. South of Center Line of Eleventh St. or Station 26+44.3 to Station 35+00 (1907)
---	1	City of Grand Rapids, Flood Protection Plans for (West) Dock Line and Cut-Off Walls from 330 FT. South of Center Line of W. Leonard St. (1907) to 50 FT. South of Center Line of Eleventh St. (1907)
---	4	City of Grand Rapids, Flood Protection, Leonard Street, West Side from Sta. 4+69.45 to Sta. 16+20.65 (1910)
---	1	City of Grand Rapids, Plan for Removing Cut-Off Wall Located S. of Leonard St. and E. of Front Ave. (1912)
---	1	Grand Rapids – Mich., City Engineers Office, Grand River Bridge Details (Bridge Street Bridge, Pearl Street Bridge, Fulton Street Bridge) (1933)
---	13	Michigan State Highway Department, I96 W.B. Crossing Scribner Ave. (Reloc.), Grand River and Monroe Ave. in the City of Grand Rapids, Sheets 13, 100, 102, 103, 109, 110, 117, 123, 124, 125, 126, 127 and 128 (1962)
---	11	Michigan State Highway Department – Plans of Proposed Bridges, Michigan Project I-96-1(15) 75, Grand Rapids – Spur Road (1962)
---	10	Michigan Department of Natural Resources, Construction Plans for Fishway at Sixth Street Dam, Grand Rapids, Michigan, Project No. 23-3056 (1974)
---	7	State of Michigan, Department of State Highways and Transportation – Plans of Proposed Bridge, Michigan Project M2001 (042), Control Section Mu41014, Job Number 02785A, US-31, Kent County, City of Grand Rapids, Sheets 1, 2, 5, 6, 7, 8 and 9 (1978)
3655	27	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Sewer Improvements Program, Separation Project, Front/Scribner Pumping Station, Contract No. 2, SRF No. 5073-02, prepared by Black & Veatch and Fishbeck, Thompson, Carr & Huber, Inc. (1991)
4233	6	City of Grand Rapids, Grand River Floodwall Improvements, Contract 1, Floodwalls Restoration, prepared by Fishbeck, Thompson, Carr & Huber, Inc. (1998)
4234	2	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, West Side Improvements, Contract No. 4, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 7 and 12 (1998)
4235	11	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 19 and 22 (1998)

4367	9	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Improvements to West Side Riverwalk at Ah Nab Awen Park from Bridge Street to 300' South and at Fish Ladder Park/I-196 Expressway from 450' North to 1070' North of Bridge Street, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 4, 5, 6, 7, 8 and 9 (1999)
4311	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Water Pump Stations, Contract No. 6, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheet 13 (1999)
---	14	Michigan Department of Transportation, NB US-131/I-296, City of Grand Rapids, Kent County, NB US-131 Over Indian Mill Creek and GR Eastern RR, prepared by URS (2012)
5426	4	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 19 and 22 (2016)
---	8	Improvements to Grand River, prepared by Architectural Metals, Inc./Flood Panel LLC (2016)

FEMA Reach W3 – West Bank, Fulton St. to I-196

GPF No.	No. of Sheets.	Title
---	1	City of Grand Rapids, West Bank Profile from 2800' Downstream of Fulton St. to Upstream City Limits (1904)
---	1	City of Grand Rapids, General Design for Dock Line Walls Approved and Adopted by the Board of Public Works (Fulton St. to 11th St.) (1892, revised 1905)
---	1	Grand Rapids – Mich., City Engineers Office, Grand River Bridge Details (Bridge Street Bridge, Pearl Street Bridge, Fulton Street Bridge) (1933)
---	15	State of Michigan, Department of State Highways and Transportation – Plans of Proposed Bridge Reconstruction, Michigan Project M2001 (012), State Project No. Mu41081, Job Number 02786A, Fulton Street (M-45), Kent County, City of Grand Rapids, Sheets 1,3, 5, 10, 11, 12, 13, 16, 19, 22, 23, 24, 37, 38 and 39 (1976)
1692	44	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, West Riverbank Park from Bridge Street to Pearl Street (1977)

---	9	The Public Museum of Grand Rapids, Grand Rapids, Michigan, Construction Documents, Bid Package #2 – Balance of Project, prepared by Beta Design Group, Sheets (1992)
4234	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, West Side Improvements, Contract No. 4, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheet 10 (1998)
4235	5	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 3, 12 and 15 (1998)
5426	6	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 1, 2, 8, 9, 10 and 19 (2016)
5455	8	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 3 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 4, 5, 7, 10, 11, 13 and 17 (2017)

FEMA Reach W4 – West Bank, West End Ditch to Fulton St.

GPF No.	No. of Sheets.	Title
---	19	City of Grand Rapids, Flood Protection from Fulton St. to Wealthy Ave., West Side, (1909)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 121+90 to Sta. 137, Sheet 4 (1909)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 137 to Sta. 153 (1909)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Market St. to Sta. 22 Rathbun Place (1910)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 150 to Sta. 169 (1910)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. 150 to Sta. 169 (1910)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West and East Sides from Sta. Wealthy Ave. to Rathbun Place (1910)
---	1	City of Grand Rapids, Flood Protection South of Wealthy Ave, West Side Butterworth Ave. to L.S. & M.S Embankment (1910)

---	22	Michigan State Highway Department – Plans of Proposed Bridge, Michigan Project I-96-1(20) 72, Holland - Grand Rapids Road, Kent County, Walker Township (1962)
---	11	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Wealthy Street Bridge Over the Grand River, prepared by Hazelet & Erdal of Michigan, Sheets 5, 6, 7, 15, 16, 17, 18, 19, 20, 21, and 22 (1974)
3756	26	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Sewer Improvements Program, Separation Project, Wealthy Street Pumping Station, Contract No. 4, SRF No. 5073-07, prepared by Black & Veatch and Fishbeck, Thompson, Carr & Huber, Inc.(1993)
---	10	Butterworth Landfill Cooperating Parties, Butterworth Landfill Final Remedial Design (100%), prepared by RMT, Inc. (1998)
4234	7	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, West Side Improvements, Contract No. 4, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 2, 3, 4, 5, 8, 9 and 11 (1998)
4235	5	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Grand River Floodwall Improvements, Storm Sewer Flap Gates, Contract 2, prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 12, 13 and 15 (1998)
---	5	Michigan Department of Transportation, Job No. 47169A, US-131/I-296, City of Grand Rapids, Kent County, Northbound US-131 over the Grand River, B04 of 41131, Sheets 2, 3, 18, 21, and 24, prepared by Alfred Benesch & Company (1999)
4457	5	City of Grand Rapids, Public Works Services, Sewer Improvements Program, Separation Project, Contract 55, Garfield Avenue from West Side Ditch to 200’ South of Butterworth Street, prepared by Black & Veatch and Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 5, 6 and 7 (2000)
5047	4	City of Grand Rapids, Grand Rapids, Michigan, Department of Public Services, Demolition of Wealthy Street Pump Station at Wealthy St. and Front Ave., prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 6 and 7 (2009)
5269	7	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 1 (Backflow Prevention), prepared by Fishbeck, Thompson, Carr & Huber, Inc., Sheets 1, 2, 3, 6 and 7 (2014)

5426	8	City of Grand Rapids, Design Development Enterprise and Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements), prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc., Sheets 1, 2, 3, 4, 5, 6, 7 and 19 (2016)

Appendix 2

Grand Rapids Flood Protective System
Policies, Procedures, and Inspection Checklist Forms

POLICIES, PROCEDURES, AND INSPECTION REPORT FORMS

FOR

FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

1. The City Environmental Services Department has established policies and procedures for the operation of the Water Resource Recovery Facility (WRRF) during emergency conditions inside and outside of the facility. Several of these policies and procedures are directly related to operations during flood conditions in the Grand River. These policies and procedures are included in this appendix.

2. Forms similar to the sample inspection report forms contained herein can be used in submitting reports to the Superintendent who will evaluate the flood protection system condition and ability to protect Grand Rapids from floods on the Grand River. The forms cover inspection, maintenance, and operation of the flood protection works. All information desired and all remarks should be given precisely and accurately. Additional sheets and sketches should be added where necessary to clearly convey the submitted information.

3. Inspection of the features comprising the flood protection system should be made as indicated below.

4. Inspections of the stormwater pump stations should be made annually. Each item of pumping equipment should be trial-operated annually.

5. Earth embankments should be inspected annually through the Office of the City Engineer, immediately following any flood in excess of 31,000 cfs (Stage = 19.34 feet) as measured at the U.S. Geological Survey (USGS) Station 04119000, Grand River at Grand Rapids, Michigan, or at such times deemed necessary by the City Engineer.

6. Periodic detailed inspections and condition evaluations of the floodwalls should be made by the Office of the City Engineer in accordance with the flood protection system asset management plan. The floodwalls shall be visually inspected on an annual basis.

7. An annual report covering inspection, maintenance and operation of the flood protection works should be submitted in April to the City Manager. This report should include all logs of operation and dated copies of all inspection check lists made during the period covered by the reports.

INSPECTION REPORT
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

SUMMARY OF PUMPING PLANTS

1. **Date of this inspection:** _____
2. **Date of last inspection:** _____

3.

Stormwater Pump Station	Dates of Inspections since last report	Dates of Pumps Operations since last report	Dates of Operation Logs since last report
Market Avenue			
Wealthy Street			
Front - Scribner			
Indian Mill Creek			
Caledonia Street			
Palmer Street			

4. **Unusual occurrences or remarks concerning trial operations and inspections during period covered by this report:** _____
   _____
   _____
   _____
   _____
   _____
5. **Have the key operating personnel been changed? If changes have been made, submit revised list of personnel.**
6. **This inspection revealed the following necessary repairs. (Enclose rough plan of anticipated repair or explain.)** _____
   _____
   _____
   _____
   _____
   _____
7. **At what date (state specific date) will the appropriate City department perform the above repairs?** _____

8. **Remarks and explanations:** _____

_____

_____

No. of additional sheets: _____

Signed _____

Superintendent of Flood Protection Works
Grand Rapids, Michigan

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

MARKET AVENUE STORMWATER PUMP STATION

1. **ACCESS ROAD** _____
2. **STORMWATER PUMP STATION:**
   a. **Doors & Locks** _____
   b. **Windows** _____
   c. **Floor** _____
   d. **Walls** _____
   e. **Roof** _____
   f. **Sump** _____
   g. **Ladders** _____
   h. **Paint** _____
   i. **Operation Diagram** _____
   j. **Operation Log Forms Available** _____
3. **FIRE HAZARDS** _____
4. **GRATINGS & ACCESS HATCHES** _____
5. **DISCHARGE WELL** _____
   a. **Flap Gate (4 Pump Discharge Pipes)** _____
6. **STORM WATER CONDUIT AND INVERTED SIPHON** _____
7. **PUMP COLUMNS** _____
8. **POWER LINES & GENERATOR RECEPTACLE** _____
   (Inspected by Power Co.) _____
9. **TRASH RACK** _____
10. **SLUICE GATE** _____
11. **WIRING SYSTEM:**
    a. **Lamps** _____
    b. **Circuit Breakers** _____
    c. **Switches** _____
    d. **Conduit** _____
    e. **Receptacles** _____
    f. **Wire & Cable** _____
12. **SWITCHGEAR:**
    a. **Utility Circuit Breaker (Primary Electric Service)** _____
    b. **Generator Circuit Breaker (Auxiliary Electric Service)** _____
    c. **Manual Transfer Switch** _____
    d. **Pump #1 Motor Breaker** _____
    e. **Pump #2 Motor Breaker** _____

MARKET AVENUE STORMWATER PUMP STATION

f. **Pump #3 Motor Breaker** _____
g. **Pump #4 Motor Breaker** _____
h. **Sump Pump #1 Motor Breaker** _____
i. **Sump Pump #2 Motor Breaker** _____
j. **Control Panel** _____
k. **Protective Devices** _____

13. **PUMPS: (Maintenance performed by Authorized Technicians)**
    a. **Pump #1 – General** _____
    b. **Pump #2 – General** _____
    c. **Pump #3 – General** _____
    d. **Pump #4 – General** _____
    e. **Sump Pump #1 – General** _____
    f. **Sump Pump #2 – General** _____
14. **WATER LEVEL DETECTION:**
    a. **Submersible Transducers** _____
    b. **Submersible Level Transducer Control Panel** _____
    c. **Level Detector Float Switch** _____

15. **SPARE PARTS:**

	Required	On-Hand
a. Control Panel Lamps	6	
b. Station Lighting Lamps	6	

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

MARKET AVENUE STORMWATER PUMP STATION

16. TOOLS:

	Required	On-Hand
a. Tool Box	1	
b. Table	1	
c. Bench	1	
d. Trash Rack Rake	1	
e. Sluice Gate Crank	1	
f. Circuit Breaker Puller	1	
g. Grease Gun	1	
h. Electrical Tape	2	
i. Screw Drivers (Assortment)	1	
j. Crescent Wrenches (Assorted Sizes)	1	
k. Allen Wrenches	1	
l. Duct Tape	2	
m. Portable Electric Heaters	2	
n. Extension Cords – 30' Length	2	

17. EQUIPMENT OR PARTS IN NEED OF REPAIR OR REPLACEMENT _____

_____

_____

18. MOISTURE CONDITIONS IN PUMPING STATION _____

_____

19. WEATHER CONDITIONS AND TEMPERATURE _____

_____

20. REMARKS AND EXPLANATIONS _____

_____

_____

21. DATE OF LAST INSPECTION _____

22. DATES OF PUMP OPERATIONS SINCE LAST INSPECTION (TRIAL & FLOOD) _____

_____

23. WERE PUMPS OPERATED AT THIS INSPECTION? _____

24. DATE OF THIS INSPECTION _____

25. INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

WEALTHY STREET STORMWATER PUMP STATION

1. **ACCESS ROAD** _____
2. **STORMWATER PUMP STATION:**
   a. **Doors & Locks** _____
   b. **Windows** _____
   c. **Floor** _____
   d. **Walls** _____
   e. **Roof** _____
   f. **Sump** _____
   g. **Ladders** _____
   h. **Paint** _____
   i. **Operation Diagram** _____
   j. **Operation Log Forms Available** _____
3. **FIRE HAZARDS** _____
4. **GRATINGS & ACCESS HATCHES** _____
5. **OUTFALL** _____
   a. **Flap Gates (10 Pump Discharge Lines)** _____
   b. **Flap Gates (3 Storm Water Pass-Through Conduits)** _____
   c. **Duck-Bill Valve (Sump Pump Discharge Line)** _____
6. **PUMP COLUMNS** _____
7. **DISCHARGE PIPES (10)** _____
8. **SUBSTATIONS & POWER LINES** _____
   (Inspected by Power Co.) _____
9. **BAR SCREENS** _____
10. **SLUICE GATES: (IN BYPASS CHAMBER)**
    a. **Sluice Gate #1** _____
    b. **Sluice Gate #2** _____
    c. **Sluice Gate #3** _____
11. **STORM WATER OUTLET CONDUITS (3)** _____
12. **DRESSER COUPLINGS: (PUMP COLUMN TO DISCHARGE PIPES)** _____
    _____
    a. **Leaks** _____
13. **WIRING SYSTEM:**
    a. **Lamps** _____
    b. **Fuses** _____
    c. **Circuit Breakers** _____
    d. **Switches** _____

WEALTHY STREET STORMWATER PUMP STATION

e. **Conduit** _____
f. **Receptacles** _____
g. **Wire & Cable** _____

14. **SWITCHGEAR:**
    a. **Fuses and Disconnect Switches (Primary Electric Service)** _____
    b. **Pump #1 Motor Fuse & Disconnect** _____
    c. **Pump #2 Motor Fuse & Disconnect** _____
    d. **Pump #3 Motor Fuse & Disconnect** _____
    e. **Pump #4 Motor Fuse & Disconnect** _____
    f. **Pump #5 Motor Fuse & Disconnect** _____
    g. **Pump #6 Motor Fuse & Disconnect** _____
    h. **Pump #7 Motor Fuse & Disconnect** _____
    i. **Pump #8 Motor Fuse & Disconnect** _____
    j. **Pump #9 Motor Fuse & Disconnect** _____
    k. **Pump #10 Motor Fuse & Disconnect** _____
    l. **Flow Channel Pump #1 Fuse & Disconnect** _____
    m. **Flow Channel Pump #2 Fuse & Disconnect** _____
    n. **Flow Channel Pump #3 Fuse & Disconnect** _____
    o. **Sump Pump #1 Fuse & Disconnect** _____
    p. **Sump Pump #2 Fuse & Disconnect** _____
    q. **Sluice Gate #1 Fuse & Disconnect** _____
    r. **Sluice Gate #2 Fuse & Disconnect** _____
    s. **Sluice Gate #3 Fuse & Disconnect** _____
    t. **Protective Devices** _____

15. **PUMPS: (Maintenance performed by Authorized Technicians)**
    a. **Pump #1 – General** _____
    b. **Pump #2 – General** _____
    c. **Pump #3 – General** _____
    d. **Pump #4 – General** _____
    e. **Pump #5 – General** _____
    f. **Pump #6 – General** _____
    g. **Pump #7 – General** _____
    h. **Pump #8 – General** _____
    i. **Pump #9 – General** _____
    j. **Pump #10 – General** _____
    k. **Flow Channel Pump #1 – General** _____

WEALTHY STREET STORMWATER PUMP STATION

l. Flow Channel Pump #2 – General _____
m. Flow Channel Pump #3 – General _____
n. Sump Pump #1 – General _____
o. Sump Pump #2 – General _____

16. WATER LEVEL DETECTION:
    a. Submersible Transducer _____
    b. Submersible Level Transducer Control Panel _____
    c. Level Detector Float Switch _____

17. SPARE PARTS:

	Required	On-Hand
a. Control Panel Lamps	6	
b. Station Lighting Lamps	6	
c. Fuses, 40 A, 480 V	2	
d. Fuses, 150 A, 12470 V	2	
e. Fuses, 20 A, 480 V	4	
f. Fuses, 30 A, 480 V	2	

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

WEALTHY STREET STORMWATER PUMP STATION

18. TOOLS:

	Required	On-Hand
a. Tool Box	1	
b. Table	1	
c. Bench	1	
d. Bar Screen Rake	1	
e. Sluice Gate Wheels	3	
f. Circuit Breaker Puller	1	
g. Fuse Puller	2	
h. Grease Gun	1	
i. Electrical Tape	2	
j. Screw Drivers (Assortment)	1	
k. Crescent Wrenches (Assorted Sizes)	1	
l. Allen Wrenches	1	
m. Duct Tape	2	
n. Portable Electric Heaters	2	
o. Extension Cords – 30' Length	2	

19. EQUIPMENT OR PARTS IN NEED OF REPAIR OR REPLACEMENT _____

_____

_____

20. MOISTURE CONDITIONS IN PUMPING STATION _____

_____

21. WEATHER CONDITIONS AND TEMPERATURE _____

_____

22. REMARKS AND EXPLANATIONS _____

_____

_____

23. DATE OF LAST INSPECTION _____

24. DATES OF PUMP OPERATIONS SINCE LAST INSPECTION (TRIAL & FLOOD) _____

_____

25. WERE PUMPS OPERATED AT THIS INSPECTION? _____

26. DATE OF THIS INSPECTION _____

27. INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

FRONT & SCRIBNER STORMWATER PUMP STATION

1. **ACCESS ROAD** _____
2. **STORMWATER PUMP STATION:**
   a. **Doors & Locks** _____
   b. **Windows** _____
   c. **Floor** _____
   d. **Walls** _____
   e. **Roof** _____
   f. **Sump** _____
   g. **Ladders** _____
   h. **Paint** _____
   i. **Operation Diagram** _____
   j. **Operation Log Forms Available** _____
3. **FIRE HAZARDS** _____
4. **GRATINGS, MANHOLES & ACCESS HATCHES** _____
5. **DISCHARGE WELL** _____
   a. **Flap Gates (6 Pump Discharge Pipes)** _____
6. **DISCHARGE PIPES:**
   a. **From Pump Discharge Well** _____
   b. **Storm Water Through-Pipe** _____
7. **OUTFALL** _____
   a. **Flap Gates (3)** _____
   b. **Riprap** _____
8. **PUMP COLUMNS** _____
9. **SUBSTATIONS & POWER LINES** _____
   (Inspected by Power Co.) _____
10. **BAR SCREENS** _____
11. **SLUICE GATES: (IN GATEWELL STRUCTURE)**
    a. **Sluice Gate #1** _____
    b. **Sluice Gate #2** _____
12. **DRESSER COUPLINGS: (PUMP COLUMN TO DISCHARGE PIPES)** _____
    _____
    a. **Leaks** _____
13. **WIRING SYSTEM:**
    a. **Lamps** _____
    b. **Fuses** _____
    c. **Circuit Breakers** _____

FRONT & SCRIBNER STORMWATER PUMP STATION

d. **Switches** _____
e. **Conduit** _____
f. **Receptacles** _____
g. **Wire & Cable** _____

14. SWITCHGEAR:

a. **Fuses and Disconnect Switches (Primary Electric Service)** _____
b. **Pump #1 Motor Fuse & Disconnect** _____
c. **Pump #2 Motor Fuse & Disconnect** _____
d. **Pump #3 Motor Fuse & Disconnect** _____
e. **Pump #4 Motor Fuse & Disconnect** _____
f. **Pump #5 Motor Fuse & Disconnect** _____
g. **Pump #6 Motor Fuse & Disconnect** _____
h. **Sump Pump #1 Fuse & Disconnect** _____
i. **Sump Pump #2 Fuse & Disconnect** _____
j. **Sluice Gate #1 Fuse & Disconnect** _____
k. **Sluice Gate #2 Fuse & Disconnect** _____
l. **Protective Devices** _____

15. PUMPS: (Maintenance performed by Authorized Technicians)

a. **Pump #1 – General** _____
b. **Pump #2 – General** _____
c. **Pump #3 – General** _____
d. **Pump #4 – General** _____
e. **Pump #5 – General** _____
f. **Pump #6 – General** _____
g. **Sump Pump #1 – General** _____
h. **Sump Pump #2 – General** _____

16. WATER LEVEL DETECTION:

d. **Submersible Transducer** _____
e. **Submersible Level Transducer Control Panel** _____
f. **Level Detector Float Switch** _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

FRONT & SCRIBNER STORMWATER PUMP STATION

16. SPARE PARTS:

	Required	On-Hand
a. Control Panel Lamps	6	
b. Station Lighting Lamps	6	
c. Fuses, 40 A, 480 V	2	
d. Fuses, 100 A, 12470 V	2	
e. Fuses, 20 A, 480 V	2	
f. Fuses, 30 A, 480 V	2	

17. TOOLS:

	Required	On-Hand
a. Tool Box	1	
b. Table	1	
c. Bench	1	
d. Bar Screen Rake	1	
e. Sluice Gate Wheels	3	
f. Circuit Breaker Puller	1	
g. Fuse Puller	2	
h. Grease Gun	1	
i. Electrical Tape	2	
j. Screw Drivers (Assortment)	1	
k. Crescent Wrenches (Assorted Sizes)	1	
l. Allen Wrenches	1	
m. Duct Tape	2	
n. Portable Electric Heaters	2	
o. Extension Cords – 30' Length	2	

18. EQUIPMENT OR PARTS IN NEED OF REPAIR OR REPLACEMENT _____

_____

_____

19. MOISTURE CONDITIONS IN PUMPING STATION _____

_____

20. WEATHER CONDITIONS AND TEMPERATURE _____

_____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

FRONT & SCRIBNER STORMWATER PUMP STATION

21. REMARKS AND EXPLANATIONS _____

_____

_____

22. DATE OF LAST INSPECTION _____

23. DATES OF PUMP OPERATIONS SINCE LAST INSPECTION (TRIAL & FLOOD) _____

_____

24. WERE PUMPS OPERATED AT THIS INSPECTION? _____

25. DATE OF THIS INSPECTION _____

26. INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

INDIAN MILL CREEK STORMWATER PUMP STATION

1. **ACCESS ROAD** _____
2. **STORMWATER PUMP STATION:**
   a. **Doors & Locks** _____
   b. **Windows** _____
   c. **Floor** _____
   d. **Walls** _____
   e. **Roof** _____
   f. **Sump** _____
   g. **Ladders** _____
   h. **Paint** _____
   i. **Operation Diagram** _____
   j. **Operation Log Forms Available** _____
3. **FIRE HAZARDS** _____
4. **GRATINGS & ACCESS HATCHES** _____
5. **DISCHARGE WELL** _____
   a. **Flap Gates on Pump Discharge Pipes (3)** _____
6. **DISCHARGE PIPES:**
   a. **From Pump Discharge Well** _____
   b. **Storm Water Through-Pipe** _____
7. **OUTFALL** _____
   a. **Storm Water Outfall Flap Gate (1)** _____
   b. **Riprap** _____
8. **PUMP COLUMNS** _____
9. **SUBSTATIONS & POWER LINE** _____
   (Inspected by Power Co.) _____
10. **BAR SCREENS** _____
11. **WIRING SYSTEM:**
    a. **Lamps** _____
    b. **Fuses** _____
    c. **Circuit Breakers** _____
    d. **Switches** _____
    e. **Conduit** _____
    f. **Receptacles** _____
    g. **Wire & Cable** _____
12. **SWITCHGEAR:**
    a. **Utility Circuit Breaker** _____

INDIAN MILL CREEK STORMWATER PUMP STATION

b. Generator Circuit Breaker (Auxiliary Electric Service) _____
c. Manual Transfer Switch _____
d. Pump #1 Motor Disconnect _____
e. Pump #2 Motor Disconnect _____
f. Pump #3 Motor Disconnect _____
g. Sump Pump #1 Motor Disconnect _____
h. Sump Pump #2 Motor Disconnect _____
i. Protective Devices _____

13. PUMPS: (Maintenance performed by Authorized Technicians)
    a. Pump #1 – General _____
    b. Pump #2 – General _____
    c. Pump #3 – General _____
    d. Sump Pump #1 – General _____
    e. Sump Pump #2 – General _____
14. WATER LEVEL DETECTION:
    a. Submersible Transducer _____
    b. Submersible Level Transducer Control Panel _____
    c. Level Detector Float Switch _____

15. SPARE PARTS:

	Required	On-Hand
a. Control Panel Lamps	6	
b. Station Lighting Lamps	6	

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

INDIAN MILL CREEK STORMWATER PUMP STATION

16. TOOLS:

	Required	On-Hand
a. Tool Box	1	
b. Table	1	
c. Bench	1	
d. Bar Screen Rake	1	
e. Sluice Gate Wheels	3	
f. Circuit Breaker Puller	1	
g. Fuse Puller	2	
h. Grease Gun	1	
i. Electrical Tape	2	
j. Screw Drivers (Assortment)	1	
k. Crescent Wrenches (Assorted Sizes)	1	
l. Allen Wrenches	1	
m. Duct Tape	2	
n. Portable Electric Heaters	2	
o. Extension Cords – 30' Length	2	

18. EQUIPMENT OR PARTS IN NEED OF REPAIR OR REPLACEMENT _____

_____

_____

19. MOISTURE CONDITIONS IN PUMPING STATION _____

_____

20. WEATHER CONDITIONS AND TEMPERATURE _____

_____

21. REMARKS AND EXPLANATIONS _____

_____

_____

22. DATE OF LAST INSPECTION _____

23. DATES OF PUMP OPERATIONS SINCE LAST INSPECTION (TRIAL & FLOOD) _____

_____

24. WERE PUMPS OPERATED AT THIS INSPECTION? _____

25. DATE OF THIS INSPECTION _____

INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

CALEDONIA STREET STORMWATER PUMP STATION

1. **ACCESS ROAD** _____
2. **STORMWATER PUMP STATION:**
   a. **Doors & Locks** _____
   b. **Windows** _____
   c. **Floor** _____
   d. **Walls** _____
   e. **Roof** _____
   f. **Sump** _____
   g. **Ladders** _____
   h. **Paint** _____
   i. **Operation Diagram** _____
   j. **Operation Log Forms Available** _____
3. **FIRE HAZARDS** _____
4. **GRATINGS & ACCESS HATCHES** _____
5. **DISCHARGE WELL** _____
   a. **Flap Gates on Pump Discharge Pipes (3)** _____
6. **DISCHARGE PIPES:**
   a. **Pump Discharge Well to Flap Gate Structure** _____
   b. **Storm Water Through-Pipe to Flap Gate Structure** _____
   c. **Flap Gate Structure to River** _____
   d. **Flap Gate** _____
7. **PUMP COLUMNS** _____
8. **SUBSTATIONS & POWER LINE** _____
   (Inspected by Power Co.) _____
9. **BAR SCREENS** _____
10. **WIRING SYSTEM:**
    a. **Lamps** _____
    b. **Fuses** _____
    c. **Circuit Breakers** _____
    d. **Switches** _____
    e. **Conduit** _____
    f. **Receptacles** _____
    g. **Wire & Cable** _____
11. **SWITCHGEAR:**
    a. **Utility Circuit Breaker** _____
    b. **Generator Circuit Breaker (Auxiliary Electric Service)** _____

CALEDONIA STREET STORMWATER PUMP STATION

c. **Manual Transfer Switch** _____
d. **Pump #1 Motor Disconnect** _____
e. **Pump #2 Motor Disconnect** _____
f. **Pump #3 Motor Disconnect** _____
g. **Sump Pump #1 Motor Disconnect** _____
h. **Sump Pump #2 Motor Disconnect** _____
i. **Protective Devices** _____

12. **PUMPS: (Maintenance performed by Authorized Technicians)**
    a. **Pump #1 – General** _____
    b. **Pump #2 – General** _____
    c. **Pump #3 – General** _____
    d. **Sump Pump #1 – General** _____
    e. **Sump Pump #2 – General** _____
13. **WATER LEVEL DETECTION:**
    a. **Submersible Transducer** _____
    b. **Submersible Level Transducer Control Panel** _____
    c. **Level Detector Float Switch** _____

15. **SPARE PARTS:**

	Required	On-Hand
a. Control Panel Lamps	6	
b. Station Lighting Lamps	6	

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

CALEDONIA STREET STORMWATER PUMP STATION

16. TOOLS:

	Required	On-Hand
a. Tool Box	1	
b. Table	1	
c. Bench	1	
d. Bar Screen Rake	1	
e. Sluice Gate Wheels	3	
f. Circuit Breaker Puller	1	
g. Fuse Puller	2	
h. Grease Gun	1	
i. Electrical Tape	2	
j. Screw Drivers (Assortment)	1	
k. Crescent Wrenches (Assorted Sizes)	1	
l. Allen Wrenches	1	
m. Duct Tape	2	
n. Portable Electric Heaters	2	
o. Extension Cords – 30' Length	2	

17. EQUIPMENT OR PARTS IN NEED OF REPAIR OR REPLACEMENT _____

_____

_____

18. MOISTURE CONDITIONS IN PUMPING STATION _____

_____

19. WEATHER CONDITIONS AND TEMPERATURE _____

_____

20. REMARKS AND EXPLANATIONS _____

_____

_____

21. DATE OF LAST INSPECTION _____

22. DATES OF PUMP OPERATIONS SINCE LAST INSPECTION (TRIAL & FLOOD) _____

_____

23. WERE PUMPS OPERATED AT THIS INSPECTION? _____

24. DATE OF THIS INSPECTION _____

INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

PALMER STREET STORMWATER PUMP STATION

1. **ACCESS ROAD** _____
2. **STORMWATER PUMP STATION:**
   a. **Doors & Locks** _____
   b. **Windows** _____
   c. **Floor** _____
   d. **Walls** _____
   e. **Roof** _____
   f. **Sump** _____
   g. **Ladders** _____
   h. **Paint** _____
   i. **Operation Diagram** _____
   j. **Operation Log Forms Available** _____
3. **FIRE HAZARDS** _____
4. **GRATINGS & ACCESS HATCHES** _____
5. **DISCHARGE WELL** _____
   a. **Flap Gates on Pump Discharge Pipes (3)** _____
6. **DISCHARGE PIPES:**
   a. **From Pump Discharge Well** _____
   b. **Storm Water Through-Pipe** _____
7. **OUTFALL** _____
   a. **Storm Water Outfall Flap Gate (1)** _____
   b. **Riprap** _____
8. **PUMP COLUMNS** _____
9. **SUBSTATIONS & POWER LINE** _____
   (Inspected by Power Co.) _____
10. **BAR SCREENS** _____
11. **WIRING SYSTEM:**
    a. **Lamps** _____
    b. **Fuses** _____
    c. **Circuit Breakers** _____
    d. **Switches** _____
    e. **Conduit** _____
    f. **Receptacles** _____
    g. **Wire & Cable** _____
12. **SWITCHGEAR:**
    a. **Utility Circuit Breaker** _____

PALMER STREET STORMWATER PUMP STATION

b. Generator Circuit Breaker (Auxiliary Electric Service) _____
c. Manual Transfer Switch _____
d. Pump #1 Motor Disconnect _____
e. Pump #2 Motor Disconnect _____
f. Pump #3 Motor Disconnect _____
g. Sump Pump #1 Motor Disconnect _____
h. Sump Pump #2 Motor Disconnect _____
i. Protective Devices _____

15. PUMPS: (Maintenance performed by Authorized Technicians)
    a. Pump #1 – General _____
    b. Pump #2 – General _____
    c. Pump #3 – General _____
    d. Sump Pump #1 – General _____
    e. Sump Pump #2 – General _____
16. WATER LEVEL DETECTION:
    a. Submersible Transducer _____
    b. Submersible Level Transducer Control Panel _____
    c. Level Detector Float Switch _____

16. SPARE PARTS:

	Required	On-Hand
a. Control Panel Lamps	6	
b. Station Lighting Lamps	6	

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

PALMER STREET STORMWATER PUMP STATION

17. TOOLS:

	Required	On-Hand
a. Tool Box	1	
b. Table	1	
c. Bench	1	
d. Bar Screen Rake	1	
e. Sluice Gate Wheels	3	
f. Circuit Breaker Puller	1	
g. Fuse Puller	2	
h. Grease Gun	1	
i. Electrical Tape	2	
j. Screw Drivers (Assortment)	1	
k. Crescent Wrenches (Assorted Sizes)	1	
l. Allen Wrenches	1	
m. Duct Tape	2	
n. Portable Electric Heaters	2	
o. Extension Cords – 30' Length	2	

26. EQUIPMENT OR PARTS IN NEED OF REPAIR OR REPLACEMENT _____

_____

_____

27. MOISTURE CONDITIONS IN PUMPING STATION _____

_____

28. WEATHER CONDITIONS AND TEMPERATURE _____

_____

29. REMARKS AND EXPLANATIONS _____

_____

_____

30. DATE OF LAST INSPECTION _____

31. DATES OF PUMP OPERATIONS SINCE LAST INSPECTION (TRIAL & FLOOD) _____

_____

32. WERE PUMPS OPERATED AT THIS INSPECTION? _____

33. DATE OF THIS INSPECTION _____

INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

SUMMARY OF LEVEE, FLOOD WALL, AND DRAINAGE STRUCTURES

1. **Date of this Inspection report** _____
2. **Date of last inspection report** _____
3. **Levee:**
   a. **Unusual occurrences or remarks concerning levee inspection**

      _____
      _____
      _____
      _____
      _____

   b. **The following necessary repairs have been revealed by the levee inspection (enclose rough plan of anticipated repairs or explain)**

      _____
      _____
      _____
      _____
      _____
      _____

4. **Flood Wall:**
   a. **Unusual occurrences or remarks concerning flood wall inspection**

      _____
      _____
      _____
      _____
      _____

   b. **The following necessary repairs have been revealed by the flood wall inspection (enclose plan of anticipated repairs or explain)**

      _____
      _____
      _____
      _____
      _____
      _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

SUMMARY OF LEVEE, FLOOD WALL, AND DRAINAGE STRUCTURES

5. **Drainage Structures:**
   a. **Unusual occurrences or remarks concerning drainage structures inspection**

   _____
   _____
   _____
   _____
   _____

   b. **The following necessary repairs have been revealed by the drainage structures inspection (enclose plan of anticipated repairs or explain)**

   _____
   _____
   _____
   _____
   _____

6. **At what date (state specific date) will the responsible City division perform the above repairs?**

   _____

7. **Remarks and Explanations**

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

   No. of Additional Sheets _____

Signed _____

Superintendent of Flood Protection Works
City of Grand Rapids

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

	Location (Station)	Condition	Type of Maintenance Required
1. Settlement or loss of grade			
2. Bank caving (either side of levee)			
3. Rain, wave or current wash			
4. Seepage, sloughing, saturated areas or sand boils			
5. Have the areas identified in Item 4 been marked on the ground?			

*** Insert river station number or name of street, railroad, or other descriptive levee landmark.**

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

6. Low spots, ponding areas			
7. Crown of levee			
8. Riprap			
9. Access roads and road ramps, surfacing			
10. Grass or sod on crown, slopes and berms			

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

11. Weeds or undesirable vegetation			
12. Accumulation of drifts, trash or debris			
13. Damage due to fire			
14. Damage due to rodents			
15. Trespassing on right-of-way (encroachment, excavation, dumping or construction)			

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

16. Miscellaneous

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

17. Remarks and explanations _____

_____

_____

_____

_____

_____

_____

No. of additional sheets _____

18. DATE OF LAST INSPECTION _____

19. DATE OF THIS INSPECTION _____

20. INSPECTOR _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

CONCRETE FLOOD WALL

INSPECTION COVERS STATION* _____ TO _____

	Location (Station)	Condition	Type of Maintenance Required
1. Settlement			
2. Bank caving			
3. Seepage, saturated areas or sand boils			
4. Have the areas identified in Item 3 been marked on the ground?			
5. Grass or sod on berm			
6. Accumulation of drift, trash or debris			
7. Bituminous monolith joints and waterstops			

*** Insert river station number or name of street, railroad, or other descriptive levee landmark.**

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – GRAND RAPIDS, MICHIGAN

CONCRETE FLOOD WALL

INSPECTION COVERS STATION* _____ TO _____

8. Concrete at joints			
9. Concrete wall (cracking, spalling or breaking)			
10. Evidence of fires built near wall			
11. Trespassing or right-of-way (encroachment, excavation, dumping, or construction)			
12. Miscellaneous			

13. Remarks and explanations _____

_____

_____

_____

_____

_____

_____

No. of additional sheets _____

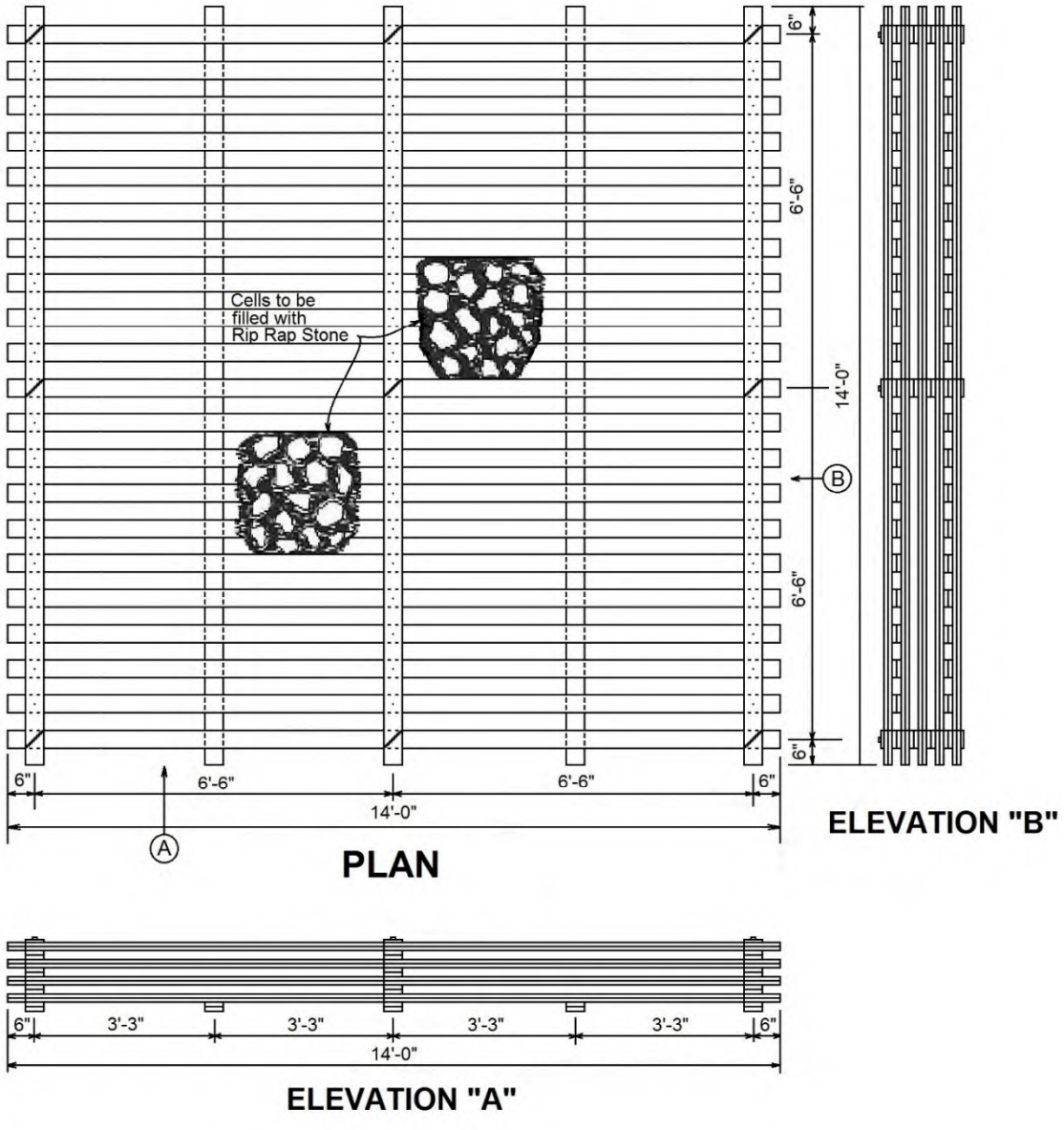
14. DATE OF LAST INSPECTION _____

15. DATE OF THIS INSPECTION _____

16. INSPECTOR _____

Appendix 3

Grand Rapids Flood Protective System
Figures – Earth Embankment (Levee) and Floodwall Remedial Measures



NOTE:

Cribs constructed of double thicknesses of 1" X 4" X 14' lumber. Nail all intersections with 1-20d. nail. Each intersection of walls securely fastened by a loop of 1/4" strand, tightly twisted. If rock or concrete blocks are unobtainable, sacks filled with gravel or soil cement may be used.

BILL OF MATERIALS

Dimensions based on rough cut lumber

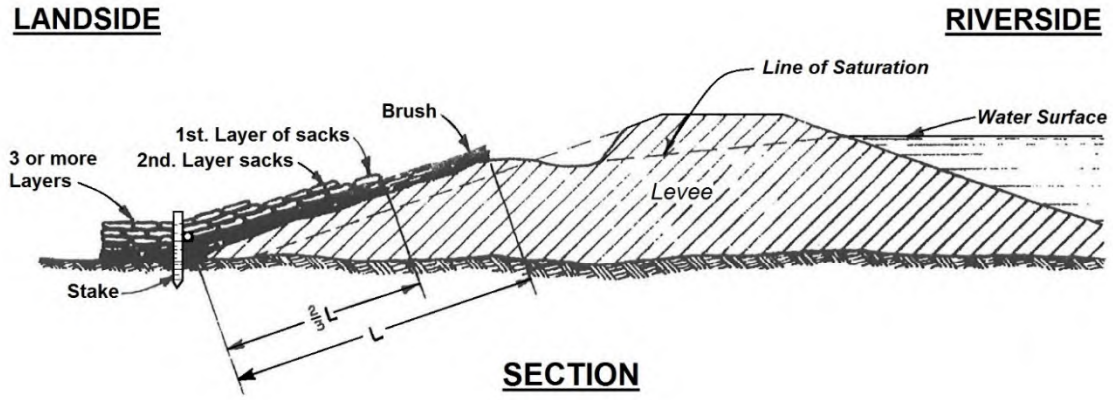
140 Pcs. 1" X 4" X 14' = 653 Bd. Ft.
12 Lbs. 20d. Common Nails
60 Ft. 1/4" Strand
1-1/2 Cu. Yds. Rip Rap Stone
Actual quantities. No allowance for waste.

FIGURE 1

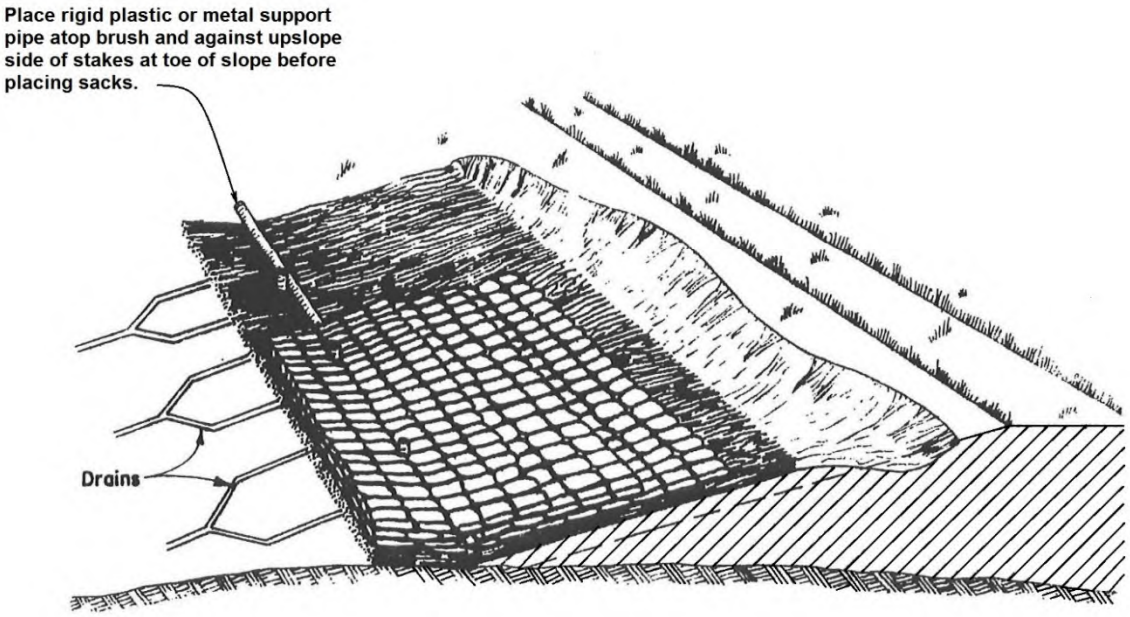
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE CAVING BANK PROTECTION

ROCK-FILLED CRIB



SECTION

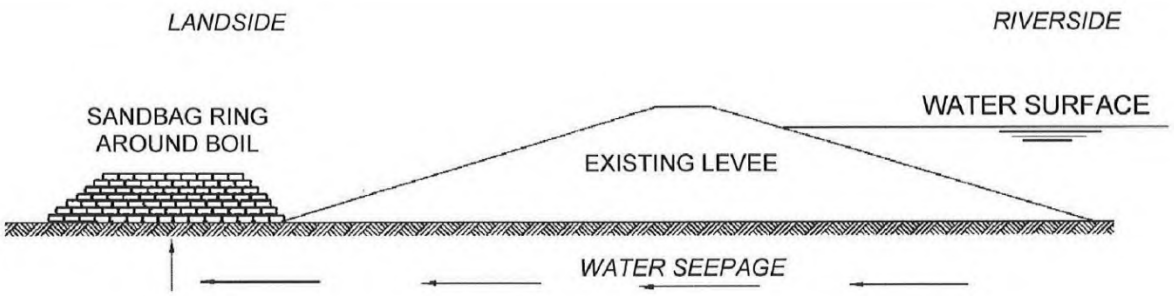


NOTE:
Cut V-Shaped drains no deeper than necessary and not more than 6" deep. Sandbags should be only 2/3 full.

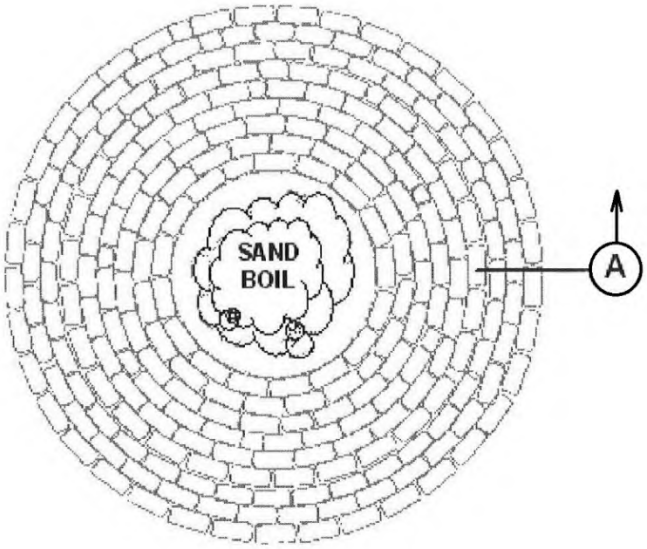
FIGURE 2
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
SLOUGHING

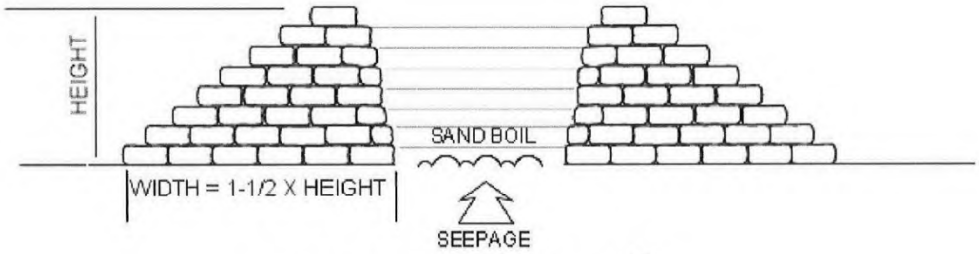
SANDBAG & BRUSH MAT



ELEVATION



PLAN VIEW



SECTIONAL ELEVATION — A

NOTES:

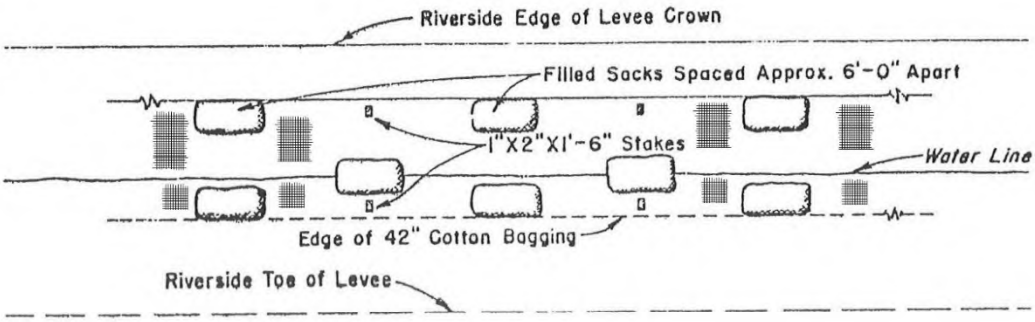
1. Do not sack a boil that does not eject soil material and whose flow is small.
2. Prepare base of sack ring by clearing debris, sod, loose soil or other objectionable material and scarify base.
3. Tamp sand bags into place.
4. Loose soil to be used between all sacks.
5. All sack joints to be staggered.
6. Bottom width to be no less than 1-1/2 times the height. Tie into levee if boil is near toe.
7. Height of sack ring should be only sufficient to create enough head to slow down flow through boil so that no more soil material is displaced and boil runs clear.
8. Never attempt to completely stop flow through boil.
9. Carry off water by omitting one sack in top layer or construct a "V"- shaped drain of boards or sheet metal to protect slope of sack ring.

FIGURE 3

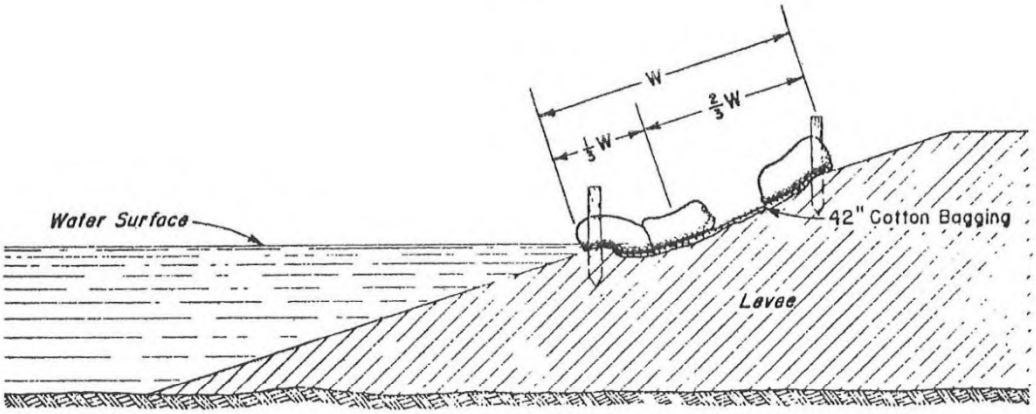
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
SAND BOIL

SACKED EARTH RING



PLAN



SECTION

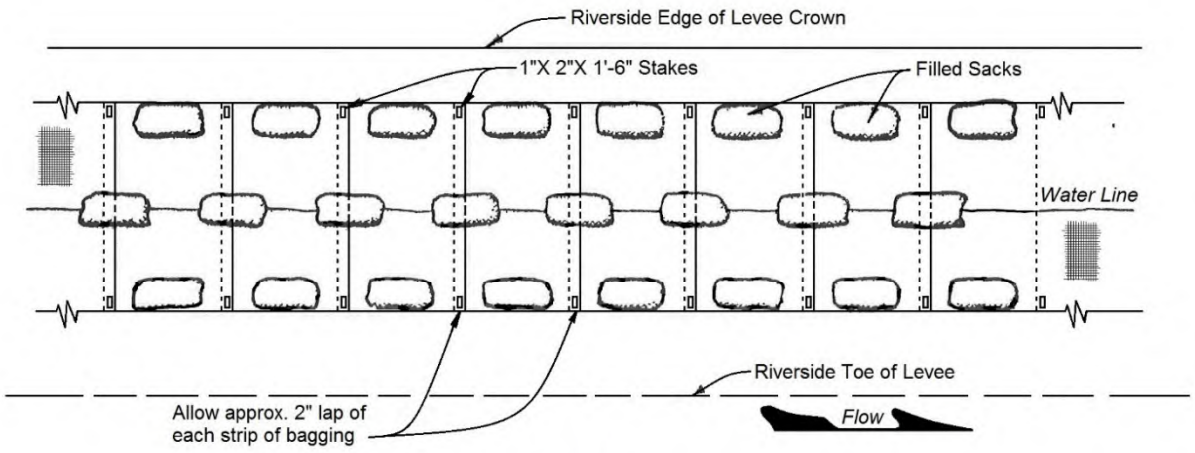
BILL OF MATERIAL TO CONSTRUCT 180 FEET OF PROTECTION		
LUMBER	BAGGING	SANDBAGS
60 - 1"X 2"X 1'-6" Stakes (Sharpened)	One roll regular (jute) Cotton Bagging 42" X 180'- 0"	90 - Filled Sacks

INSTRUCTIONS:
1. Lay 42" cotton bagging (jute) longitudinally along riverside slope of levee with approximate 2/3 width above water surface.
2. Weight bagging along edges and at water surface with filled sacks spaced approximately 6' apart. Drive stakes alternately between sacks along both edges of bagging.
3. If additional width is required, lace two or more widths of bagging together and lay as desired.
4. Plastic sheeting or burlap may be substituted for cotton bagging.

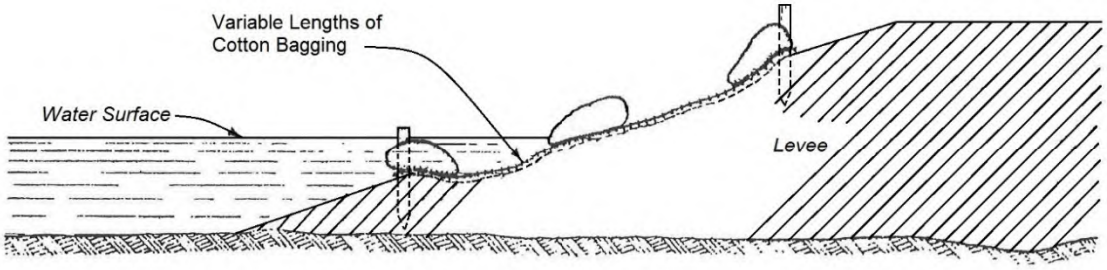
FIGURE 4
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

SANDBAG & COTTON BAGGING - NO. 1



PLAN



SECTION

Notes:

1. Lay lengths as required of Cotton Bagging approximately parallel with levee slope and across damaged section.
2. Lap strips with river current to prevent lifting.
3. Weight top and edges of bagging with filled sacks as shown above.
4. The filled sacks should be wired or tied to each strip before laying in place.
5. Stake the corners of each strip above the water surface
6. Plastic sheeting or burlap may be substituted for cotton bagging.

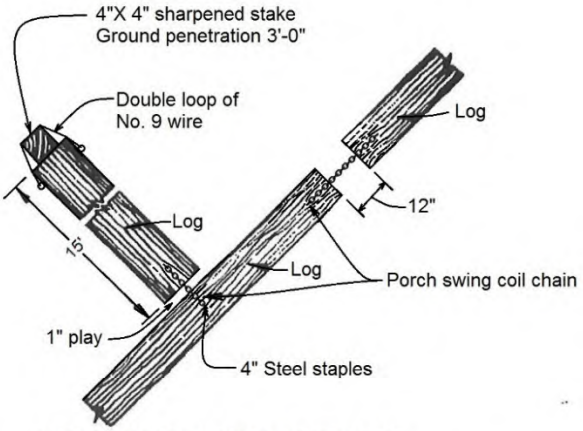
BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
120 pieces 1"X 2" x 1'-6" (Sharpened)
SANDBAGS
180 Filled Sacks Cotton Bagging as Required

FIGURE 5

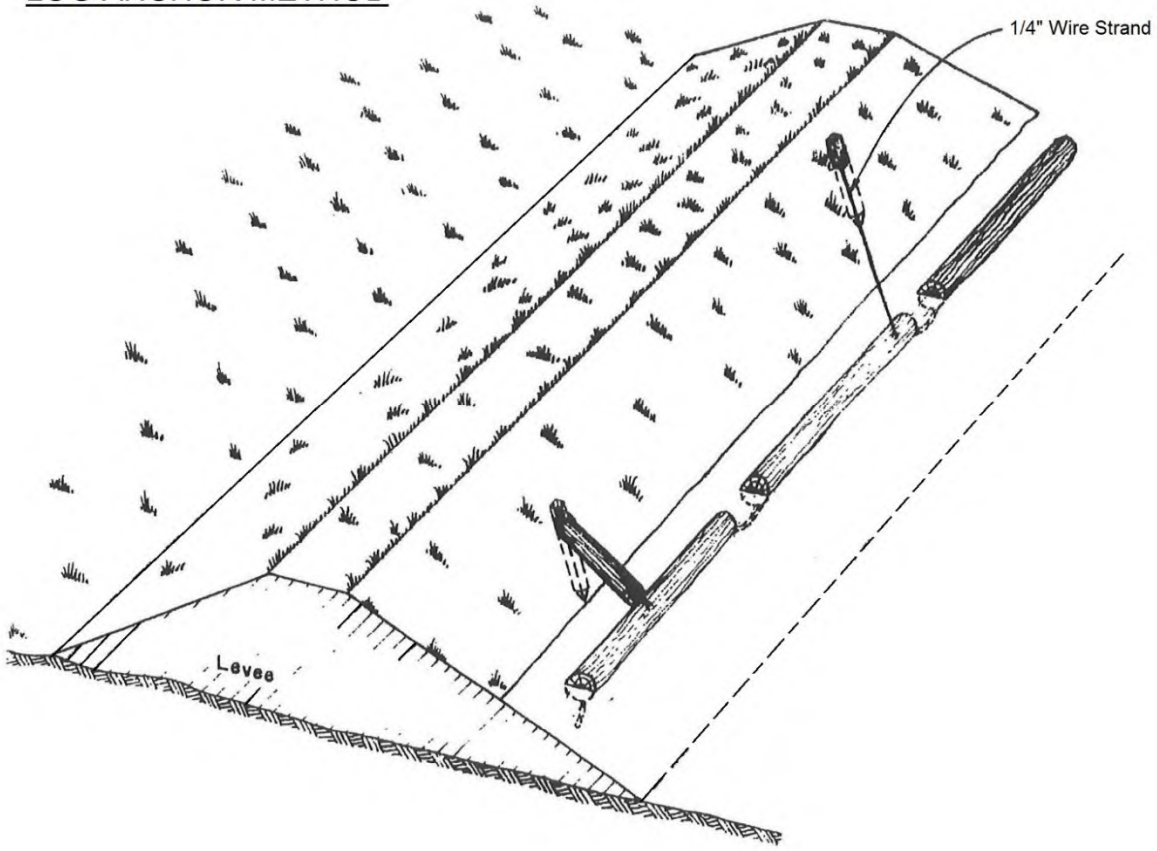
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE WAVE WASH PROTECTION

SANDBAG & COTTON BAGGING - NO. 2



LOG ANCHOR METHOD



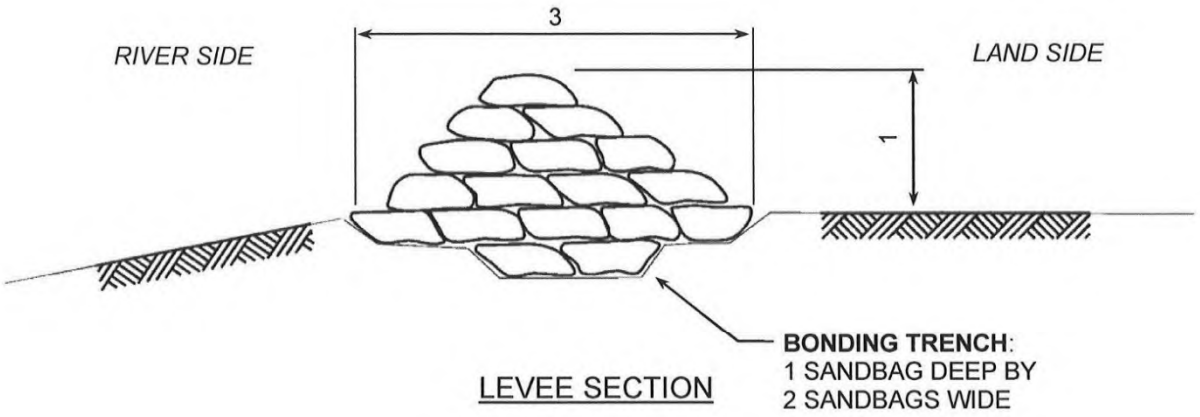
Notes:
1. Do not drive steel staples all the way in. Staples should protrude sufficiently to allow enough play for rotation of logs.
2. Substitute 3 doubled loops of No. 9 wire if porch swing coil chain is not available.
3. Anchor logs spaced a maximum of 50' apart.

FIGURE 6

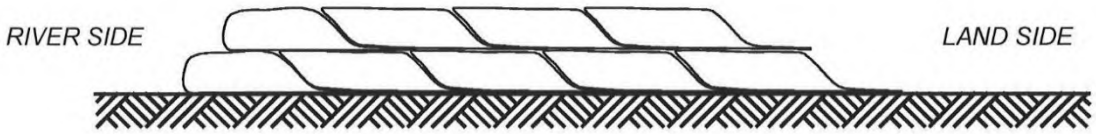
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

LOG BOOM



LEVEE SECTION



METHOD OF LAPPING SACKS

LEVEE HEIGHT	NUMBER OF SAND BAGS REQUIRED FOR LENGTH OF LEVEE									
	50 FT	100 FT	175 FT	200 FT	250 FT	300 FT	350 FT	400 FT	450 FT	500 FT
1 Foot	300	600	1,050	1,200	1,500	1,800	2,100	2,400	2,700	3,000
2 Feet	1,050	2,100	3,675	4,200	5,250	6,300	7,350	8,400	9,450	10,500
3 Feet	2,250	4,500	7,875	9,000	11,250	13,500	15,750	18,000	20,250	22,500
4 Feet	3,900	7,800	13,650	15,600	19,500	23,400	27,300	31,200	35,100	39,000
5 Feet	6,000	12,000	21,000	24,000	30,000	36,000	42,000	48,000	54,000	60,000

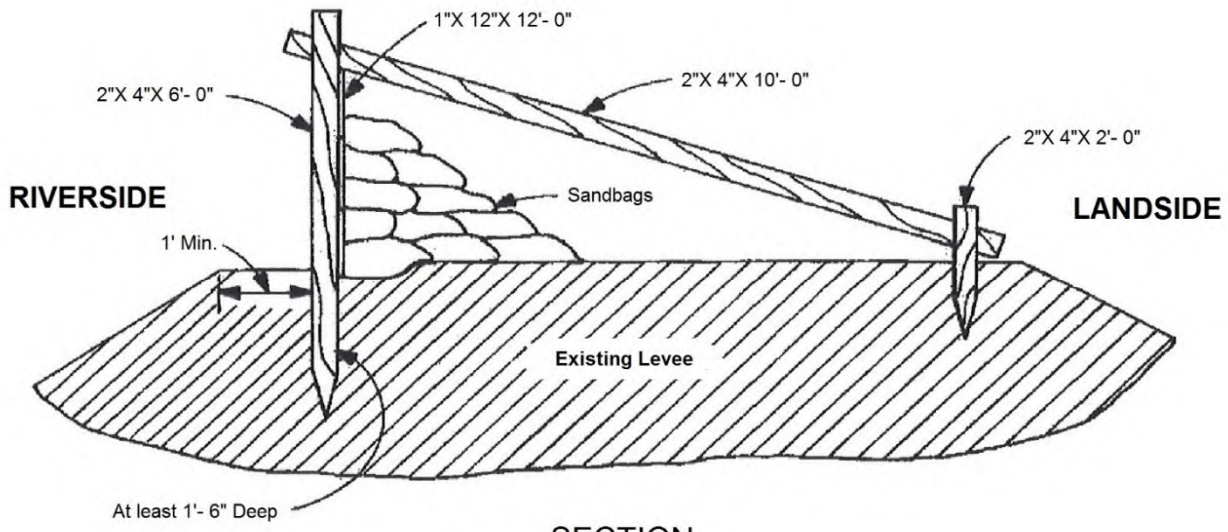
Notes:
1. Start upstream.
2. Strip sod before laying.
3. Alternate direction of sacks with bottom layer parallel to flow.
4. Next layer perpendicular to flow with open ends of sacks directed away from wet side.
5. Lap unfilled portion under next sack.
6. Tying of sewing sacks is not necessary.
7. Tamp thoroughly in place. Sacks should be approximately 1/2-full of sand or earth.
8. Width of sack levee should be 3 times the height.

FIGURE 7

CITY OF GRAND RAPIDS, MICHIGAN

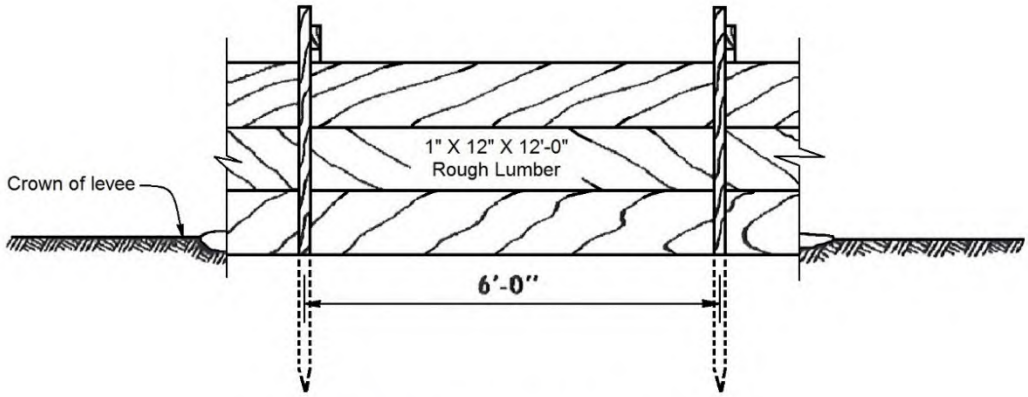
HIGH WATER MAINTENANCE OVER TOPPING

SANDBAG TOPPING



SECTION

* **Note:**
Earth fill may be substituted for sacked earth in times of emergency.



RIVERSIDE ELEVATION

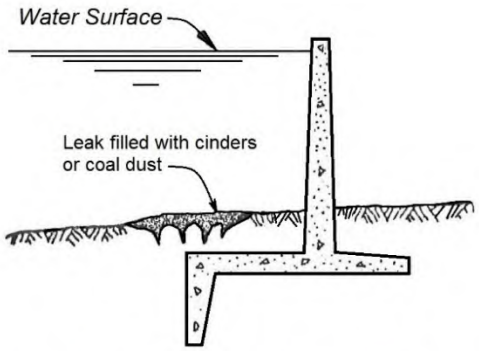
BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
25 pieces 1" X 12" X 12' 17 pieces 2" X 4" X 10' 17 pieces 2" X 4" X 6'** 17 pieces 2" X 4" X 2'** ** (Sharpened)
NAILS
1 lb. 8d nails 2 lbs. 16d nails
SANDBAGS
1100 bags

FIGURE 8

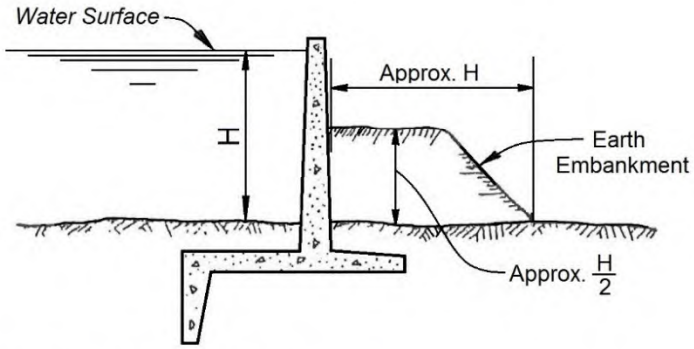
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE OVER TOPPING

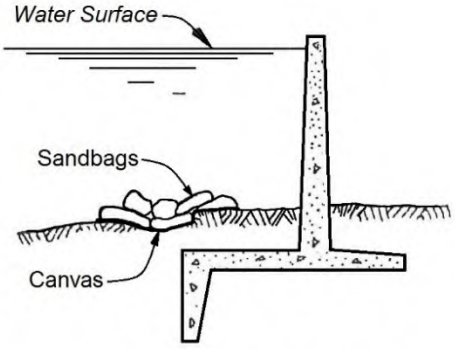
LUMBER AND SACK TOPPING



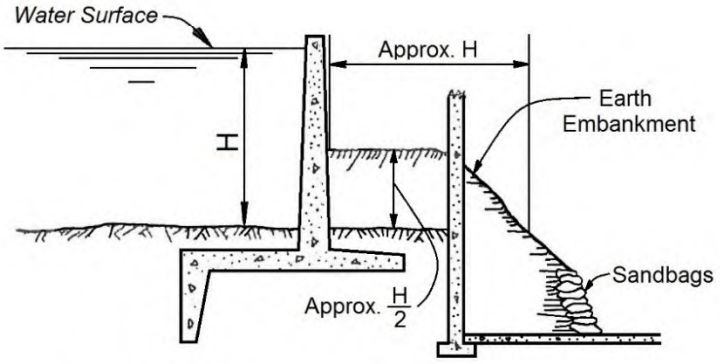
(A) Small leaks sealed with cinders, coal dust, etc.



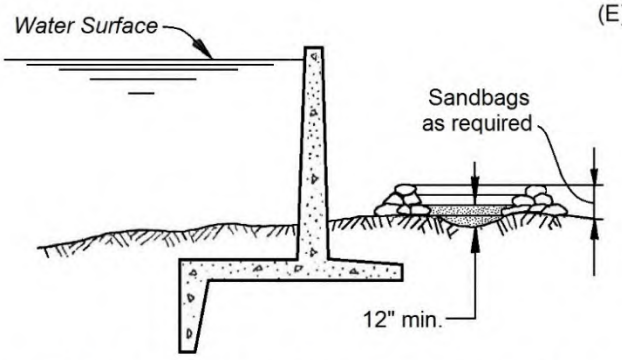
(D) Wall stabilized by earth embankment
(Preferably sand or sand and gravel)



(B) Larger holes covered with canvas sunk
and weighted by sandbags



(E) Wall stabilization when close to deep basement
Note: Struts should not be used except
against base or immediately above.



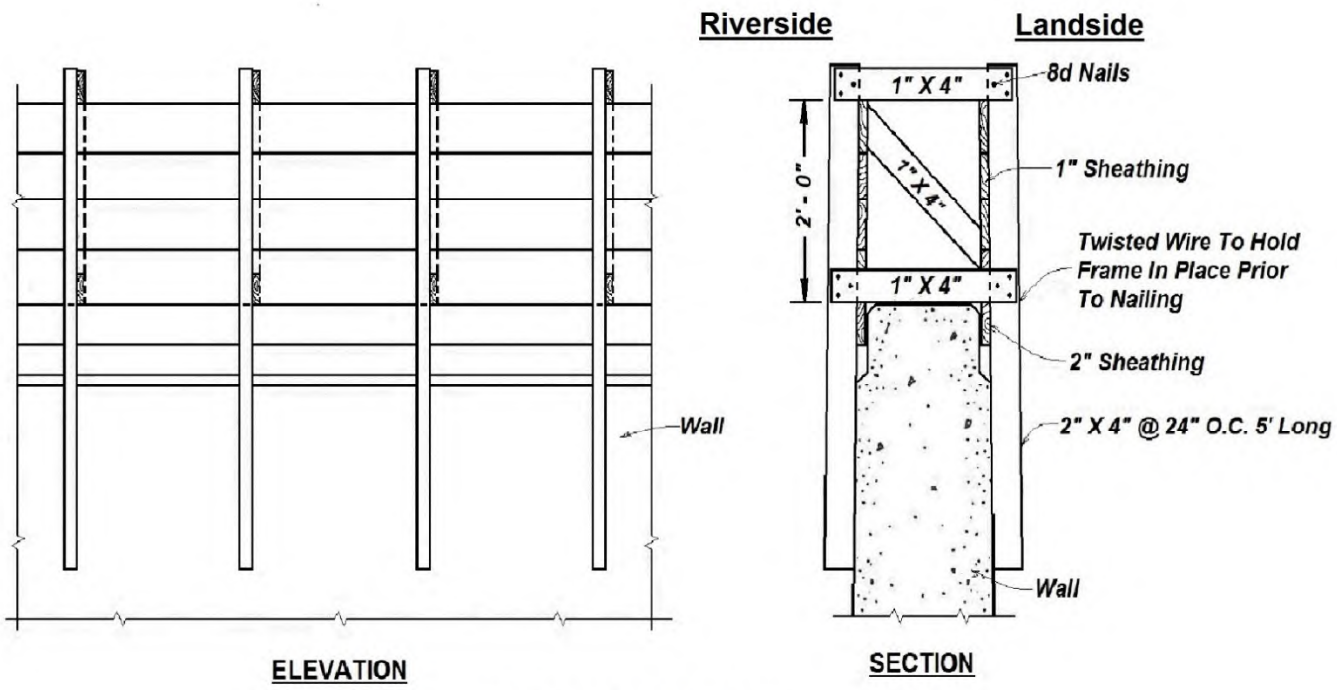
(C) Landside boils ringed with sandbags as required. Boil area
within ring to be covered with 12" min. pervious material
(bank-run gravel, etc.)

FIGURE 9

CITY OF GRAND RAPIDS, MICHIGAN

FLOODWALL

SEEPAGE & STABILIZATION CORRECTIVE MEASURES



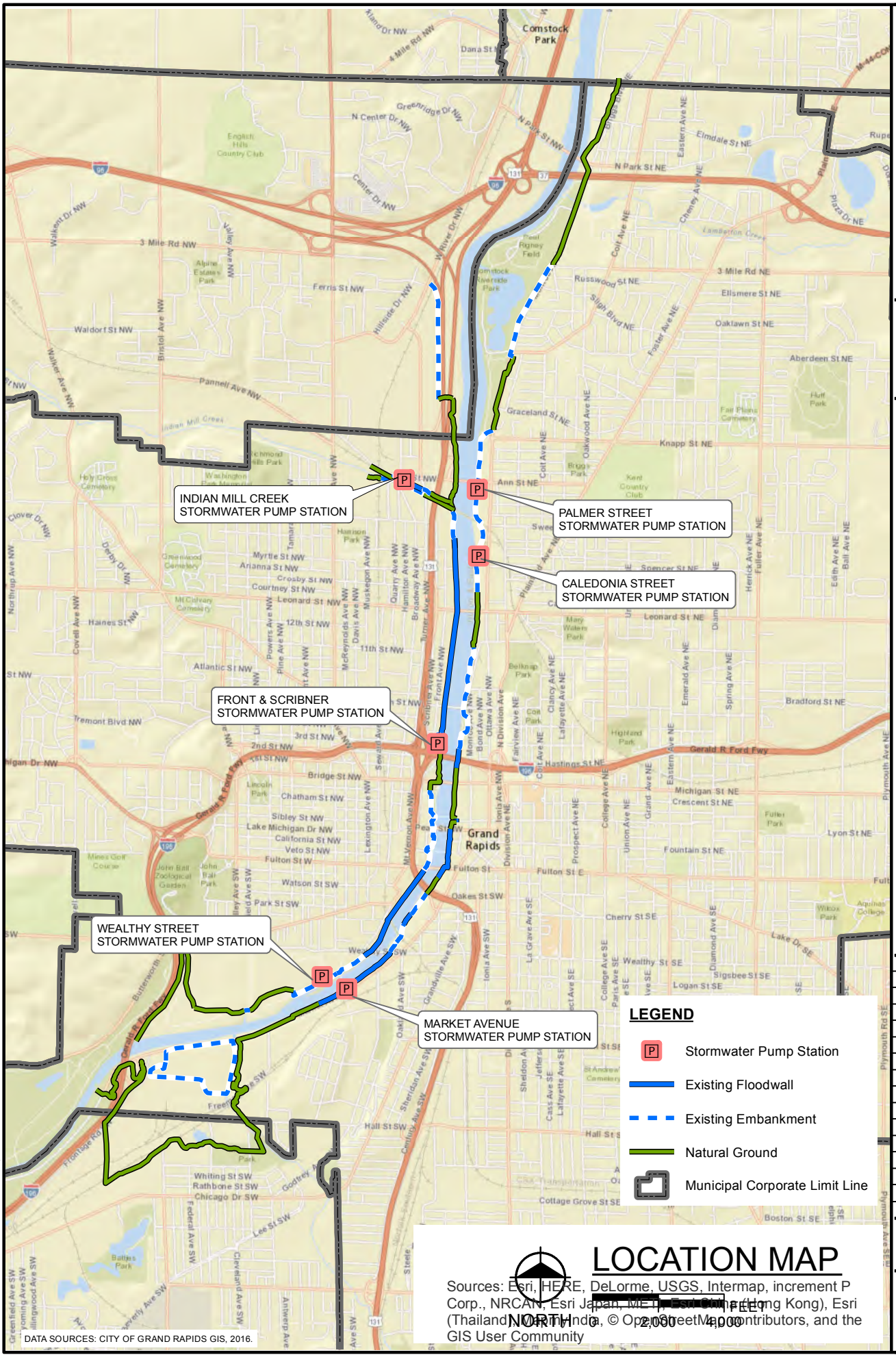
TYPICAL WALL

FIGURE 10

CITY OF GRAND RAPIDS, MICHIGAN

FLOODWALL

FLOODWALL EXTENSION



LOCATION MAP

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

DATA SOURCES: CITY OF GRAND RAPIDS GIS, 2016.

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Flood Protection and Lift Station Location OMM.mxd Date: 4/24/2017 11:39:34 AM User: mcl

fishbeck

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 8.5"x11" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

City of Grand Rapids
Kent County, Michigan

Grand River Flood Protection System

PROJECT NO.
G120330LMP

FIGURE NO.
11

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Appendix 4

Grand Rapids Flood Protective System
Operations To Be Performed At Various River Stages

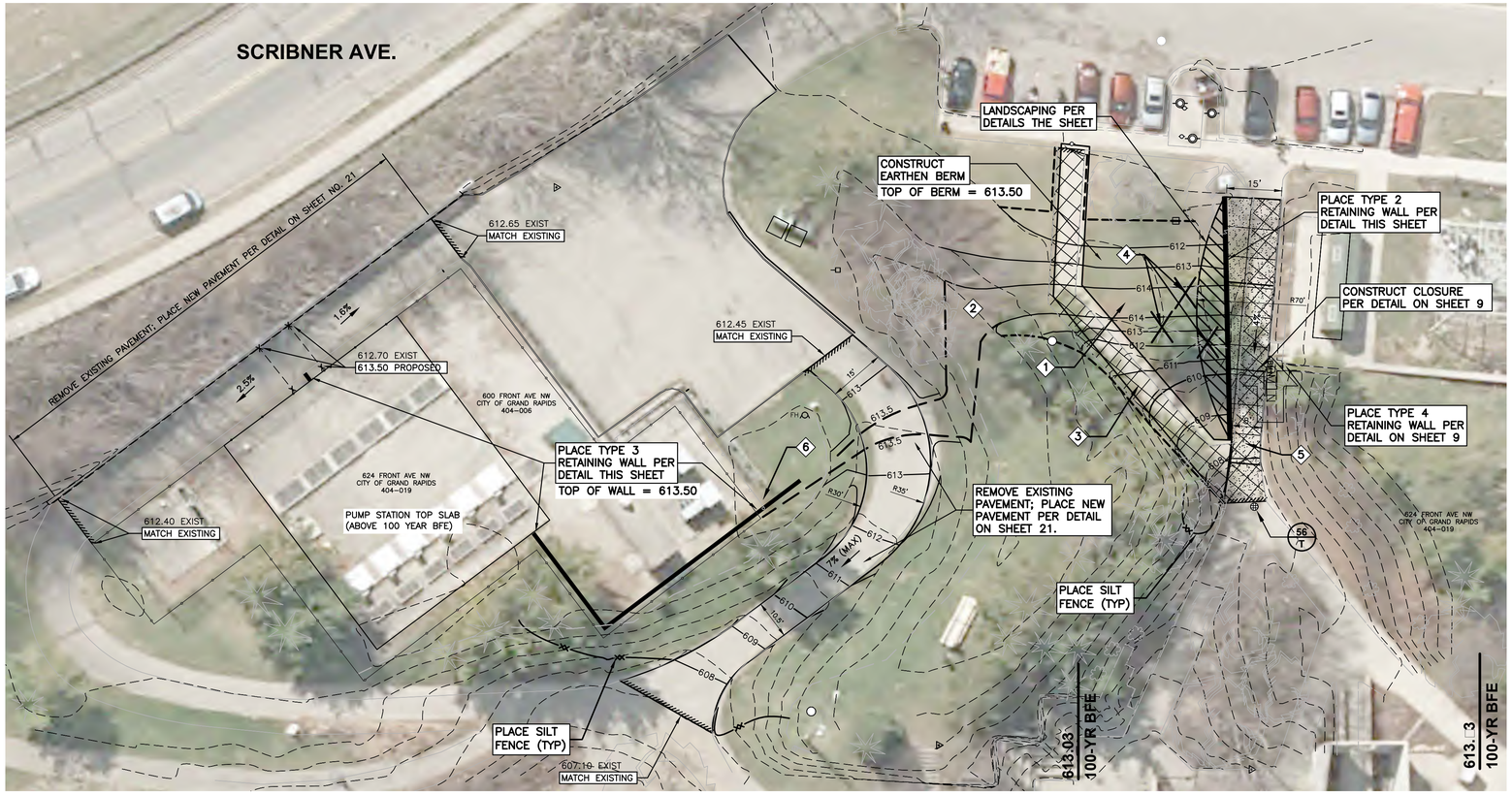
Flood Protection System - Operations, Maintenance & Inspection Manual
Operations to be Preformed at Various River Stages

Item No.	Address/Item	Location of Item	Description of Item	Critical Elevation (when problem occurs)		Action Required	Materials Needed (during 100-year event)	Equipment Needed (to deliver and onsite)	Responsible Department
				USGS Flood Stage (at Blue Bridge) 100-year = 25.36	NAVD 88 (at Location of Item)				
1	Storm Water Valve MH castings in Berm at WRRF	**East Side** - WRRF	Two 24" and two 12" storm sewers enter the WWTP from the CSX property to the south. The CSX property is below the the BFE. There are valves on these sewers in the grass embankment between the asphalt drive and perimeter fence. If these valves are open during an extreme flood the WRRF is susceptible to flooding.	19.9	602.0	Close all four valves.	None	2" Square valve key	Environmental Services Department
2*	Underground Tanks at WWRF	East Side - WRRF	Partially filled tanks can become bouyant if groundwater levels are high.	12.0	581.8 groundwater elevation	Check groundwater level around empty or partially empty tanks. Fill tanks as necessary per WWTP O&M Manual.	None	None	Environmental Services Department
3*	Primary Effluent Retention Basin at WWRF	East Side - WRRF	High groundwater levels may exceed the underdrains ability to keep the basin from floating.	12.0	588.8 groundwater elevation	Fill basin to the same elevation and the Grand River level.	None	None	Environmental Services Department
4	East Side Interceptor	**East Side** - Along Eastside of Grand River from MARB to Pearl Street	When the river rises the East Side Interceptor may become bouyant. The pipe is 12' wide and 11.25' tall and is cast-in-place concrete. The invert elevation at the Market Avenue Pump Station is approximately 584.0. The normal water level in the pipe is approximately 24".	12.0	594.5	Keep water level in East Side Interceptor no lower than 15 feet below the Grand River.	None	None	Environmental Services Department
5	240 Front Avenue	**West Side** - Floodwall between Letellier and Emperor Streets (Outfall 83D)	4" core in floodwall for driveway drainage	21.0	604.8	Install 4" inflatable sewer plug.	• 4" inflatable sewer plug = 1 Stored at Wastewater Treatment Plant	Small air compressor	Environmental Services Department
6	242 Front Avenue (Chesapeake & Ohio Railroad)	**West Side** - RR Bridge between Emperor and Butterworth Streets	The top off railroad ballast is slightly below the BFE.	24.5	608.6	Install prefabricated closure.	• prefabricated temporary closure Stored at Wastewater Treatment Plant	Flat bed delivery truck	Environmental Services Department
7*	Fulton/Monroe/Market Avenue Intersection	**East Side** - Fulton/Monroe/Market Avenue Intersection	The area is susceptible to shallow flooding, less than 12 inches in depth, should an extreme rainfall event occur during an extreme flood.	23.5	607.6	Close roads and/or connect portable pumps to quick connect located in chamber outside the curbline at the northeast corner of the intersection and pump water from intersection. (Pump hose to fit Andrews #600B 6" male N.P.T. aluminum quick coupler)	• Sandbags = 3,000 Sand = 28 cyd	• Portable pumps • Flat bed delivery truck • Fork lift	• Traffic Safety Environmental Services Department
8*	Bond Avenue at Newberry Street	**East Side** - Bond Avenue at Newberry Street	The area is susceptible to shallow flooding, less than 12 inches in depth, should an extreme rainfall event occur during an extreme flood.	24.0	612.7	Close roads and/or drain area with portable pumps.	• Sandbags = 3,000 Sand = 28 cyd	Portable pumps	• Street Maintenance Department • Environmental Services Department
9	624 Front Avenue (Fish Ladder Park)	**West Side** - Front Avenue and 4th Street	The sidewalk from the parking lot to the Fishladder is not high enough for extreme flood events.	23.5	611.0	Erect closure by placing aluminum stop logs into guides cast in retaining walls on either side of the sidewalk.	Aluminum stop logs stored at Front Avenue Stormwater Pumping Station	Flat bed delivery truck	Environmental Services Department
10	678 Front Avenue	**West Side** - Floodwall south of 6th Street (Outfalls 109C & 109D)	5" core in floodwall for riverwalk drainage & 4" transformer vault drain.	21.0	609.6	Install 4" & 5" inflatable sewer plugs.	• 4" inflatable sewer plug = 1 • 5" inflatable sewer plug = 1 Stored at Wastewater Treatment Plant	Small air compressor	Environmental Services Department
11*	Myrtle Street from Grand River to Scribner Avenue	**West Side** - Myrtle Street from Grand River to Scribner Avenue	The area is susceptible to shallow flooding, less than 12 inches in depth, should an extreme rainfall event occur during an extreme flood.	20.0	611.0	Close roads and/or drain area with portable pumps.	• Sandbags = 10,000 Sand = 195 cyd	Portable pumps	Environmental Services Department
12*	Jennette Avenue and Silvia Street	**West Side** - Jennette Avenue and Sylvia Street intersection	Shallow flooding occasionally occurs at high Indian Mill Creek flood staeg.	NA	620.8	Close intersection.	• Type 3 Lighted Barricades = 4 • Sandbags = 50 cyd	Flat bed delivery truck	Street Maintenance Department
13*	525 Ann Street	**West Side** - Jeanette Avenue and Sylvia Street intersection.	Trench drain for loading dock	24.5	615.2	Construct 150' of sandbag berm (1' to 1.5')	• Sandbags = 2,250 Sand = 21 cyd	Flat bed delivery truck	Environmental Services Department
14*	2201 & 2401 Monroe Avenue (Riverside Park)	**East Side** - Guild Avenue entrance drive to Riverside Park	The Guild Avenue entrance drive is below the BFE. If river levels area high enough Monroe Avenue will flood between Melbourne Street and 3 Mile. The houses on the eastside of Monroe Avenue in this same stretch are also at risk of flooding, particular homes between Guild Street and Boltwood Drive that have first floors lower than the BFE. These are: 2342 through 2526 Monroe Avenue; 37 Katherine Drive; 28 & 45 Pershing Drive; 64 Parklane Drive; 100 Boltwood Drive.	23.0	614.9	Construct 100' of sandbag berm (0' to 3') across Guild entrance drive.	• Sandbags = 4,500 Sand = 42 cyd	Flat bed delivery truck high low	Environmental Services Department
15*	2201 & 2401 Monroe Avenue (Riverside Park)	**East Side** - Guild Avenue to 3 Mile Road	The existing flood control berm is slightly lower than the BFE. If the river levels are high enough and same issue described in item 15 will result.	23.5	614.4	Construct 3,000' of 2' highh sandbag berm on top of existing berm from Guild to Three Mile.	• Sandbags = 63,000 Sand = 585 cyd	Flat bed delivery truck high low	Environmental Services Department
16*	Elmdale Street @Grand River (Sanitary Lift Station)	**East Side** - Elmdale Street @ Grand River	The river can over to the wetwell. It is also above the level of floor drains or houses contributory to the lift station.	22.0	615.8	If river is over wet well, turn off pumps.	None	None	Environmental Services Department
17*	Elmdale Street @ Grand River	**East Side** - Elmdale Street @ Grand River	This street frequently floods when the Grand River is at flood stage. Also subject to flooding due to sewer surcharging.	16.0	609.5	Close roadways.	• Type 3 Lighted Barricades = 3 • Sandbags = 4 cyd	Flat bed delivery truck	Environmental Services Department

* Flood control measures beyond those required to meet minimum certification requirements; not included in Emergency Action Plan.

Appendix 5

Fish Ladder Park Closure Structure



GRAND RIVER

APPROXIMATE FILL VOLUME = 210 CYD

BENCHMARK

BENCHMARK N ELEVATION: 609.67

CHISELED SQUARE ON SE CORNER OF FIRST CONCRETE STEP, 10 FEET SOUTH AND 6 FEET EAST OF SE CORNER OF RESTROOM BUILDING AT FISH LADDER PARK

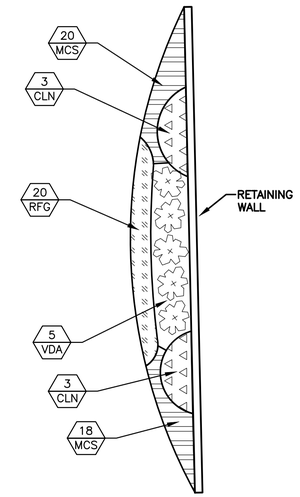
NORTH

SCALE

PLAN: 1"=20'

PLANT LIST

	KEY	BOTANICAL NAME	COMMON NAME	SIZE	ROOT	SPACING
ORNAMENTAL GRASSES	CLN	CHASMANTHIUM LATIFOLIUM	NORTHERN SEA OATS	1 GAL.	CONT.	24" O.C.
PERENNIALS	MCS	MONARDA 'CAMBRIDGE SCARLET'	CAMBRIDGE SCARLET BEE BALM	1 GAL.	CONT.	18" O.C.
	RFG	RUDBECKIA FULGIDA 'GOLDSTURM'	BLACK EYED SUSAN	1 GAL	CONT.	18" O.C.
SHRUBS	VDA	VIBURNUM DENTATUM	ARROWWOOD VIBURNUM	3 GAL.	CONT.	60" O.C.



KEY NOTES

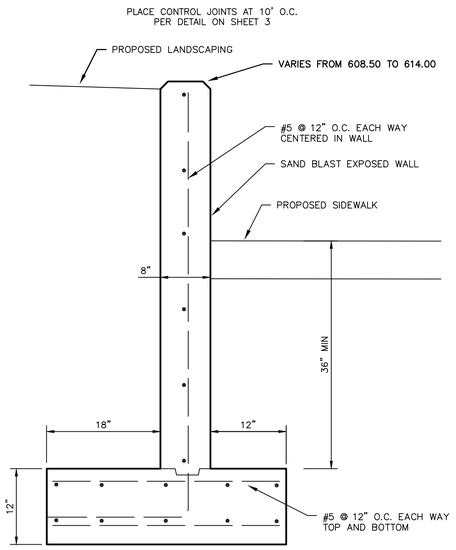
1. REMOVE SOD AND TOPSOIL FROM NEW GRADING AREA. PLACE FILL TO ACHIEVE NEW ELEVATIONS AS SHOWN. TOP OF BERM = 614. PLACE 4" TOPSOIL AND SOD DISTURBED AREAS.
2. PLACE 4" TOPSOIL AND SEED DISTURBED AREAS.
3. REMOVE EXISTING CONCRETE WALK AND GRAVEL BASE.
4. REMOVE EXISTING PINE TREES.
5. PLACE 6" THICK CONCRETE WALK. SAWCUT 8'x8' SQUARES (MAX)
6. REMOVE AND REINSTALL FENCE AND GUARD RAILING.

SOIL EROSION AND SEDIMENTATION CONTROL

1. SEE SHEET 20 FOR SOIL EROSION AND SEDIMENTATION CONTROL NOTES AND DETAILS.
2. PREDOMINANT SOILS TYPE: URBAN LAND (NRCS WEB SOIL SURVEY)
3. PROXIMITY TO GRAND RIVER: 50 FEET

LANDSCAPING DETAIL

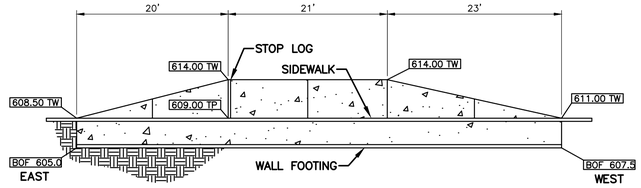
NO SCALE



CONCRETE RETAINING WALL - TYPE 2

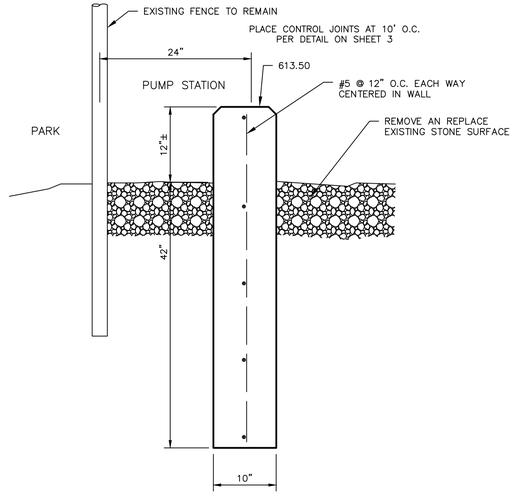
(624 FRONT AVE.)

SCALE: 1"=1'



RETAINING WALL - ELEVATION VIEW

SCALE: 1"=10'



CONCRETE RETAINING WALL - TYPE 3

(624 FRONT AVE.)

NO SCALE

624 FRONT AVENUE FISH LADDER PARK

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

Drawn by NRT	GPF No.	Sheet No.
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Check: Office		

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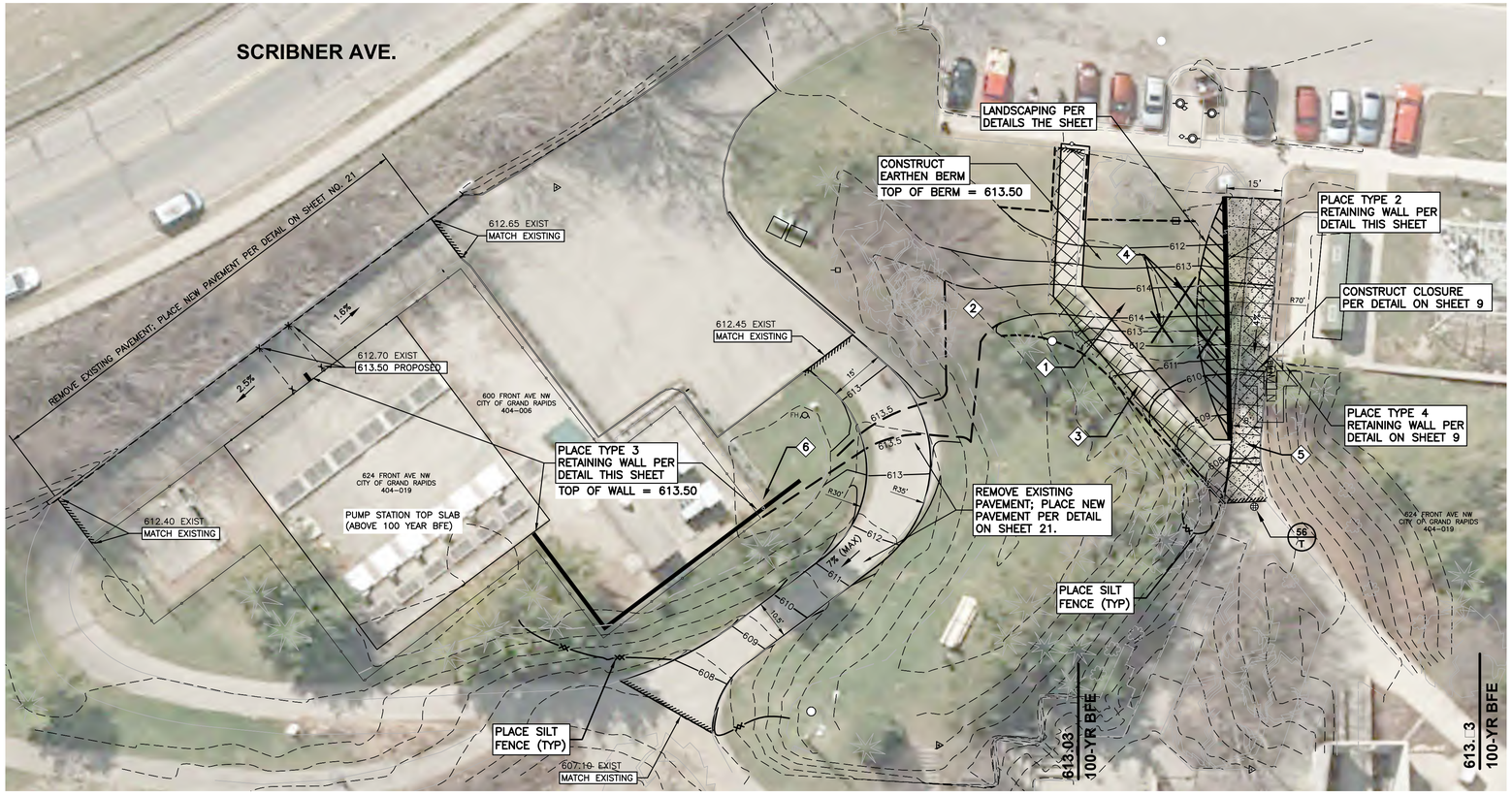

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BENCHMARK

BENCHMARK N ELEVATION: 609.67

CHISELED SQUARE ON SE CORNER OF FIRST CONCRETE STEP, 10 FEET SOUTH AND 6 FEET EAST OF SE CORNER OF RESTROOM BUILDING AT FISH LADDER PARK

NORTH

SCALE

PLAN: 1"=20'

PLANT LIST

	KEY	BOTANICAL NAME	COMMON NAME	SIZE	ROOT	SPACING
ORNAMENTAL GRASSES	CLN	CHASMANTHIUM LATIFOLIUM	NORTHERN SEA OATS	1 GAL.	CONT.	24" O.C.
PERENNIALS	MCS	MONARDA 'CAMBRIDGE SCARLET'	CAMBRIDGE SCARLET BEE BALM	1 GAL.	CONT.	18" O.C.
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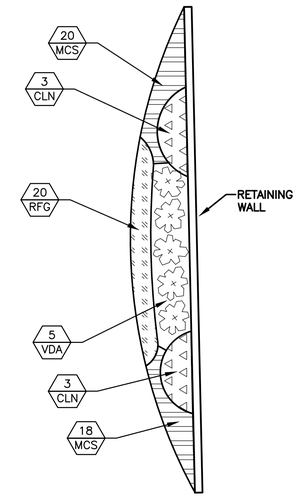

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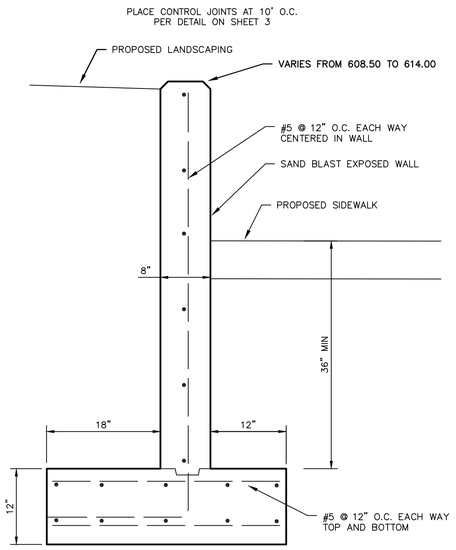
3. PROXIMITY TO GRAND RIVER: 50 FEET

LANDSCAPING DETAIL

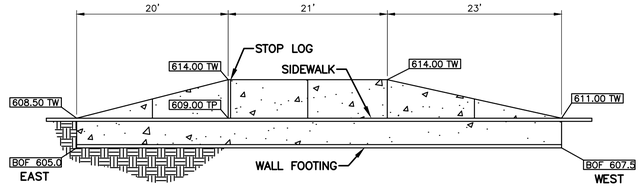
NO SCALE



CONCRETE RETAINING WALL - TYPE 2

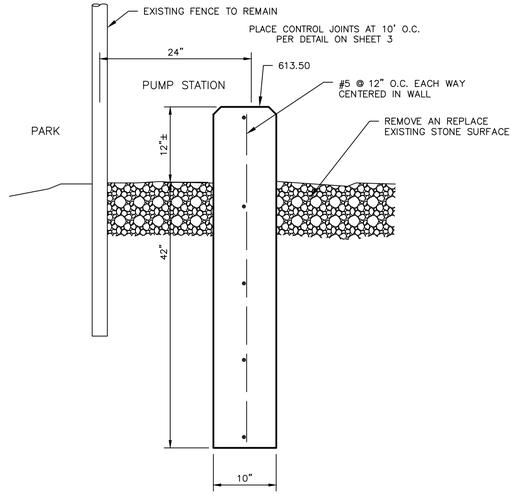
(624 FRONT AVE.)

SCALE: 1"=1'



RETAINING WALL - ELEVATION VIEW

SCALE: 1"=10'



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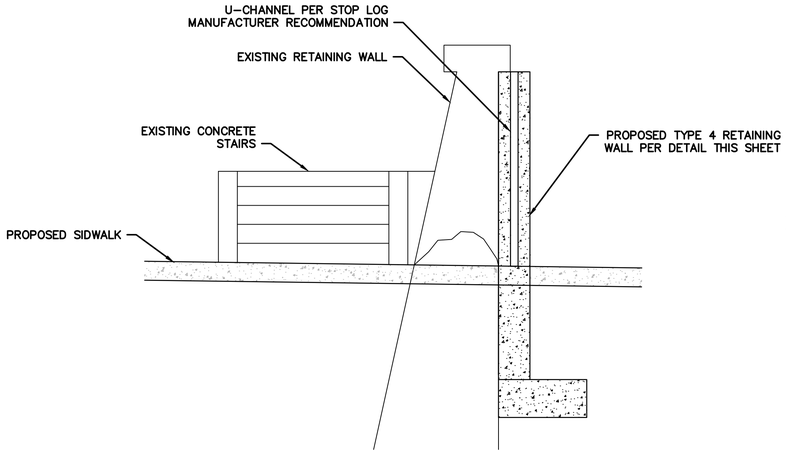
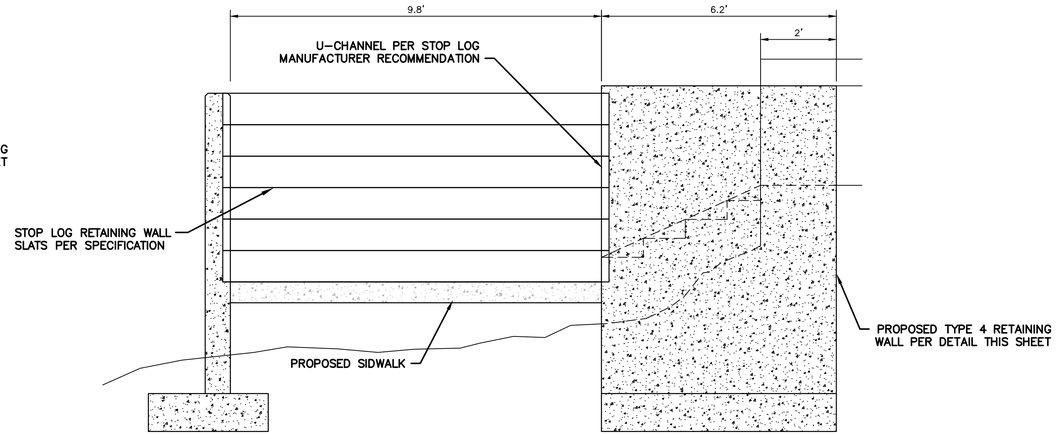
PLOT INFO: Z:\2012\120330FB\CAD\CD2\08_120330FB.DWG LAYOUT: 08 DATE: 7/1/2016 TIME: 6:03:31 PM USER: JNK



CLOSURE DETAIL SECTION (B-B)

SCALE: 1"=2'

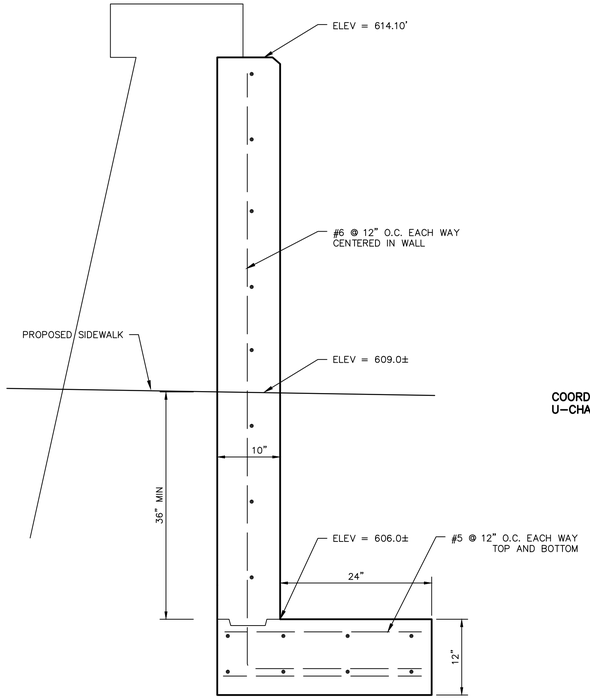


CLOSURE DETAIL SECTION (A-A)

SCALE: 1"=2'

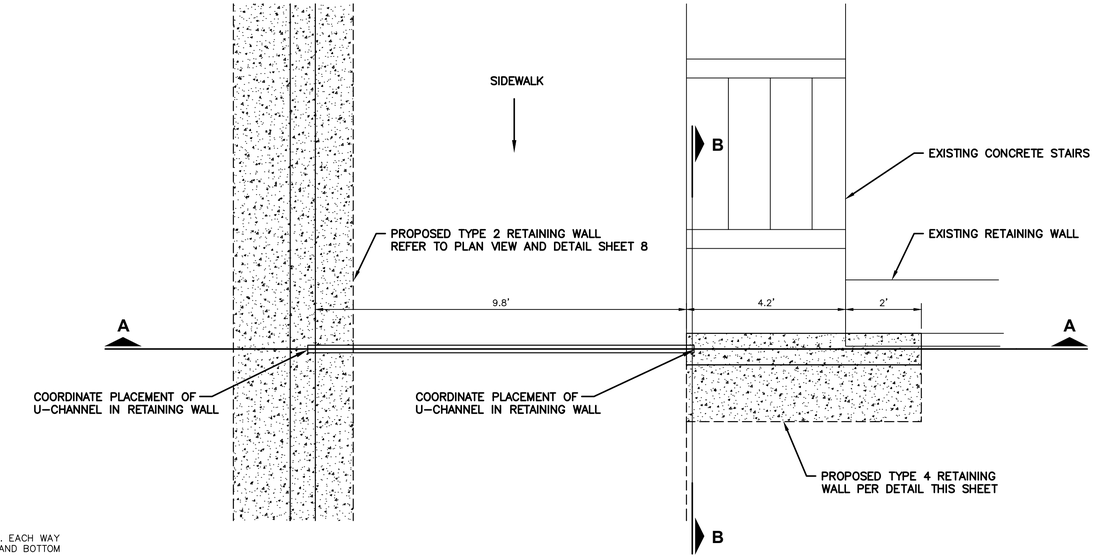
NOTES

1. ASSUMED SOIL CAPACITY = 3000 PSF. SOIL CAPACITY TO BE VERIFIED IN FIELD.
2. PROVIDE KEYWAY AT WALL–FOUNDATION CONNECTION.
3. UNLESS NOTED OTHERWISE, PROVIDE 2" CLEAR COVER TO REINFORCING BARS.
4. USE BLACK REINFORCING BARS.
5. MINIMUM LAP SPLICE LENGTH, IN INCHES, SHALL BE AS FOLLOWS:
   #5 – 17"
   #6 – 20"
   #7 – 32"
6. UNLESS NOTED OTHERWISE, PROVIDE 3/4" CHAMFERS ON ALL EXPOSED EDGES.
7. UNLESS NOTED OTHERWISE, DOWELS AND BENT BARS TO HAVE STANDARD ACI/CRSI 90 OR 180 DEGREE BEND AS INDICATED.



CONCRETE RETAINING WALL - TYPE 4 (624 FRONT AVE.)

SCALE: 1"=1'



CLOSURE DETAIL (PLAN VIEW)

SCALE: 1"=2'

624 FRONT AVENUE FISH LADDER PARK

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

Drawn by NRT	GPF No.	Sheet No.
Check: Field		of 23
Check: Office		

PLOT INFO: Z:\2012\120330FB\CAD\CD2\09_120330FB.DWG LAYOUT: 09 DATE: 6/29/2016 TIME: 5:50:44 PM USER: JNK

DIVERSCO CONSTRUCTION

570 Market Ave. SW
Grand Rapids, MI 49503
Ph : 616-458-6379

Letter of Transmittal

To: Jeremy P. McDonald P.E.
FTCH
1515 Arboretum Dr.

Transmittal #: 4
Date: 10/14/16
Job: Grand River Flood Wall Contract #2

Subject: Removable Aluminum Flood Barriers

WE ARE SENDING YOU ✔ Attached — Under separate cover via the following items:

- ✔ Shop drawings — Prints — – Plans — Samples
- – Copy of letter — Change order — ✔ Specifications — ☐

Document Type	Copies	Date	No.	Description
submittal	1	10/14/16		Removable Aluminum Flood Barriers

THESE ARE TRANSMITTED as checked below:

- ✔ For approval — I Approved as submitted — Resubmit copies for approval
- For your use — Approved as noted — Submit copies for distribution
- As requested — – Returned for corrections — – Return corrected prints
- For review and comment — –
- – FOR BIDS DUE — PRINTS RETURNED AFTER LOAN TO US

Remarks:

Copy To:

From: Mark A. Robinson Manager **Signature:**

If enclosures are not as noted, kindly notify us at once.

DIVERSCO
CONSTRUCTION

570 Market Ave. SW
Grand Rapids, MI 49503
Ph : 616-458-6379

Submittal

Job: Grand River Flood Wall Contract #2

Spec Section No:
Submittal No: 4
Revision No:
Sent Date: 10/14/16

Spec Section Title: Removable Aluminum Flood Barriers

Submittal Title: Removable Aluminum Flood Barriers

Contractor:
DIVERSCO CONSTRUCTION CO.

FISHBECK, THOMPSON, CARR & HUBER, INC.

Submittal Review	
REVIEWED, NO EXCEPTIONS NOTED	☒
REVIEWED WITH CORRECTIONS NOTED	☐
REVISE AND RESUBMIT	☐
REJECTED, RESUBMIT	☐
RECEIVED FOR RECORD	☐

FTC&H's review and approval of this submittal are expressly limited as provided in the Contract Documents and are only to determine compliance with information given in Contract Documents and conformance with design concept of completed Project as a functioning whole. CONTRACTOR is, and FTC&H is NOT, responsible for all matters relating to fabrication, shipping, handling, storage, assembly, installation and construction, for all safety aspects of performing the Work and for coordinating the Work.

Joe Platte, PE 10/20/16
Signature Date

☐ REVIEW MEMO ATTACHED

4

Contractor's Stamp

Diversco Construction Co., Inc.

☒ Approved ☐ Resubmit
☐ Approved As Noted ☐ Reviewed

Date 10-19-16

This action does not release supplier or subcontractor from complete compliance with plans.

Architect's Stamp

Engineer's Stamp

FLOOD PANEL

INDEX:

General Notes	Notes
Elevations and plan	A1
Details	J, MS, MS.1

Approval Stamp

STATE OF MICHIGAN
JOSEPH R. PLATTE
ENGINEER
No. 43898
LICENSED PROFESSIONAL ENGINEER

Approval Review

☒ Approved for release to production

☐ Approved as corrected for release to production

☐ Revise and re-submit

☐ Submit specific item

This review is only for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Corrections or comments made on the shop drawings during this review do not relieve the contractor from compliance with the plans and specifications. Approval of a specific item shall not include approval of an assembly of which the item is a component. Contractor is responsible for: dimensions to be confirmed and correlated at the job site. This review does not pertain to the fabrication process or to the means, methods, sequences and procedures of construction or installation of this product or coordination of the work of all trades and for performing all work in a safe and satisfactory manner.

Approved By (signature): Joseph R Platte

Approved By (Print Name): Joseph R. Platte

Company Name: FTCH

Approval Date: 10/20/2016

JOB LOCATION	ARCHITECT OF RECORD	ENGINEER OF RECORD	FLOOD CERTIFICATE ENDORSEMENT:
ADDRESS:	ARCHITECT NAME:	ENGINEER NAME: Joseph R Platte	NAME OF AOR OR EOR
	COMPANY NAME:	COMPANY NAME: FTCH	
	ADDRESS:	ADDRESS: 1515 Arboretum Dr.	
	CITY/STATE:	CITY/STATE: Grand Rapids, MI 49546	
	PHONE:	PHONE: 616-464-3937	

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ARCHITECTURE METALS LTD/FLOOD PANEL LLC
5500 MILITARY TRAIL
SUITE 22-220
JUPITER, FL 33458
561-744-2727 FAX 561-744-2755
WWW.FLOODPANEL.COM

TITLE: Improvements to Grand River

AS-BUILT 6/2017

DATE: 10.13.16

GENERAL NOTES IBC:

1. The structural design of these removable flood panels has been designed for hydrostatic flood loads with water pressures corresponding to maximum water height as depicted in the enclosed drawings plus hydrodynamic pressure. Free board of 1 foot in ht. is added to the system height of each opening in accordance with the documents listed below in notes 2,3 and 5.
2. It shall be determined, on a job by job basis, the required Panel height and flow speed for the design of Removable Flood Panels, based on FEMA's criteria (See Note #3) as well as per ASCE 24–05 Standard. Installation and construction of these Flood Panels for use within flood hazard areas shall be in accordance with the American Society of Civil Engineers Flood Resistant Design and Construction Standard SEI/ASCE 24–05.
3. Design criteria has been based on the 2012 Edition of the International Building Code, the corresponding provisions of ASCE 24–05, FEMA flood proofing non–residential structures manual FEMA 102, FEMA P–936 dated July, 2013 and FEMA Technical Bulletin 3–93. Design flood loads have been determined in accordance with ASCE 7–10. Design wind loads have been determined in accordance with ASCE 7–10 for 130 mph Basic Wind Speed for category 2 building.
4. Flood Panels shall not be installed within areas where ice flows or ice jams occur.
5. In order to certify flood elevation, Flood Panel design have tested by an independent testing lab for water infiltration in accordance with FEMA 102 manual for flood proofing of non–residential structures, specifications Section 8, Page 70.
6. Flood Panel installer to use gaskets and approved sealants following all the recommendations and specifications of the manufacturers respectively.
7. Owner, General contractor or installer to verify all dimensions, wall and floor conditions at site before proceeding with the work, and shall notify this engineer if any discrepancy is found that would alter the structural design of these Flood Panels.
8. Existing slabs and walls adjacent to opening where Flood Panel is to be installed shall be given a surface treatment by means of water proof sealer before flood Panel is installed. Surface must be smooth, square, plumb and level.
9. Existing slabs and walls adjacent to openings where Flood Panels are to be installed shall be structurally designed by engineer of record, to sustain the same hydrostatic, hydrodynamic and impact pressures that correspond to maximum water elevation above finished floor at top of Panel , based on criteria mentioned on Note #3.
10. Drop–in anchors embedded into concrete for removable support installation shall be covered with a cap or similar device to protect their inside hold from dust, so that machine screws can easily be installed at time of flood warning. Concrete anchors by others.
11. Separation of Panel to window/door shall be measured from back of Panel to window/door including any knob, handle, or protruding device, and shall be 2" minimum.
12. All aluminum extrusions to be 6063–T6 alloy, and 6005–T5 alloy.
13. All sheet metal screws shall be as manufactured by ITW/Buildex "TEK Screws", and to be made of non–corrosive material.
14. All bolts to be galvanized steel ASTM A–307 designation or 304 Series Stainless Steel.
15. All gaskets installed shall be neoprene per drawings.
16. All welding to conform to the American Welding Society AWS D1.2. 1998 Regulations. Use certified welders. Use ER–5356 Electrodes.
17. The engineer, Architecture Metals Ltd. or Flood Panel LLC. is not responsible for construction safety at site which is the owner, general contractor or installer's responsibility. Flood Panel Manufacturer to be responsible for providing the tenant with shop drawings and proper instructions for the installation of these Flood Panels.
18. Surfaces against which the sealing gasket presses must be built "paper–smooth" to prevent excessive water extrusion, beyond that allowed by requirements. All surfaces must be plumb, square and level.
19. To receive a warranty for the flood barriers provided by Flood Panel LLC as depicted in this set of drawings, the following information must be provided by the building owner to Flood Panel LLC:

To receive credit for flood proofing, a completed Flood proofing Certificate for Non–Residential Structures is required for non–residential and business buildings in the Regular Program communities, located in zones A1–A30, AE, AR, AR Dual, AO, AH, and A with BFE.

In order to ensure compliance and provide reasonable assurance that due diligence had been applied in designing and constructing flood proofing measures, the following information must be provided with the completed Flood proofing Certificate:

1. Photographs of shields, gates, barriers, or components designed to provide flood proofing protection to the structure installed and deployed on the building.
2. Written certification that the barrier system was inspected during and after initial installation and is installed per the drawings, engineering and instructions provided by the manufacturer.
3. Written certification that the envelope of the structure is watertight with walls substantially impermeable to the passage of water required under 44 Code of Federal Regulations (44 CFR 60.3 (c)(3))
4. A comprehensive Maintenance Plan for the entire structure to include but not limited to:
   - Exterior envelope of the structure
   - All penetrations to the exterior of the structure
   - All shields, gates, barriers, or components designed to provide flood proofing protection to the structure
   - All seals or gaskets for shields, gates, barriers, or components
   - Location of all shields, gates, barriers, and components as well as all associated hardware, and any
   - Materials or specialized tools necessary to seal the structure.

U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
National Flood Insurance Program
NFIP Flood proofing

19. Responsibility for filing the building "Flood Proofing Certificate" is the responsibility of the owner's architect and/or engineer and not of Architecture Metals Ltd. or Flood Panel LLC.

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General Notes

ARCHITECTURE METALS
FLOOD LOG SHOP
DRAWINGS

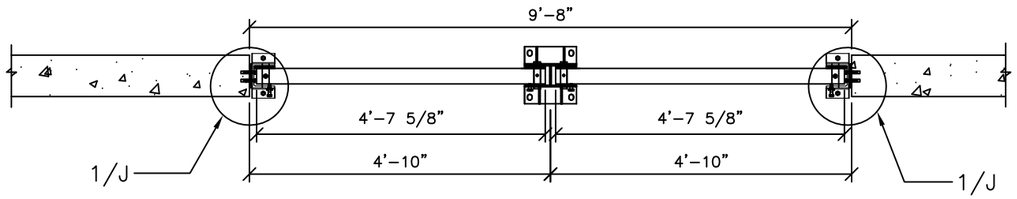
No.	Revision/Issue	Date

Firm Name and Address
ARCHITECTURE METALS
5500 MILITARY TRAIL
STE 22–220
JUPITER, FL 33458
561–630–0020

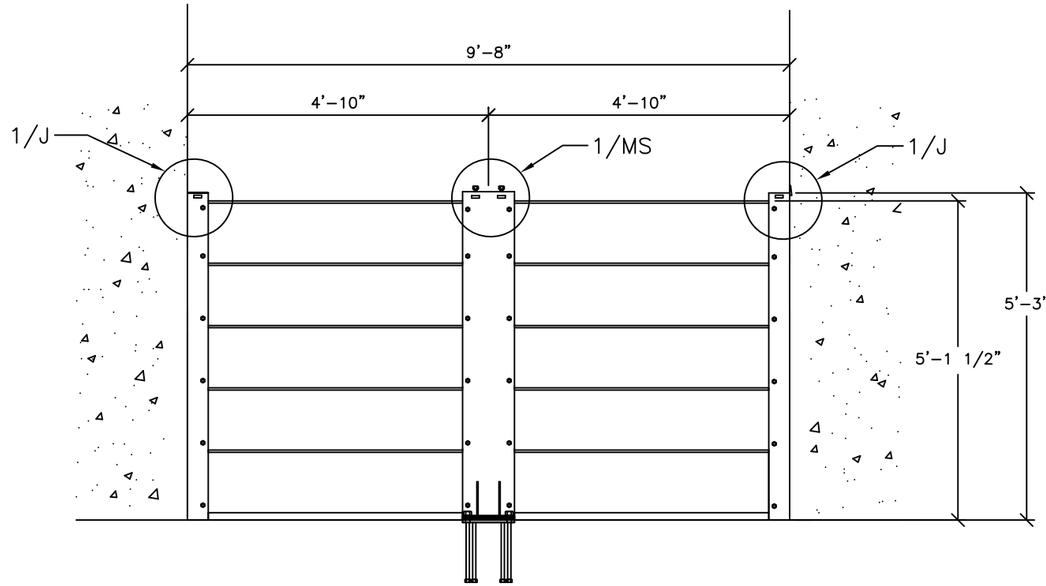
Project Name and Address
IMPROVEMENTS
TO GRAND RIVER

Project
Date 10.13.16
Scale NTS
Sheet NOTES

PLAN



ELEVATION



OPENING 01
FLOOD LOG ARRAY
J/MS/J
60" HT.
NTS

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JUPITER, FL 33458
561–630–0020

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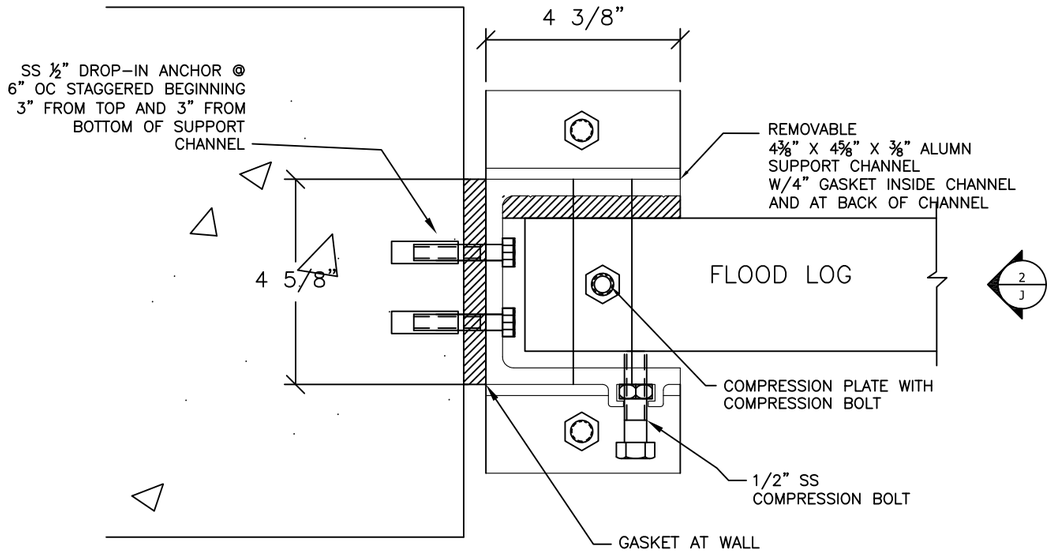
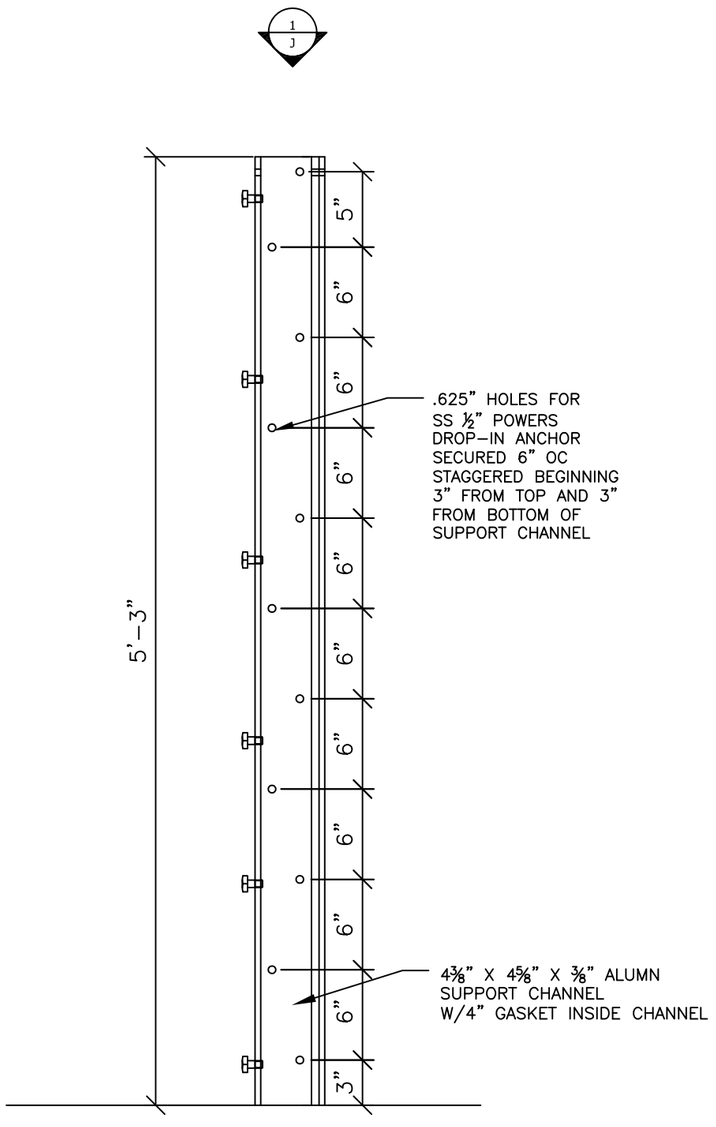
IMPROVEMENTS
TO GRAND RIVER

Project	Sheet
Date 10.13.16	A1
Scale NTS	



1/J
PLAN VIEW JAMB MOUNT
REMOVABLE SUPPORT BRACKET
NTS



2/J
5 FT FLOOD LOG HT
REMOVABLE ALUMN. JAMB
MOUNT WALL SUPPORT BRACKET
JAMB VIEW

General Notes

ARCHITECTURE METALS
FLOOD LOG SHOP DRAWINGS

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5500 MILITARY TRAIL
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JUPITER, FL 33458
561–630–0020

Project Name and Address
IMPROVEMENTS TO GRAND RIVER

Project	Sheet
Date 10.13.16	J
Scale NTS	

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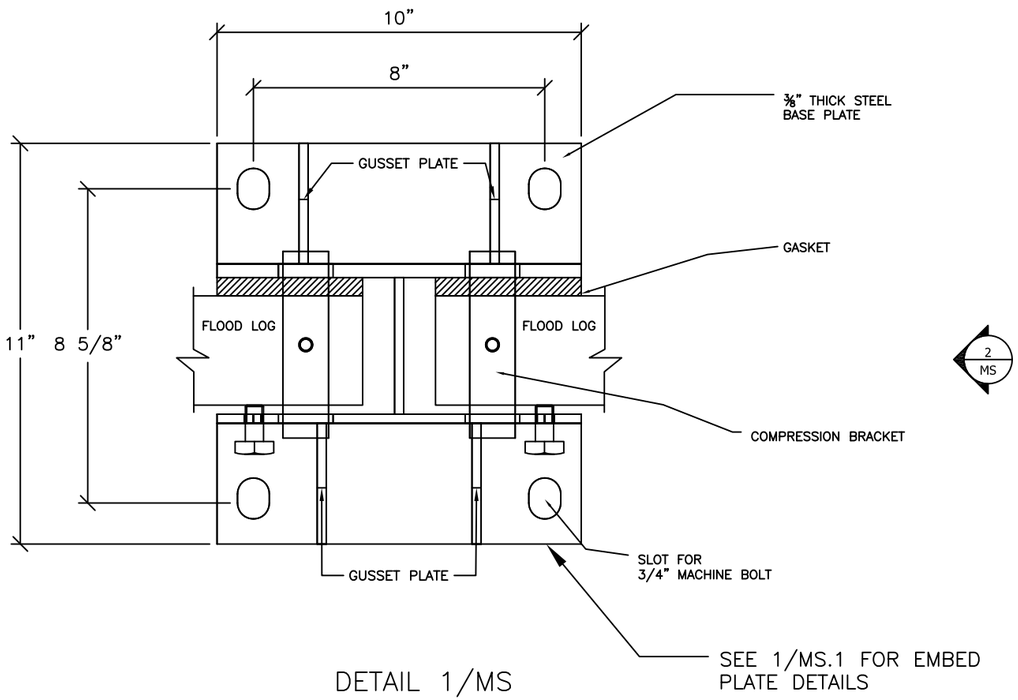
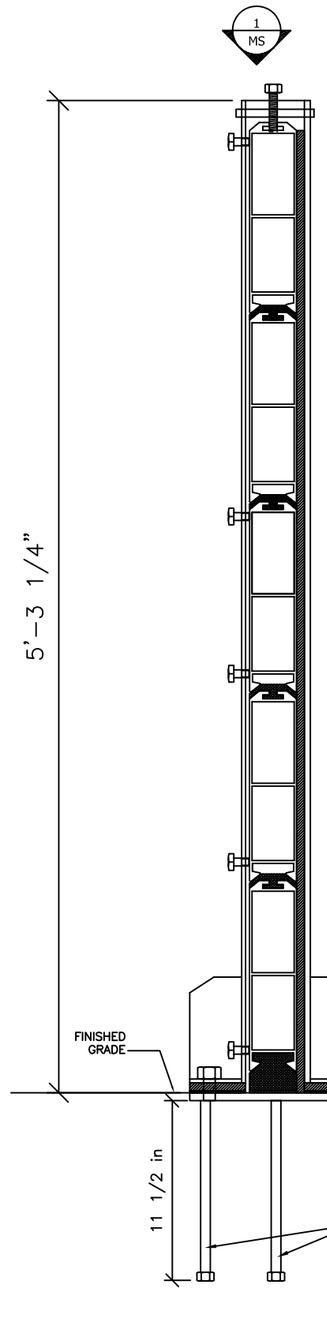


DETAIL 1/MS
PRIMED/PAINTED STEEL
MID–SPAN SUPPORT
BRACKET PLAN VIEW
NTS



DETAIL 2/MS
PRIMED STEEL
MID–SPAN
SUPPORT
BRACKET
SECTION VIEW
NTS

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FLOOD LOG SHOP DRAWINGS

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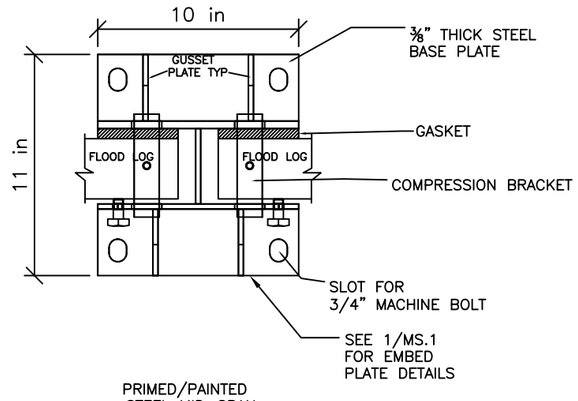
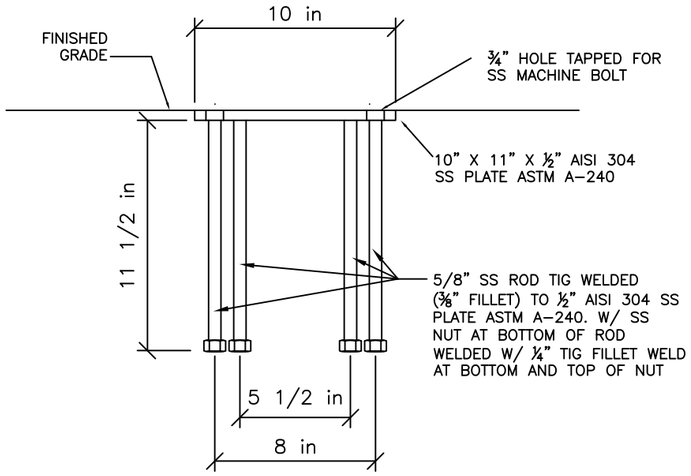
JUPITER, FL 33458
561–630–0020

Project Name and Address
IMPROVEMENTS TO GRAND RIVER

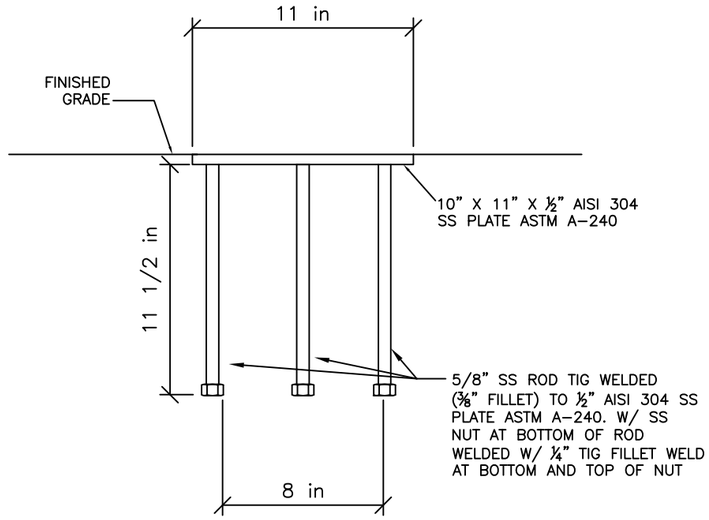
Project	Sheet
Date 10.13.16	MS
Scale NTS	



PRIMED/PAINTED STEEL MID-SPAN SUPPORT BRACKET PLAN VIEW NTS

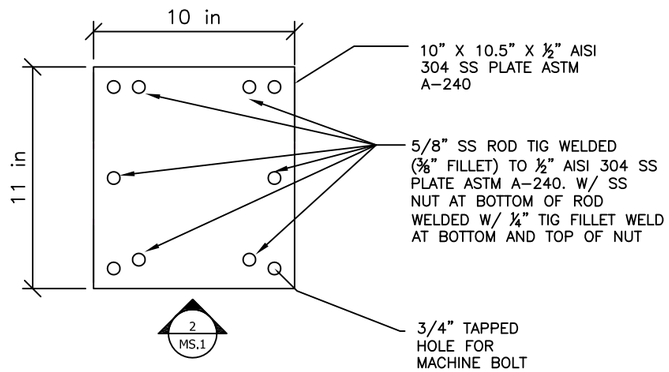


DETAIL 2/MS.1
MID-SPAN SUPPORT EMBED PLATE SECTION



DETAIL 3/MS.1
MID-SPAN SUPPORT EMBED PLATE SECTION

3 MS.1



DETAIL 1/MS.1
MID-SPAN SUPPORT EMBED PLATE PLAN

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General Notes

ARCHITECTURE METALS
FLOOD LOG SHOP
DRAWINGS

No.	Revision/Issue	Date

Firm Name and Address
ARCHITECTURE METALS
5500 MILITARY TRAIL
STE 22-220
JUPITER, FL 33458
561-630-0020

Project Name and Address
IMPROVEMENTS TO GRAND RIVER

Project	Sheet
Date 10.13.16	MS.1
Scale NTS	

Appendix 6

Inflatable Plug Manufacturer's Literature

Test Ball® Plugs – Underground

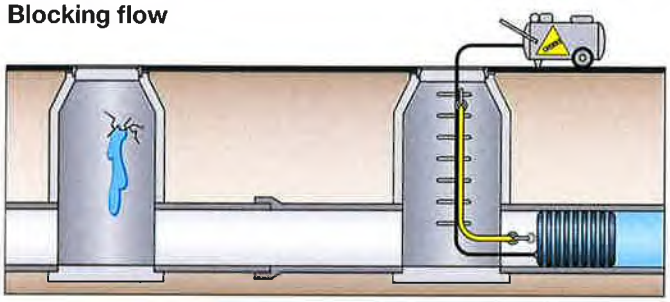
Cherne's Original Single Size and Multi-Size Test Ball Plugs are our most economical pneumatic plugs for blocking flow to do maintenance in sanitary and storm sewer systems. These plugs may also be used as a back plug for sewer air tests.

All of the single-size and multi-size Test Ball plugs have eyebolts for attaching a rope or clevis for lifting and lowering the plug. And each plug also has a removable Schrader valve for easy replacement or substitution with a quick disconnect fitting.

Made from natural rubber, these plugs are tough, tear-resistant and will work on any type of pipe, including out-of-round pipe.



Blocking flow



Single Size Original Test Balls

Part Number	Nominal Size	Usage Range	Maximum Back Pressure		Inflation Pressure	Product Weight	Deflated Length	Deflated Diameter	Inflation Thread	Chain / Eye bolts
041386	8" (200 mm)	7"-8.25" (178-210 mm)	17 psi (1,2 bar)	40 ft. (12 M)	25 psi (1,7 bar)	3.4 lbs (1.6 kg)	10.25" (257 mm)	6.75" (172 mm)	1/4" (1)	3/8" (1)
041394	10" (250 mm)	9"-10.25" (229-260 mm)	17 psi (1,2 bar)	40 ft. (12 M)	25 psi (1,7 bar)	5.6 lbs (2.5 kg)	11.75" (298 mm)	8.75" (221 mm)	1/4" (1)	3/8" (1)
041408	12" (300 mm)	10.5"-12.25" (267-311 mm)	17 psi (1,2 bar)	40 ft. (12 M)	25 psi (1,7 bar)	10.9 lbs (5 kg)	13.75" (351 mm)	10.25" (262 mm)	1/4" (1)	3/8" (1)
041416	15-16" (375-400 mm)	14" - 16.25" (356-413 mm)	13 psi (0,9 bar)	30 ft. (9,1 M)	25 psi (1,7 bar)	29.5 lbs (13.4 kg)	19.75" (502 mm)	13.75" (346 mm)	1/4" (1)	3/8" (2)

Multi-Size Original Test Balls

Part Number	Nominal Size	Usage Range	Maximum Back Pressure		Inflation Pressure	Product Weight	Deflated Length	Deflated Diameter	Inflation Thread	Chain / Eye bolts
275048	4" - 6" (100-150 mm)	3.75"-6.25" (92-159 mm)	17 psi (1,2 bar)	40 ft. (12 M)	30 psi (2,1 bar)	2 lbs (0.91 kg)	9.8" (250 mm)	3.5" (85 mm)	1/8" (1)	1/4" (1)
275058	6" - 8" (150-200 mm)	5.25"-8.25" (135-210 mm)	17 psi (1,2 bar)	40 ft. (12 M)	30 psi (2,1 bar)	3.5 lbs (1.6 kg)	14" (356 mm)	5" (127 mm)	1/4" (1)	3/8" (1)
275088	8" - 12" (200-300 mm)	7"-12.25" (178-311 mm)	11 psi (0,75 bar)	25 ft. (8 M)	20 psi (1,4 bar)	6.63 lbs (3 kg)	16" (406 mm)	6.75" (171 mm)	1/4" (1)	3/8" (1)
275128	12" - 18" (300-450 mm)	10.75"-18.25" (273-464 mm)	11 psi (0,75 bar)	25 ft. (8 M)	25 psi (1,7 bar)	22.4 lbs (10.2 kg)	24" (610 mm)	10.5" (267 mm)	1/4" (1)	3/8" (1)

Always block plugs when conducting air tests.

Appendix 7

CSX RR Bridge Closure Structure

Installation Instructions - CSX Bridge Abutment Closure (Westside of the Grand River)

Existing Conditions
100-Year Flood Elevation = 609.44 (USGS Flood Stage at Blue Bridge = 25.46')
Top of RR Abutment = 608.67 (USGS Flood Stage at Blue Bridge = 24.69')
Unprotected Height = 0.77'
Top of Adjacent Floodwalls = 610.00
Width Between Floodwalls = 38.65'
Temporary Closure Storage Location = GR WWTP (less than 1 mile from site)
Closure includes all materials and fasteners necessary for installation.

Action Level = If USGS Flood Stage at Blue Bridge is predicted to be above 24.50'.

Reference Temporary Closure Drawings 1 through 7 in Appendix 3 of the Closure Evaluation (44 CFR 65.10 (b) (2))

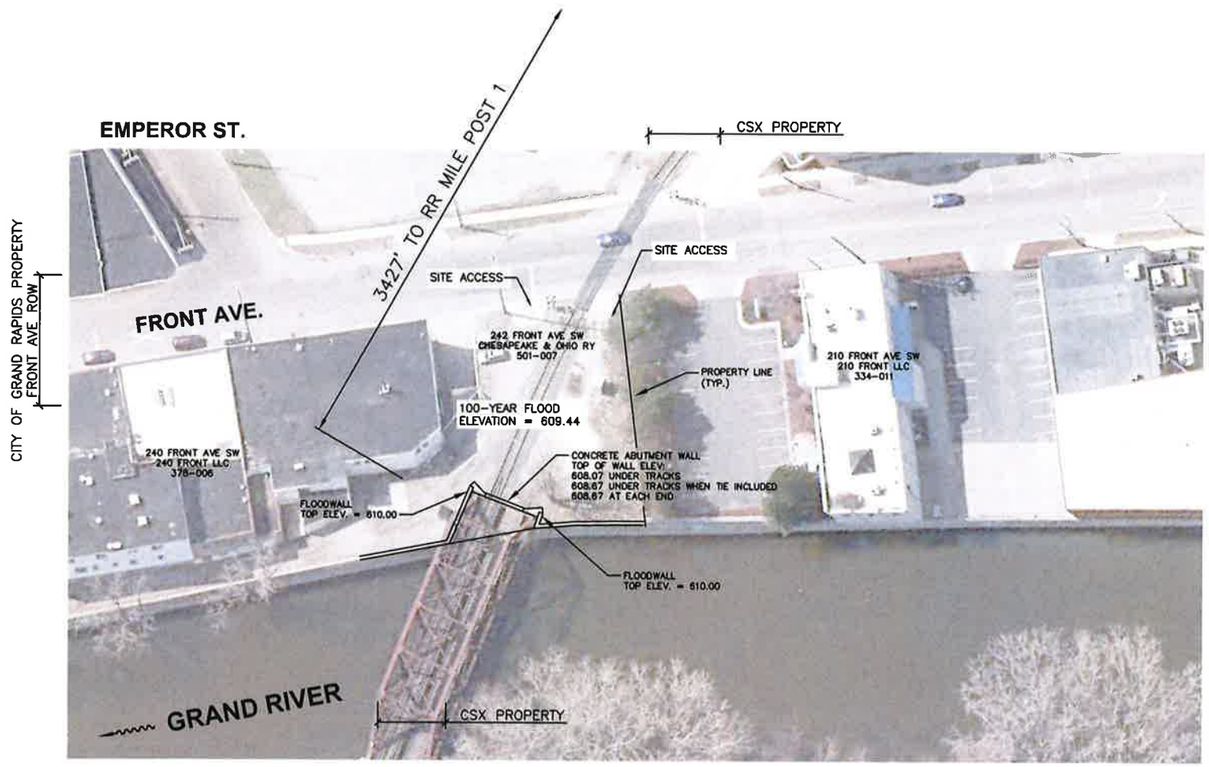
- Contact CSX Bridge and Rail Emergencies at (800) 232-0144
- Remove existing loose railroad tie as shown on Sheet 2; Replace with new 7.2" x 10" x 9'-7" hardwood tie as shown on Sheet 3.
- Shift second existing loose railroad tie to align with abutment face as shown on Sheet 2.
- Place ½" x 8" wide NBR gasket material on top of ties and concrete abutment wall per Sections "A thru F" on Sheet 5.
- Set steel brackets 1, 2 and 3 (Sheet 3) and steel brackets 4, 5, 6 and 7 (Sheet 4) over NBR gasket as shown on Sheet 5.
    - Install ½" x 8" NBR gasket between existing vertical floodwall and steel brackets 1 and 7; See note on Section "A" on Sheet 5.
    - Secure brackets to existing structure (floodwall and ties) per Section "A thru F" on Sheet 5.
- Position the five ½" NBR gasket plates per Sheets 3 and 4 and Section "F" on Sheet 5.
- Position ½" x 4" wide NBR gasket strip as shown on Sections "A thru E" on Sheet 5.
- Install steel stop log 3, NBR gasket plates 2-5 and steel backing plates (Sheet 4) per Section "F" on Sheet 5.
- Install wooden stop logs 1 and 2 (Sheet 3), NBR gasket plate 1, ½" x 4" NBR gasket strip (Sheet 3) per Sections "B thru E" on Sheet 5.
- Install wooden stop log 4 (Sheet 4) and ½" x 4" NBR gasket strips per Sections "B, C and E" on Sheet 5

CSX Closure
Project: 120330FB
Date: August 12, 2019
By: JRP
RE: Parts List

Item No.	Item	Unit	Quantity
1	7.2"x10" Nominal Hardwood Tie	EA	1
2	1/8" Thick Steel Bracket HDG (Bracket 1)	EA	1
3	1/8" Thick Steel Bracket HDG (Bracket 2)	EA	1
4	1/8" Thick Steel Bracket HDG (Bracket 3)	EA	1
5	1/8" Thick Steel Bracket HDG (Bracket 4)	EA	1
6	1/8" Thick Steel Bracket HDG (Bracket 5)	EA	1
7	1/8" Thick Steel Bracket HDG (Bracket 6)	EA	1
8	1/8" Thick Steel Bracket HDG (Bracket 7)	EA	1
9	2"x12" SPF Dimension Lumber (Stop Log 1)	EA	1
10	2"x12" SPF Dimension Lumber (Stop Log 2)	EA	1
11	1/8" Thick Steel Plate for Track Rails HDG (Stop Log 3)	EA	1
12	2"x12" SPF Dimension Lumber (Stop Log 4)	EA	1
13	1/2" NBR Gasket Plate for 5" Conduit Penetration (Gasket 1)	EA	1
14	1/2" NBR Gasket Plate for Track Rail (Gasket 2)	EA	1
15	1/2" NBR Gasket Plate for Track Rail (Gasket 3)	EA	1
16	1/2" NBR Gasket Plate for Track Rail (Gasket 4)	EA	1
17	1/2" NBR Gasket Plate for Track Rail (Gasket 5)	EA	1
18	1/8" Thick Steel Backing Plate for Gaskets 2-5 HDG	EA	4
19	1/2"x4" NBR Gasket Strip	LF	40
20	1/2"x8" NBR Gasket Strip	LF	40
21	1/2" x 2" SS Bolt (with washers and nut)	EA	35
22	1/2" x 3" SS Bolt Hex (with washers and nut)	EA	20
23	1/2"x 6" Lag Bolt (with flat washer)	EA	15
24	1/2" SS Drop-In Achor	EA	15

SHEET 1 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 1
Sheet: 1 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: 1" = 40'



EXISTING CONDITIONS
SCALE: 1" = 40'-0"

NORTH



PROPOSED IMPROVEMENTS
SCALE: 1" = 40'-0"

NORTH

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CITY OF GRAND RAPIDS
CSX RAILROAD BRIDGE - WEST ABUTMENT
TEMPORARY FLOOD CONTROL CLOSURE

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SHEET NO.
1 of 7

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PLOT INFO: Z:\2019\120330FB\WORK\PERMITS\REGULATORY\CSX CLOSURE PERMIT\SHEETS 1 THROUGH 8 TEMPORARY OPTION 3.DWG LAYOUT: 01_PLAN VIEW OF SITE DATE: 8/13/2019 TIME: 3:31:24 PM USER: JRP

Installation Instructions - CSX Bridge Abutment Closure (Westside of the Grand River)

Existing Conditions
100-Year Flood Elevation = 609.44 (USGS Flood Stage at Blue Bridge = 25.46')
Top of RR Abutment = 608.67 (USGS Flood Stage at Blue Bridge = 24.69')
Unprotected Height = 0.77'
Top of Adjacent Floodwalls = 610.00
Width Between Floodwalls = 38.65'
Temporary Closure Storage Location = GR WWTP (less than 1 mile from site)
Closure includes all materials and fasteners necessary for installation.

Action Level = If USGS Flood Stage at Blue Bridge is predicted to be above 24.50'.

Reference Temporary Closure Drawings 1 through 7 in Appendix 3 of the Closure Evaluation (44 CFR 65.10 (b) (2))

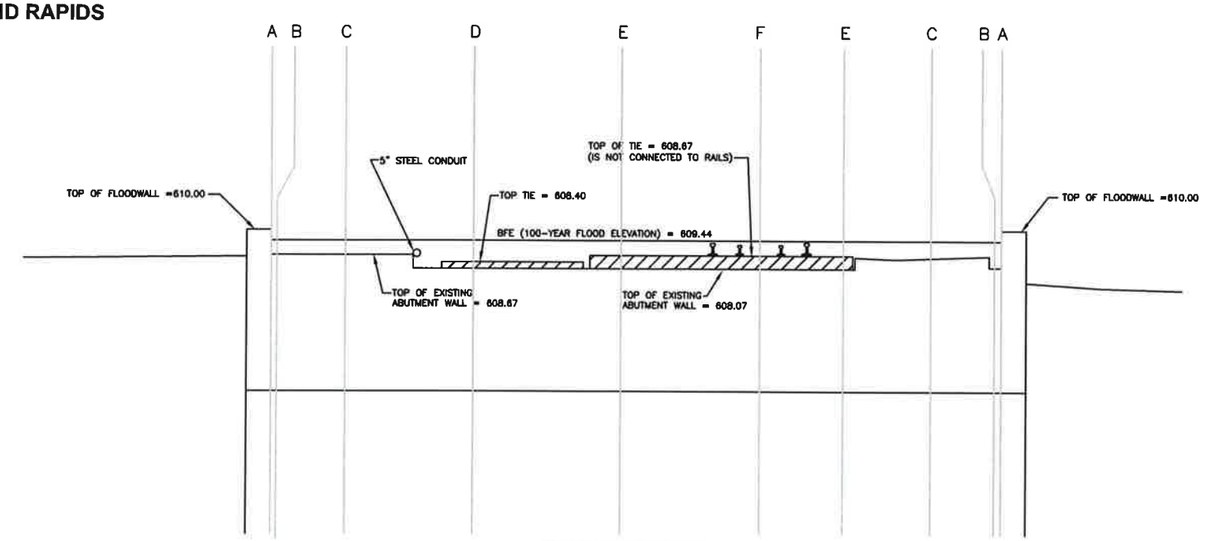
- Contact CSX Bridge and Rail Emergencies at (800) 232-0144
- Remove existing loose railroad tie as shown on Sheet 2; Replace with new 7.2" x 10" x 9'-7" hardwood tie as shown on Sheet 3.
- Shift second existing loose railroad tie to align with abutment face as shown on Sheet 2.
- Place ½" x 8" wide NBR gasket material on top of ties and concrete abutment wall per Sections "A thru F" on Sheet 5.
- Set steel brackets 1, 2 and 3 (Sheet 3) and steel brackets 4, 5, 6 and 7 (Sheet 4) over NBR gasket as shown on Sheet 5.
    - Install ½" x 8" NBR gasket between existing vertical floodwall and steel brackets 1 and 7; See note on Section "A" on Sheet 5.
    - Secure brackets to existing structure (floodwall and ties) per Section "A thru F" on Sheet 5.
- Position the five ½" NBR gasket plates per Sheets 3 and 4 and Section "F" on Sheet 5.
- Position ½" x 4" wide NBR gasket strip as shown on Sections "A thru E" on Sheet 5.
- Install steel stop log 3, NBR gasket plates 2-5 and steel backing plates (Sheet 4) per Section "F" on Sheet 5.
- Install wooden stop logs 1 and 2 (Sheet 3), NBR gasket plate 1, ½" x 4" NBR gasket strip (Sheet 3) per Sections "B thru E" on Sheet 5.
- Install wooden stop log 4 (Sheet 4) and ½" x 4" NBR gasket strips per Sections "B, C and E" on Sheet 5

CSX Closure
Project: 120330FB
Date: August 12, 2019
By: JRP
RE: Parts List

Item No.	Item	Unit	Quantity
1	7.2"x10" Nominal Hardwood Tie	EA	1
2	1/8" Thick Steel Bracket HDG (Bracket 1)	EA	1
3	1/8" Thick Steel Bracket HDG (Bracket 2)	EA	1
4	1/8" Thick Steel Bracket HDG (Bracket 3)	EA	1
5	1/8" Thick Steel Bracket HDG (Bracket 4)	EA	1
6	1/8" Thick Steel Bracket HDG (Bracket 5)	EA	1
7	1/8" Thick Steel Bracket HDG (Bracket 6)	EA	1
8	1/8" Thick Steel Bracket HDG (Bracket 7)	EA	1
9	2"x12" SPF Dimension Lumber (Stop Log 1)	EA	1
10	2"x12" SPF Dimension Lumber (Stop Log 2)	EA	1
11	1/8" Thick Steel Plate for Track Rails HDG (Stop Log 3)	EA	1
12	2"x12" SPF Dimension Lumber (Stop Log 4)	EA	1
13	1/2" NBR Gasket Plate for 5" Conduit Penetration (Gasket 1)	EA	1
14	1/2" NBR Gasket Plate for Track Rail (Gasket 2)	EA	1
15	1/2" NBR Gasket Plate for Track Rail (Gasket 3)	EA	1
16	1/2" NBR Gasket Plate for Track Rail (Gasket 4)	EA	1
17	1/2" NBR Gasket Plate for Track Rail (Gasket 5)	EA	1
18	1/8" Thick Steel Backing Plate for Gaskets 2-5 HDG	EA	4
19	1/2"x4" NBR Gasket Strip	LF	40
20	1/2"x8" NBR Gasket Strip	LF	40
21	1/2" x 2" SS Bolt (with washers and nut)	EA	35
22	1/2" x 3" SS Bolt Hex (with washers and nut)	EA	20
23	1/2"x 6" Lag Bolt (with flat washer)	EA	15
24	1/2" SS Drop-In Achor	EA	15

SHEET 2 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 2
Sheet: 2 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: 1" = 4'



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(LOOK EAST TOWARDS THE GRAND RIVER)
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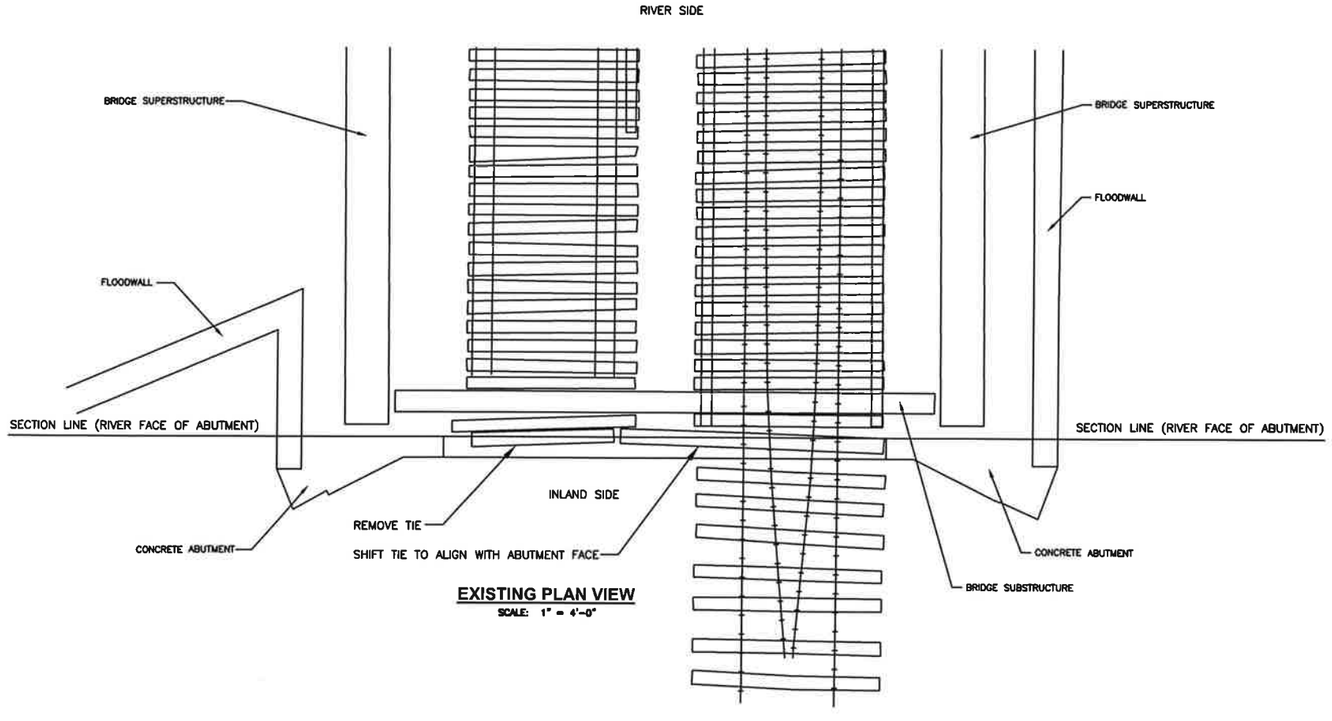

EXISTING PLAN VIEW
SCALE: 1" = 4'-0"

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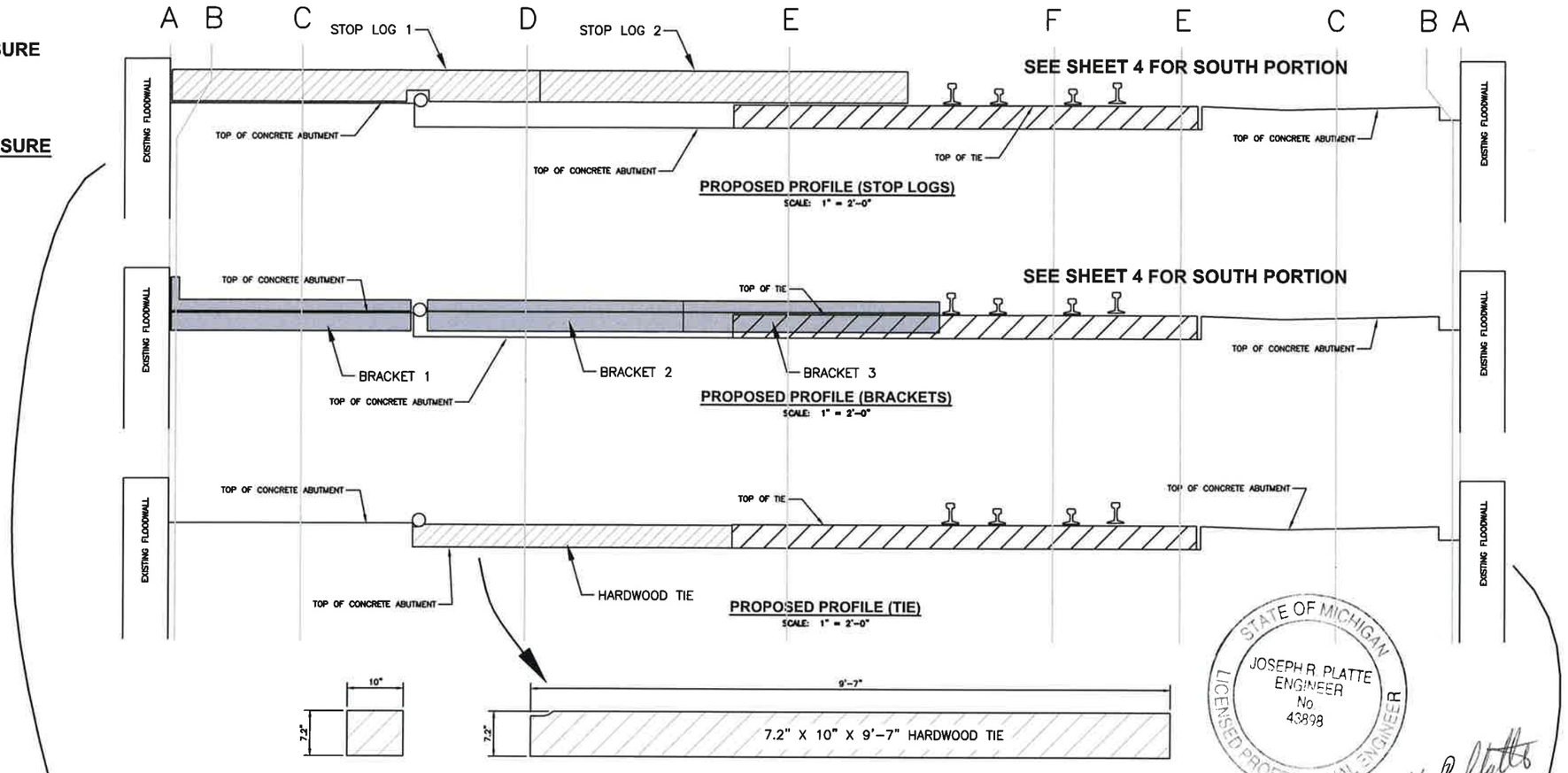
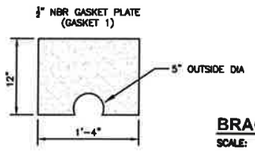
SHEET 3 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

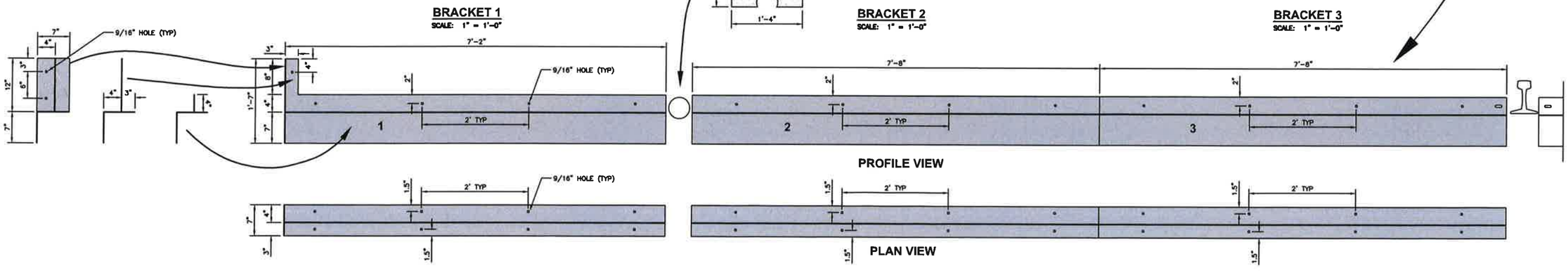
NORTH PORTION OF TEMPORARY CLOSURE
(SEE SHEET 4 FOR SOUTH PORTION)
(SEE SHEET 5 FOR CROSS-SECTIONS)

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 3
Sheet: 3 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: See Details









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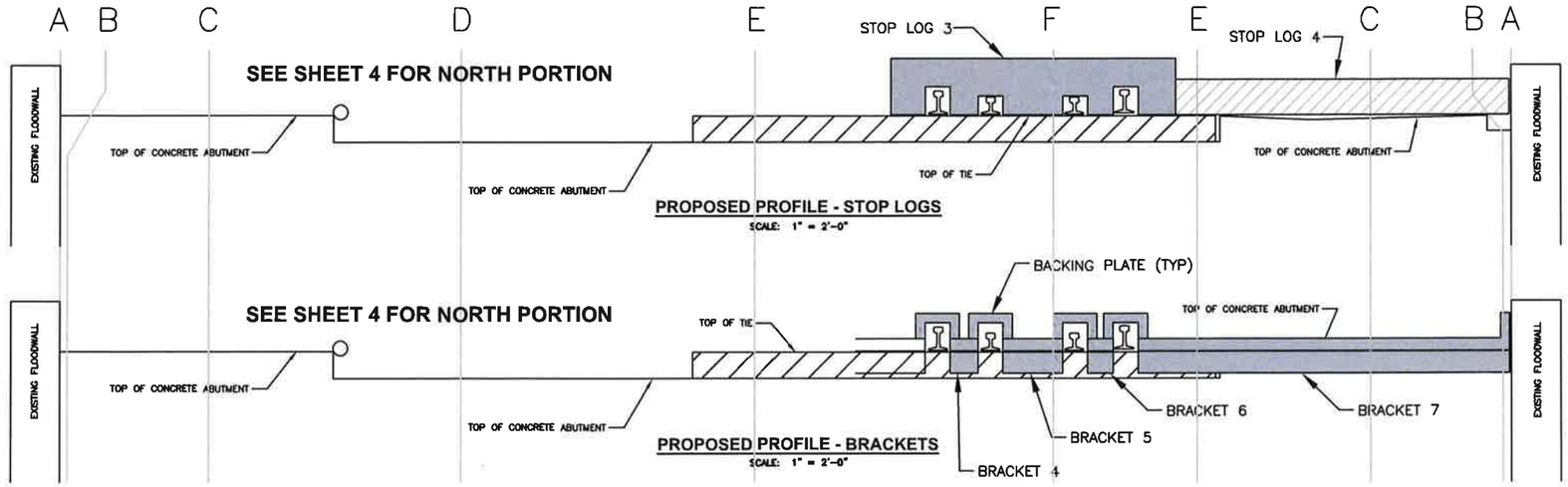
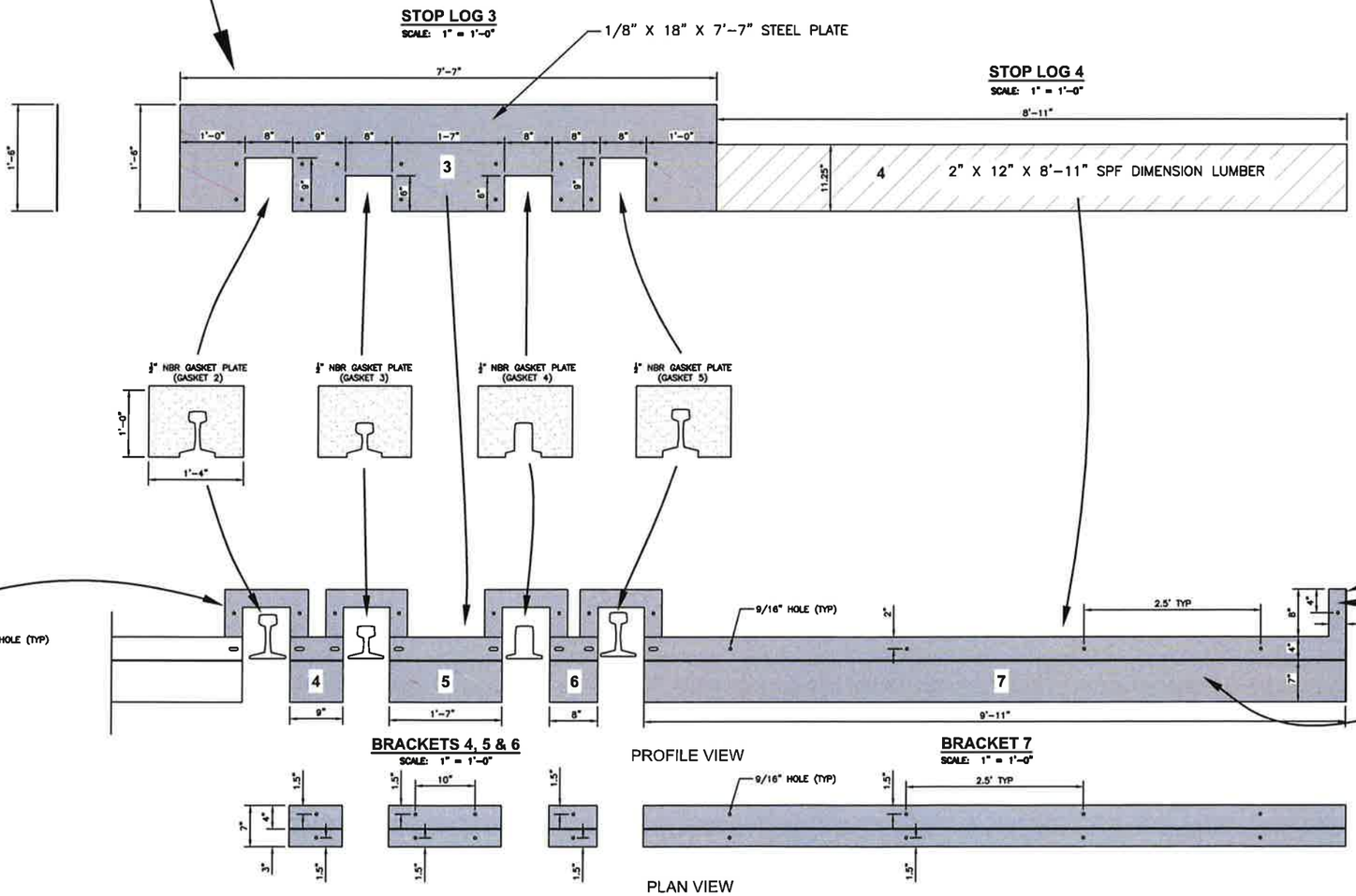
SHEET 4 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

SOUTH PORTION OF TEMPORARY CLOSURE
(SEE SHEET 3 FOR NORTH PORTION)
(SEE SHEET 5 FOR CROSS-SECTIONS)

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 4
Sheet: 4 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: See Details





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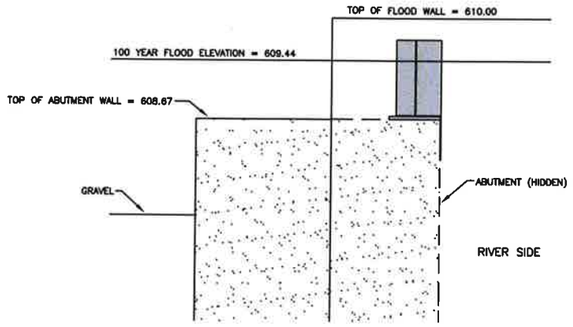
SHEET 5 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 5
Sheet: 5 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: See Details



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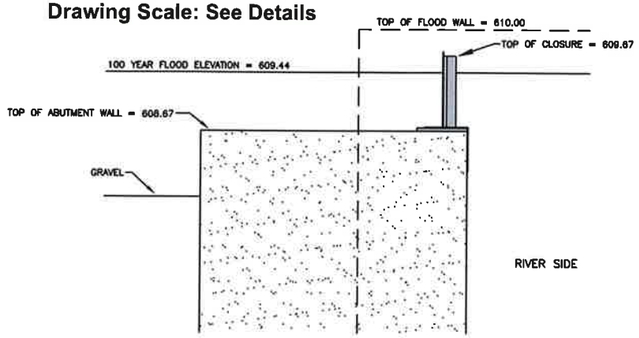

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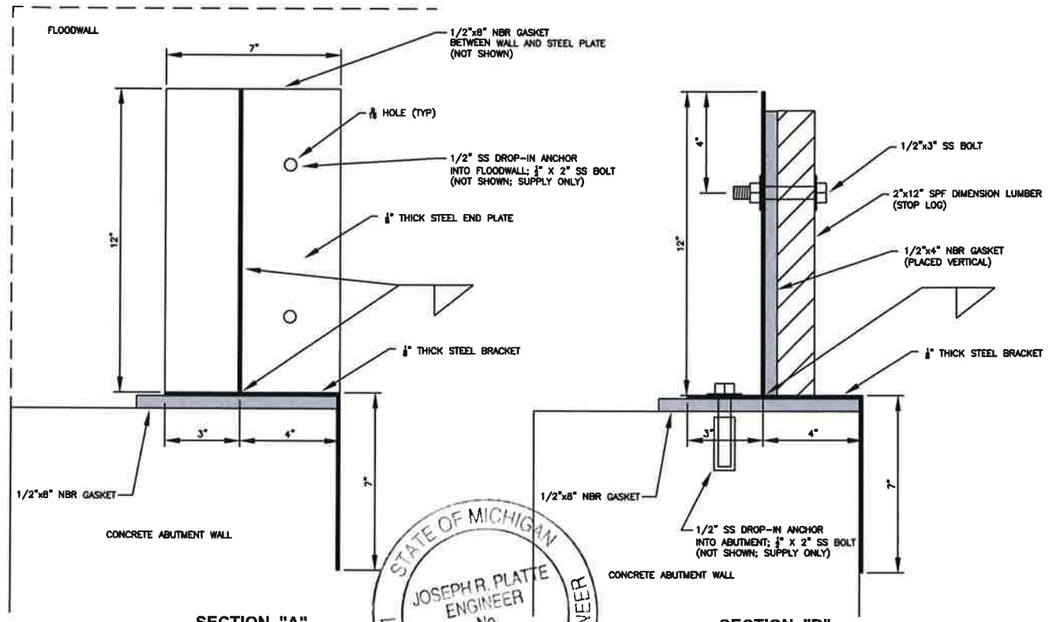

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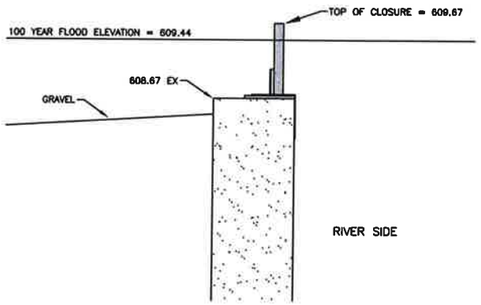
SECTION "B"
SCALE: 1" = 3"



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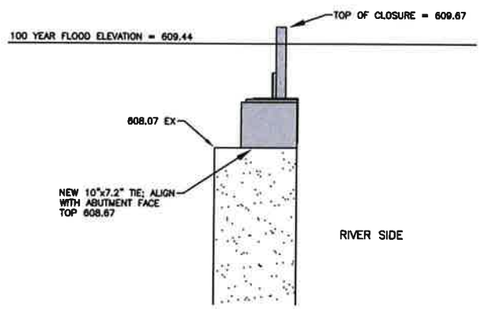

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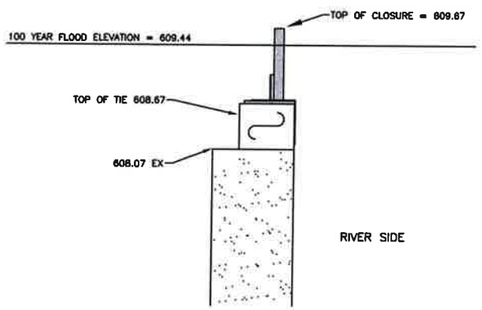

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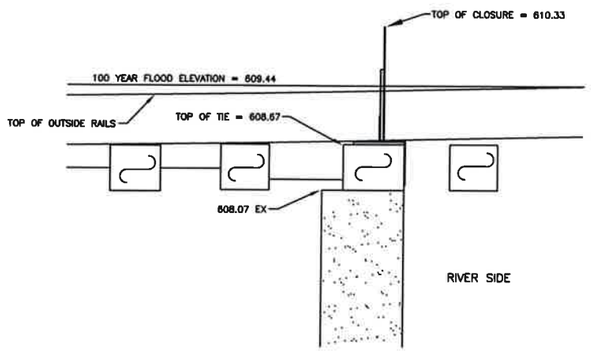

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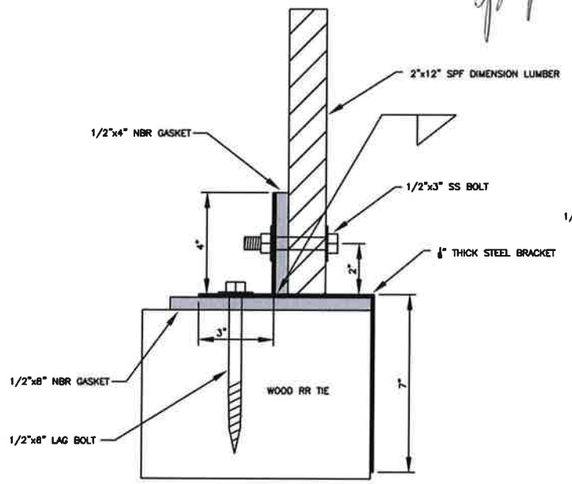

SECTION "C, D & E"
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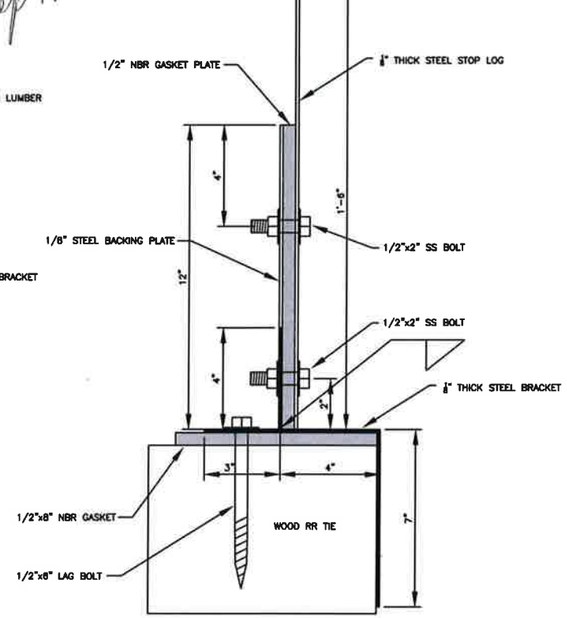

SECTION "F"
SCALE: 1" = 3"

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DRAWING NO. 1
SHEET 6 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

100–YEAR FLOOD ELEVATION = 609.44

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 6
Sheet: 6 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: NA



NORTH SIDE LOOKING TOWARD RIVER



SOUTH SIDE LOOKING TOWARD RIVER

SOUTH SIDE LOOKING TOWARD RIVER

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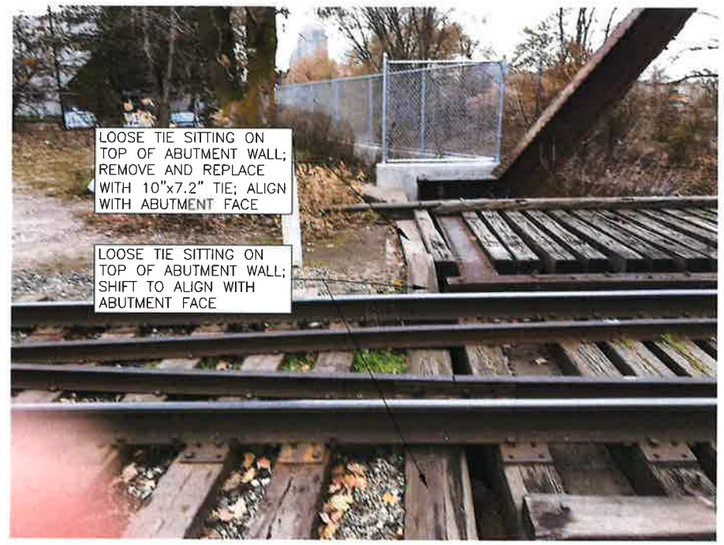
SHEET 7 OF 7
PROPOSED TEMPORARY TRACK CLOSURE
100-YEAR FLOOD EVENT

100-YEAR FLOOD ELEVATION = 609.44

Location: CITY OF GRAND RAPIDS
Latitude: 42.958940
Longitude: -85.681464
Drawing No.: 7
Sheet: 7 of 7
Drawing Date: 8/13/2019
Last Revised: NA
Drawing Scale: NA



SOUTH SIDE LOOKING NORTH



SOUTH SIDE LOOKING NORTH



SOUTH SIDE LOOKING NORTH

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Grand River Flood Protection System
44 CFR 65.10 (c&d)
Operations, Maintenance and Inspection Manual

Prepared For:
City of Walker
Walker, Michigan

Project No. 120330LMP
January 31, 2020



FINAL

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Grand River Flood Protection System
44 CFR 65.10 (c&d)
Operations, Maintenance & Inspection Manual

Prepared For:
City of Walker
Walker, Michigan

January 30, 2020
Project No. 120330LMP

Final

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Safety 6
Inspections 6

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Earth Embankment (Levee) Inspection 8
Earth Embankment (Levee) Operation 8

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Appendix 6 As-built Drawings

List of Abbreviations/Acronyms

BFE	Base Flood Elevation
City	City of Walker
EAP	Emergency Action Plan
EGLE	Michigan Department of Environment, Great Lakes, and Energy
GRFPS	Grand River Flood Protection System
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
NIMS	National Incident Management System
NREPA	Natural Resources and Environmental Protection Act
NWS	National Weather Service
OM&I	Operation, Maintenance & Inspection
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
SCADA	Supervisory Control and Data Acquisition
SPS	Stormwater Pump Station
USGS	U.S. Geological Survey
WRRF	Water Resource Recovery Facility

Preface

The Grand River Flood Protection System (GRFPS) was constructed along the left and right banks of the Grand River to provide protection for the residents, commercial and institutional establishments, and industries of Walker and Grand Rapids, Michigan from the 100-year return interval flood. The flood protection system was constructed in segments and modified through the years making use of natural stream banks, floodwalls, levees, and road and railroad embankments.

This manual is compiled to assist City of Walker (City) officials in the operation, maintenance and inspection (OM&I) of the GRFPS within the city boundaries including levees and backflow prevention devices. The procedures described in this manual are generally for conditions in the Grand River when the stage, as measured by the U.S. Geological Survey (USGS) gage, upstream of the Fulton Street Bridge in Grand Rapids, is less than 12 feet; however, this manual also provides guidance on flood preparatory measures that may be enacted when flood conditions are predicted to occur. For flood conditions where the stage is above 12 feet and predicted to rise to 18 feet or higher, refer to the GRFPS Emergency Action Plan (EAP).

The successful functioning of the GRFPS is not assured by the mere construction of an adequate system of levees, walls, gates, SPSs, etc. If the GRFPS is to function, it must be carefully maintained throughout normal river stage periods and properly operated during flood periods. Failure to do so can result in severe losses in property and life and may undermine the confidence of the citizens in their reliance on the system. The necessity for proper continuous maintenance cannot be too highly stressed. Considerable damage may be incurred through failure of a minor element of the system at flood times caused by neglect, deterioration, or damage that could have been prevented by proper maintenance. Proper maintenance and operation require that responsible local officials have a thorough understanding of the functions of the various units of the system and the knowledge of best methods of maintaining the system and operating it during flood emergencies. It is with this purpose in mind that this manual has been prepared for the guidance of those responsible for the maintenance and operation of the GRFPS.

Introduction

System Overview

Reach W-1 of the GRFPS is located along the west back of the Grand River in the Cities of Walker and Grand Rapids, Kent County, Michigan. A general plan of the protected area is shown on Figure 11. The protected area in Reach W-1 is approximately 169 acres of which 118 are in the City of Walker, the GRFPS consists of a combination of natural ground and earth embankments built along the banks of the Grand River, which protect approximately 169 acres on the right (west) bank consisting of residential, commercial, institutional, and industrial properties.

Construction History

In Walker, the protective structures consist of earth embankments, flap gates, a short wall and a relief sewer. The construction of the road embankment for U.S. Route 131 occurred in the 1950's when the two-lane State Route M-13, predecessor to U.S. Route 131, was converted into a full freeway. The construction of the I-96 embankments and ramps took place between 1956 and 1962.

The existing storm water collection system serving Turner Avenue discharges to the Grand River at 3 locations. Three small private outfalls also exist. Flow from these pipes discharges to the US-131 drainage system where it is conveyed under US-131 through multiple large culverts. In 2015 six new flap gates were installed on outfalls upstream of the US-131 drainage system to prevent Grand River floodwaters from backing up into Turner Avenue.

In 2016, a relief storm sewer was installed to tie the existing Turner Avenue storm sewer system to storm sewers leading to the Indian Mill Creek Storm Water Pump Station in Grand Rapids. In addition, a short wall was built along US-131 provides approximately once foot of freeboard above the base flood elevation.

Floodplain management regulations are codified in the City of Walker Code of Ordinances, Chapter 42 – Floods and Chapter 67 - Stormwater Management and Control.

Procedures

Purpose

The successful functioning of the GRFPS can be assured by following the procedures set forth in this manual. By doing so, the benefits and protection against floods for which the GRFPS were designed can be secured.

Proper OM&I require that responsible local officials have a thorough understanding of the functions of the various units of the flood protection system; the best methods of maintaining them during normal river stages; and of operating them during flood emergencies. It is with this purpose in mind that this manual has been prepared for the guidance of the City in the OM&I of the GRFPS. This manual assembles and correlates all the details essential for satisfactory OM&I of the flood protection system, so maximum flood protection may be available during the service life of each component of the entire asset.

Duties of the Superintendent

The Superintendent of the flood protection system should be the City Engineer and designated members of his/her support staff. The duties of the Superintendent should include the OM&I oversight, records keeping, and correspondence with the other City officials and departments. The Superintendent should have available the names, addresses, and telephone numbers of all key personnel, and a reasonable number of substitutes. The key personnel should have similar information on all the persons that will be required for assistance in the discharge of their duties. These persons should include the following:

- An assistant to act in the Superintendent's place in cases of his/her absence or indisposition.
- Supervisors in sufficient number to lead maintenance, operation and inspection of the GRFPS. High qualities of leadership and responsibility are necessary for these positions.

The Superintendent should ascertain that key persons have read the portions of the OM&I Manual pertaining to their duties.

The Superintendent should be responsible for the development of an organization capable of providing for the efficient OM&I of the GRFPS, and the necessary maintenance of the entire asset during normal stages of the river.

The provisions of this manual include general requirements that cover practically all types of local flood protection works. They are supplemented by technical data and instructions pertinent to the GRFPS which are necessary for its efficient OM&I.

OM&I Management

The general requirements for the OM&I management of the GRFPS are as follows:

- The structures and facilities should be continually maintained as necessary to obtain the maximum benefits.
- The Superintendent shall be responsible for the efficient OM&I of all the structures and facilities and for routine inspection and maintenance of the entire asset.
- A reserve supply of materials needed during a flood emergency should always be kept on hand.
- No encroachment or trespass which will adversely affect the efficient operation or maintenance of the GRFPS should be permitted upon the rights-of-way for the GRFPS.
- No improvement or construction shall be permitted within the limits of the GRFPS right-of-way, nor should any change be made in any feature of the GRFPS without prior determination by the City Engineer that such improvement, construction, or alteration will not adversely affect the functioning of the GRFPS. Such improvements or alterations, as may be found to be desirable and permissible under the above determination, should be constructed in accordance with standard engineering practice. Record drawings or

prints showing such improvements or alterations as finally constructed should be furnished to the City Engineer after completion of the work.

- At no time should the level of flood protection provided by the GRFPS during construction or any alterations, including excavation, of improvements that pass over, under, or through the GRFPS, be less than that provided for a 100-year flood (1% annual chance of occurrence). All temporary or permanent flood prevention measures made to the GRFPS to facilitate construction must be approved by the City Engineer.
- The City Engineer or authorized representatives should always have access to all portions of the GRFPS.

Permits for Use of Rights-of-Way

The rights-of-way for the GRFPS have been procured and protective works have been constructed thereon for the protection of life and property in times of flood. The Office of the City Engineer provides for the legitimate use of the rights-of-way in addition to crossing by gas lines, oil lines, and utilities, or other use of a similar nature.

A permit from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) may be required for construction along or modifications to the flood protection system under Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended. The routine OM&I of the GRFPS is the responsibility of the Department of Public Works, and will be completed in accordance with this manual. The right-of-way for the GRFPS is issued, recorded, and maintained in document form by the Office of the City Engineer.

Adjacent Construction by Others

When owners of properties adjacent to the levees and/or floodwalls initiate new construction, particularly if it involves deep excavation, the City Engineer should be notified and take such action as may be necessary to assure that there is no encroachment on right-of-way, that adequate shoring is used to prevent disturbing flood protection foundations, and that the work insofar as possible is performed outside of flood periods.

River Stage Prediction

It is the responsibility of the City Engineer to keep advised of predicted river stages. This information will enable the City Engineer to make all the necessary preparations required for the operation and erection of those features of the system for the protection of the areas against high river stages in advance of their occurrence.

The river stages referred to herein correspond to automated gage readings taken at the USGS Station 04119000, Grand River at Grand Rapids, Michigan. The gage station is located at latitude 42˚ 57’ 52”, longitude 85˚ 40’ 35” referenced to North American Datum of 1927, in NE 1/4 Section 25, Township 7 N, Range 12 W, Kent County, Michigan, on the right (west) river bank, 500-feet upstream from the Fulton Street bridge in Grand Rapids and 1.7 miles upstream from Plaster Creek. The datum for the gage is 585.70-feet National Geodetic Vertical Datum of 1929 (NGVD 29) (elevation 585.25-feet North American Vertical Datum of 1988 [NAVD 88]). Current river stage information can be obtained from the National Weather Service (NWS) Forecast Office, Grand Rapids, Michigan, Advanced Hydrologic Prediction Service at: http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4 or the USGS Michigan Water Science Center at: http://waterdata.usgs.gov/mi/nwis/sw

The predicted stages are available for up to five days in advance. This is sufficient time to allow the City Engineer to make all necessary emergency preparations and conduct such operations as may be required for various river stages as described in this manual and the National Incident Management System (NIMS). It should be kept in mind that the predicted stage is only an approximation and may possibly range higher.

Procedure at Various River Stages

Appendix 4 lists the operations to be performed at various river stages.

The actual time of mobilization of the various personnel will be dependent upon the rate of rise of the Grand River (see "Grand River – Rate of Rise – Closure Operation" in Emergency Closure Structures), the various functions to be performed, the condition of the flood protection system, the time required to erect sandbag and other closures, and other pertinent requirements of the Special Operation & Maintenance During High Water Periods section of this manual.

Reference Drawings

A list of reference drawings including record drawings is included in Appendix 1. The station references used in this manual are referenced to a survey baseline along the centerline of the Grand River that begins at Station (Sta.) 2003+05.20, at the right lane edge of pavement on the east bound lanes of the Interstate 196 (I-196) bridge. The survey baseline station numbers increase in the upstream direction.

Elevations

The GRFPS was constructed at different times under different construction contracts. Therefore, different vertical datums were used throughout the history of construction. To the extent possible, the elevation datum for all elevations used in this manual are identified in its paragraphs. The user of this manual should be careful to discern which vertical datum is being used when comparing to published flood elevations. The conversion between elevations using the NAVD 88 and those using NGVD 29 is given by:

NAVD 88 = NGVD 29 – 0.4495 feet

Safety

The Superintendent should provide a health and safety plan in accordance with the Occupational Safety and Health Administration law and regulations for all personnel involved in the maintenance of the GRFPS. The Superintendent and maintenance personnel should familiarize themselves with the safety procedures and implement them during routine maintenance and flood operations. Safety precautions should be complied with as follows:

- Personnel should remain alert to the possibility of hazardous gases at the structures, primarily at the manholes and junction chambers, and take appropriate safety measures when inspecting, maintaining, or operating the structures.
- Two persons should always be present during maintenance, inspection, or operation of all drainage structures. The buddy system should be used to provide necessary help and assistance to each other in the event an accident occurs.
- Since a potential drowning hazard exists during flood emergencies, emergency response teams from the City's Fire Department with appropriate personnel and equipment shall respond accordingly.

Inspections

Annual inspections of the portion of the GRFPS within Walker will be completed by the Department of Public Works, or their consultants. Repair and maintenance of the GRFPS should be completed as soon as possible under the direction of the City Engineer.

Earth Embankments (LEVEES)

Earth Embankment Maintenance

The pertinent requirements for maintenance of the earth embankments are as follows:

The City Engineer shall provide for maintenance as may be required to insure serviceability of the earth embankments in time of flood. Measures should be taken to promote the growth of sod, exterminate or remove burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable, measures should be taken to retard bank erosion by placement of riprap stone or by planting suitable plants on areas riverward of the levees. Inspection of the earth embankment should be completed by the City Engineer, or designee, to ensure the above maintenance measures are being effectively carried out and to be certain that:

- No unusual settlement, sloughing, or material loss of grade or earth embankment cross section has taken place.
- No caving has occurred on either the land side or the river side of the earth embankment which might affect the stability of the earth embankment section.
- No seepage, saturated areas, or sand boils are occurring.
- Toe drainage systems are in good working condition and that such facilities are not becoming clogged.
- Drains through the earth embankments and backflow gates on said drains are in good working condition.
- No revetment work or riprap has been displaced, washed out, or removed.
- No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod.
- Access roads to and on the earth embankments are being properly maintained.
- Crown of the earth embankment is shaped to drain readily and roadway, if any, is well shaped and maintained.
- There is no unauthorized vehicular traffic on the earth embankment.
- Encroachments are not being made on the earth embankment right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Burrowing Animals

Burrowing animals (muskrats and groundhogs) create seepage paths in earth embankments. Burrowing animals should be removed from the earth embankment and the burrows filled with a mud-pack prepared by adding water to a 90 percent soil and 10 percent cement mixture until a slurry or thin cement consistency is attained. After filling the burrow with the mud pack mixture, the burrow entrance should be filled with dry earth and seeded.

Drift

Drift (river-borne debris) should be removed from the earth embankment and other grassed areas on the right-of-way at the end of each winter flood season before the new growth of grass starts in the spring, and after each flood occurring during the growing season.

Gullies, Holes, and Washes

Gullies, holes, and washes in the levee, slopes, and berms should be repaired using compacted clay soils in an approved manner.

Earth Embankments Crest Depressions

Gaps occurring where trail or road crossings have been worn down or where the earth embankment may be below grade should be remedied. It is advisable to run levels occasionally to determine whether depressions have occurred in the top of the earth embankment. The profile of the top of the earth embankment should be maintained to the elevations shown on the construction plans.

Spare Cover Vegetation

All areas deficient in sod should be reseeded or resodded.

Seeding

When new permanent seeding is necessary to obtain cover for bare areas, it is recommended that such work be done in the late summer, between July 15 and September 15, or in the spring between April 10 and June 5. Temporary seeding can be performed up to a month before or a month after the above dates, respectively; however, temporary seeding must be followed-up with permanent seeding during the appropriate season.

Sodding

Where sodding is considered the most favorable method of reestablishing a good stand of grass on the earth embankment, it should be performed in advance of the flood season to ensure knitting of the transplanted sod with the prepared base. Sodding should preferably be done between May 1 and October 20, if irrigation can be provided as needed. Sod should not be laid between June 10 and September 10 without irrigation.

Grass Mowing

Grass should be mowed as necessary to help maintain a good stand of grass.

Earth Embankment (Levee) Inspection

Sample check list forms for use in performing inspections of earth embankments (levees) are included in Appendix 2.

Earth Embankment (Levee) Operation

When the Grand River flood stage exceeds 12 feet at the USGS gauge station, the earth embankment should be patrolled daily, or more frequently as conditions warrant, to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

- There are no indications of slides or sloughs developing.
- Wave wash or scouring action is not occurring.
- No low reaches of earth embankment exist that may be overtopped.
- No other conditions exist which might endanger the structure as determined by the City Engineer.

Earth Embankment Damage Due to High Water:

If it is found that sand boils, scouring, or other hazardous conditions are occurring, immediate steps should be taken to control the situation and repair or correct any damage. In the face of such dangerous conditions due to high water, the provisions of the NIMS shall be implemented. Suggested methods of operations for combating such flood conditions are given in the Special Operation & Maintenance During High Water Periods section of this manual.

Sand Boils and Seepage Areas:

When sand boils or other seepage areas are observed which are of small magnitude, posing no major threat to structure safety, and therefore are not economically feasible to repair, their locations should be recorded for future action.

Drainage Structures

Maintenance

Under the classification of drainage structures include: culverts, manholes, storm sewers, and flap gates. The various backflow prevention measures on the pipe penetrations through the GRFPS with outfalls below the Base Flood Elevation (BFE) are described in detail in the Closure Analysis Report.

Adequate measures should be taken to ensure that inlet and outlet channels are kept open and that trash, or debris is not allowed to accumulate near drainage structures. Flap gates on drainage structures should be examined, lubricated, and operated annually. Periodic inspections should be made by the Superintendent to be certain that:

- Pipes, riprap, and headwalls are in good conditions.
- Inlet and outlet channels are open.
- Care is being exercised to prevent the accumulation of trash and debris near the structures, and that no fires are being built near bituminous coated pipes.
- Erosion is not occurring adjacent to the structure which might endanger its water tightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections.

In addition, there are flap gates on the outlets of the storm drains at the locations listed in Table 1. Note that all the gates in the following tables are flap gates unless otherwise noted.

Table 1 – Drainage Structures West Side of Grand River				
River Station	Outfall No.	Facility ID No.	Pipe Size & Material	Flap Gate Location
2257+00	135-B1	2084177	36" RCP	At riverside toe of embankment for U.S. Route 131 and at head of channel draining to river north of Ann Street, NW
2268+00	135-C1	*	12" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of and between 2204 Turner Avenue, NW and 2280 Turner Avenue, NW
2273+00	135-C2	*	12" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of and between 2280 Turner Avenue, NW and 2356 Turner Avenue, NW
2277+00	135-C3	*	12" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of south end of building at 2400 Turner Avenue, NW
2277+00	135-C4	*	24" RCP	On end of pipe in drainage swale on west side of U.S. Route 131 at rear of south end of building at 2400 Turner Avenue, NW
2285+00	135-F	2312878	60" RCP	At head of drainage ditch at north end of building at 2400 Turner Avenue, NW and behind building at 2474 Turner Avenue, NW

Pipe Material Key RCP = reinforced concrete pipe

The flap gates should be operated, serviced, and lubricated annually to be certain that they swing freely and do not bind. Clear all debris that prevents full closing of the flap gate. Caution: To prevent possible damage, do not allow the flaps to slam against their seats.

Inspection

Drainage structures should be inspected annually. Sample inspection check list forms are provided in Appendix 2.

Operation

Whenever a flood stage exceeding 18 feet as measured at the USGS Station 04119000, Grand River at Grand Rapids, Michigan, is predicted by the NWS Forecast Office, Advanced Hydrologic Prediction Service (see Permits for Use of Rights-of-Way section), all gates should be inspected before water reaches the invert of the pipe and any object which might prevent closure of the gate should be removed. All drainage structures in earth embankments (levees) should be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps should be taken to correct any adverse condition.

Flap Gate Operation Caution

Observe cautions for operating the flap gates as directed in the maintenance instructions.

Flap Gate Operation

The flap gates should be inspected in order that objects that would prevent the gate from seating properly or sealing may be removed. The flap gates should be closely monitored until it is determined that they are securely closed and that no more debris will pass through their outlets. Water will pass through a flap gate outlet when the landside water surface is above the riverside water surface. Until both surfaces are above the crown of the pipe, floating debris and trash will attempt to pass through the drainage structure and can possibly keep the gate from seating properly when the water on the riverside reaches an elevation above that on the landside.

Emergency Closure Structures

Maintenance

When the flap gates on the drainage structures fail to close or leak excessively during a flood, emergency closure structures will be required. Emergency closures consist of either sewer plugs or other closures. The sewer plugs and other closures should be inspected annually to be certain that:

- Proper closure can be made promptly when necessary (no obstructions are found in the area where the closure would be installed that would obstruct installation).
- Sufficient materials and supplies are on hand for the placement of sewer plugs and other closures (e.g. sandbags, lumber, wire, etc.) and that the location of such materials and supplies will be readily accessible in times of emergency.
- Sewer plugs are clean and free of leaks, bulges, cracks, or other damage that would prevent proper installation.

Inspection

The other closures and sewer plugs should be inspected annually. Sample inspection check list forms are provided in Appendix 2. The forms contain an inventory of materials necessary for the complete erection and operation of the closures. All materials should be checked against the check list to ascertain their presence at the City storage location. It is advisable to check the material storage areas immediately before impending high water to see that no materials are missing. Any irregularities observed during inspections should be noted and immediate measures taken to correct them.

Operation

The closing of flow paths for flood waters should be started in sufficient time to permit full closure before flood waters flow into the protected areas. The closures will be inspected frequently during flood periods to ascertain that no undue leaking is occurring and that drains provided to care for ordinary leakage are functioning properly.

Closures and Sewer Plug Closing

The sewer plug and other closures should be installed as instructed in the Special Operation & Maintenance During High Water Periods section of this manual. The installation of closures require labor crews, backhoes, dump trucks, and experienced supervisors to minimize the time involved to complete the closures. The sandbags, filled approximately two-thirds full of earth, are laid with ends not tied and with joints staggered. The untied end is lapped under the adjacent sack. Each layer of sacks should be laid in alternate directions. The riverside face should have a batter of approximately 1 on 1, and the landside slope should be approximately 1 on 2-1/2, with the width of sacking at the top of the levee being 3-feet. The installation of sewer plugs requires experienced crews with portable air compressors and pneumatic hoses.

Grand River - Rate of Rise - Closure Operation

It is imperative that ample time be allowed to install the closures before the water reaches the predicted flood elevation. It is the responsibility of the Superintendent to keep advised of predicted river stages and of possible additional local rainfall. This information will enable the Superintendent to make all the necessary preparations required for the erection of those features of the system for the protection of the area against high river stages in advance of their occurrence. River stage predictions for the Grand River and forecasts of local rainfall are issued by the NWS, Advanced Hydrologic Prediction Service, NOAA, Grand Rapids Michigan, at the internet web site: http://water.weather.gov/ahps2/hydrograph.php?wfo=grr&gage=gdrm4

With this information, it will be possible to perform such operations as may be required for various stages. The predicted stages are usually available five days in advance. This is sufficient time to allow the Superintendent to make all necessary emergency preparations. Due consideration must be given to the rate of rise of the river. Table 2 contains Rates of Rise in feet per hour for various gage readings up to flood crest of major flood experiences. By comparing a predicted flood with records of past floods (Table 2), it is possible to estimate and use as a guide Rates of Rise to be expected at various gage readings over the period required to effect closure. There are many factors determining the Rates of Rise, and the City Engineer shall be consulted in understanding the predictability of the Grand River and the Rates of Rise that may be anticipated. The period required to install each closure must also consider the possible delays because of inexperienced help and other delays.

Table 2 - Grand River - Rates of Rise in Feet Per Hour, Grand Rapids, Michigan

Gage Readings (Zero of Gage = 585.7 feet)	Feb.2018 Flood	April 2013 Flood	Mar. 1985 Flood	May 2004 Flood	Oct. 1986 Flood	April 1960 Flood
12[(1)]						
	0.15	0.13	0.24	0.09	0.03	0.12
13						
	0.11	0.08	0.22	0.07	0.05	0.10
14						
	0.11	0.08	0.26	0.07	0.04	0.13
15						
	0.12	0.10	0.17	0.07	0.05	0.12
16						
	0.09	0.05	0.32	0.06	0.06	0.10
17						
	0.13	0.01	0.28	0.06	0.05	0.10
18						
	0.10	0.09	0.14	0.05	0.03	0.09
19						
	0.07	0.07	0.24	0.06	0.05	0.03
20						
	---	0.04	---	---	---	---
21						
	---	0.03	---	---	---	---
22						
Crest Stage	20.67	21.85	19.64	19.54	19.25	19.25

NOTES:

(1) Action stage - River is bank full upstream and downstream of floodwalls in downtown Grand Rapids.

Clean Up

Upon final recession of flood waters, the sandbags and other closures should be disassembled and emptied of sand into stockpiles. All closures should be inspected, repaired or replaced, as required, and restored to appropriate storage locations. Sewer plugs should be deflated, removed from the pipes, and inspected for damage and leaks. All damaged and unsalvageable materials should be removed and disposed.

Special O&M During High Water Periods

General

This section of the manual is supplementary in nature and describes standard practices that have been used to advantage on levees and floodwalls during high-water emergencies. Most of the methods described herein have been developed during years of experience with the various problems that arise during periods of high water, but they are not intended to restrict the Superintendent, or others concerned, to a rigid set of rules for every possible circumstance. In all cases, the Superintendent should follow standard engineering practices in meeting emergency situations.

Earth Embankment (Levee) System

The earth embankment system may be subjected to certain dangers during flood periods from current, ice, debris, or wave action. These dangers diminish with the degree of maintenance that the earth embankment system receives during normal river stages. Properly constructed earth embankments (levees), if adequately maintained, should withstand any major flood. However, certain unexpected conditions that arise during floods and threaten the earth embankment (levee) system may be met with assurance if prompt action is taken and proper methods of treatment are used. Measures to cope with sand boils, seepage, sloughs, wave wash, ice impact or jams, scour, and possible overtopping of neglected low spots in the earth embankments (levees) and floodwalls, are described herein. Prompt and adequate maintenance will result in minimizing the necessity for such measures during high water periods.

Preparedness

It will be noted in the following paragraphs that various materials and equipment are required to combat such unforeseen conditions as may arise during a flood emergency. It is imperative to know in advance just where such materials and equipment may be secured in emergencies, even though such emergencies may never arise. A definite plan should be prepared by the Superintendent that will enable him to foresee just what materials he will need, where they may be obtained in time for use, what manpower and transportation will be needed, what routes will be open at particular river stages, etc. This information will be particularly vital as the possibility of earth embankment (levee) and/or floodwall overtopping is approached. Such a plan, once formed, must be checked prior to each flood season since the sources of material supply could very likely change during the year. The essential element in a flood emergency is time, therefore local interests should give early attention to the preparation of a list of sources from which the necessary labor, lumber, hardware, sandbags, suitable earth for sacking, equipment, etc., can readily be secured to cover any contingency. Such items should be provided as rapidly as is possible when the need arises.

Materials

For all practical purposes, the materials of consequence used during flood emergencies are:

Sandbags.

- Lumber (rough, common pine)
- Sacked or loose earth
- Plastic tarps/sheets
- Wire (No. 9) and nails

A reserve supply of emergency materials should be kept on hand or be immediately available through arrangements with local suppliers or manufacturers. The principal consideration in obtaining lumber and other materials for emergency construction is their availability. Stored materials subject to damage or deterioration should be checked, and damaged portions replaced, before the start of each high-water season.

Sacked Earth or Loose Earth

Sacks filled with earth can be used in almost every phase of emergency high water work. It may best be used when the point of placement is readily accessible by truck. It is advisable to use sacked earth under other conditions. Sacks should be filled about two-thirds full, with the material shaken down into the sack loosely (never tamped). Sacks need not be tied or sewn together at the top if used for capping or on the land side of the earth embankment (levee). Earth-filled sacks used for wave wash, or as weights, should be filled and the ends tied. Sand should be used only if earth is not available, or if the time element is an important factor as in the distance required for hauling. In some cases, it may be better to fill sacks elsewhere and haul them to the site.

Sandbags

The term "sandbags" as used in flood emergency construction might to be considered a misnomer in that the bags are ordinarily filled with earth. Sand is used only when they are used as weights or when earth availability is a problem. An adequate initial supply of sandbags should be maintained to make all necessary sandbag closures. Bags must be checked annually to detect any deterioration. They should be stored in a dry location where there is free passage of air around them to prevent spontaneous combustion. Any bags that are damp, wet, or oily, should not be returned to storage with the main supply. Sacks used for sandbags are mildew treated burlap or ultraviolet light-resistant polypropylene. When they are two-thirds full, they hold about one-third cubic foot of earth. Any type and suitable size sack can be used if burlap or polypropylene is not available.

Earth

The most suitable type of earth to be used for flood emergency construction is a silty loam or a silty clay loam; however, almost any available soil can be used with plastic tarps/sheets to provide a waterproof barrier or liner.

Preliminary Preparations

The City should have a trained organization, who may readily be assembled by the Superintendent immediately upon receipt of information that a Grand River flood stage > 12' is forecast. This organization should be capable of quick expansion so that sufficient personnel are available to complete the necessary work. As his/her initial activity, the Supervisor should make a detailed inspection, particularly with reference to the following matters:

- Condition of earth embankments (levees and recent repairs)
- Condition of drainage structures
- Transportation facilities; roads, rail, and traffic/rail control signals
- Material supply; quantity, location, and condition
- Communications; verify that phones to be used by emergency personnel are operational

Initial Work

After initial inspection, the Supervisor should perform the following work immediately where required. To accomplish such work, he/she should have organized labor and obtained the supplies and equipment as may be necessary.

- Where new earth embankment (levee) construction has been performed on the riverside of earth embankment (levee), preparation should be made in advance to combat wave wash by facing with sandbags.
- Inspect all flap gates, before the seats are submerged, to ascertain that they are clear of obstructions and will seat properly.
- Ascertain that all roads to and along the earth embankments (levees) are in good condition. The Superintendent should obtain the assistance of the local road forces to have all necessary roads put in usable condition. The Superintendent should be informed at all times of all roads in the vicinity that are closed for

repair. An up-to-date route layout should be available at all times showing routes over which any and all types and weights of equipment can be sent to any point in the protection system.

- Locate necessary tools and materials (sacks, sandbags, lumber, lights, etc.), and distribute and store them at points where active maintenance is anticipated.
- Check and repair of all telephones necessary for operation; obtain lists of all team forces, bus, automobile, and truck transportation that can be made available.
- Make thorough arrangements with reliable citizens of the community for supply, transportation, subsistence, and shelter for the necessary labor.
- Investigate all drainage ditches on the landside of the earth embankments (levees) and open these drains when obstructions exist.

Methods of Treatment – General

After the above preliminary organizations and precautions have been completed, the various methods of combating possible flood emergencies are ready to be employed. Temporary treatment of emergency situations is described in the following paragraphs.

Seepage - Earth Embankments (Levees)

Seepage emerging from the slope, or at the landside toe of an earth (levee) embankment, can cause sloughing of the slope or even lead to piping (internal erosion) of fine sand or silt material. In many cases, high water stages do not act against the earth embankment (levee) long enough for this to happen, but the possibility of the combination of high water and a period of heavy precipitation may bring this about. To prevent sloughing where the slope is deeply saturated, small V-shaped drains should be cut in the landside slope to remove the seepage water. If the earth embankment (levee) should become saturated over a relatively large area, it may become necessary to take the measures outlined below to prevent sloughing.

Slope Drainage - Earth Embankments (Levees)

Drainage of the slope should be provided at all places on the landside of the earth embankment (levee) where seepage appears. The drains should be V-shaped, no deeper than necessary, and never more than 6-inches deep. The sod should not be cut unnecessarily. In all instances, drains should be cut straight down the earth embankment (levee) slope. Where possible near the toe of the slope, the small drains should be Y'd together and lead into large drains which lead to ponding areas or SPSs.

Sloughing - Earth Embankments (Levees)

Sloughing is the slipping, or flowing out of position, or the landside slope of an earth embankment (levee), due to being saturated through seepage to the point where that part of the earth embankment (levee) becomes unstable. Reaches in the earth embankment (levee), where the material is of such nature that prolonged high stages may cause sloughing, should be thoroughly drained as described above. After this operation, a single layer of willow brush, if obtainable, or any small trees or limbs, should be laid up and down the slope, butts upward and tops downward, and weighted with earth-fill sacks. If the slope begins to slough down, a log or heavy timber should be laid on top of the willows at the toe of the material sloughed off and fastened to long stakes which have been driven several feet into the ground. A buttress of earth filled sacks should then be built at the toe and extended up the slope. The buttress at the toe should be built in the shape of a small berm. Sandbags or weights should not be placed more than two-thirds of the distance from the toe of the material sloughed off to the bottom of the slough. See Figure 2.

Sand Boils - Earth Embankments (Levees)

A sand boil is a definite stream of seepage water issuing from the earth, usually near the landside toe of an earth embankment (levee). The source of this water is usually from pervious materials underlying the earth embankment (levee) or floodwall. Sand boils are serious in any location and should be watched closely, especially when within 100-feet of the earth embankment (levee) toe. A sand boil which discharges clear water in a small steady flow, is ordinarily not a serious threat to the safety of the earth embankment (levee) or floodwall, and need not be ringed. However, if the flow increases or carries a substantial load of sand and silt, corrective action should be taken immediately to prevent possible earth embankment (levee) failure. A neglected sand boil may gradually undermine an earth embankment (levee) and cause failure by subsidence of the levee.

The accepted method of treating a sand boil is to construct a watertight ring of sand bags around the boil, high enough to create a head of water within the ring sufficient to reduce the velocity of flow. See Figure 3. The ring should not be built to a height which stops the flow of water completely. The sacks are filled about two-thirds full of earth, and are laid flat in a ring around the boil with the joints staggered, each layer being placed in alternate directions. The sacks should be lapped at least one-third. The ends are left untied, and are lapped under the sacks. Each complete layer should be tramped or tamped into place after placement. The base width of the ring should be not less than one and one-half times, and preferably twice, the contemplated height. A drain is provided by omitting one bag in the top layer, or by constructing a V-shaped drain of two boards or a piece of sheet metal inserted near the top of the ring.

If ground weakness is indicated close to the sand boil, it is well to include the weak ground within the ring, thereby avoiding the possibility of a breakthrough later. Several sand boils within a relatively small radius should be enclosed as a group in a sub-levee or single sack ring. Sand boils at the toe of the levee or floodwall are sacked in the same manner as those away from the earth embankment (levee), and in the case of an earth embankment (levee), using the earth embankment (levee) slope as one side of the closure.

Sandbags, Cotton Bagging, or Plastic Sheeting

Sections of cotton bagging or plastic sheeting should be placed over the washed areas as shown on Figure 4. If the washed area is considerable, or protection is desired to a predicted higher stage, the bagging may be cut into lengths and laid up and down the slope to cover the area. The strips should be lapped with the current to prevent lifting. See Figure 5. Bagging must be thoroughly weighted down with stone or sandbags to be effective. In using this method, stakes should be driven through the bagging approximately 6-feet apart below the water surface and at the top of protection, to be sure that the bagging is being held in place. As an alternative, sacked earth material may be used as a means to fill small washed areas or holes. The sacks should be placed close together beginning about 2-feet under the water surface. Each succeeding row of sacks should overlap the preceding row like shingles on a roof. The joints should be staggered. All holes should be filled with sufficient sacked earth to meet the original grade line. All sacks should be tamped into place so that wave action will not readily wash them away.

Log Boom

If sacking for the prevention of washes caused by floating ice cannot be placed or used effectively, it is desirable to make a log boom of any available large timbers to deflect ice from the embankment. The logs should be fastened together with steel staples and coil chain, or heavy wire, with a distance of about 12-inches between end faces. The staples at each end of the log should be driven on a line parallel to the axis of the log, and should be allowed to protrude sufficiently to permit enough room for rotation of the logs. Wire or chain should be passed or wrapped around the logs as staples may pull out. The boom should be strung along the levee slope and anchored about 15-feet out from the water's edge by means of logs or timbers, spaced not more than 50-feet apart, tied to stakes near the shoreline. See Figure 6. The booms should also be anchored to the slope approximately every 200-feet, or as conditions may require, with cables placed at angles of about 45 degrees.

Additional stakes can be driven up the levee slope in anticipation of a rising river, and the anchor logs and cable ties adjusted as required. This method of protection is particularly effective against ice flows.

Scour

Current scour, or erosion of the riverside slope of the levee, is caused by abnormally high current velocities. Conditions which could cause scour may be detected by the appearance of eddies and general turbulence of the water. Immediate steps should be taken to protect the levee when current scour appears.

Overtopping - Earth Embankment (Levee)

Overtopping, or the flow of water over the earth embankment (levee) crown, is a serious threat to the stability of the earth embankment (levee). The danger from overtopping and the necessity for preventive action cannot be over-emphasized. It is very difficult, if not impossible, to close a breach in an earth embankment (levee) after the substantial amount of material has been washed out. The various methods of increasing the height of the earth embankment (levee) to prevent overtopping are described in the following paragraphs. The required height of topping can best be determined by running a line of levels and setting grade stakes, so that a topping grade parallel to a predicted high-water profile can be established. A freeboard of about 2-feet above predicted high water is sufficient for determining height of topping.

Sandbag Topping

This method of raising levees may be used when the required additional height is less than 3-feet. It is constructed of layers of earth filled sacks, which form a small berm on the crown of the levee, as shown on Figure 7. The top layer should be at least 3-feet wide and the side slopes should be about 1 on 1, or not less than required to provide a base width sufficient to prevent failure. In no case should the base width be less than three times the height. The landside slopes should be about 1 on 2-1/2 when the topping is placed on a smooth surface, such as concrete or asphalt instead of earth.

The earth levee crown is prepared by stripping the sod to the required width and to within 1-foot of the riverside edge. The surface is then scarified by plowing furrows, or by similar means to a depth of at least 2-inches. A trench should be dug to accommodate a row of sandbags parallel to the axis of the levee. These steps are very important as they provide a good bond between the topping and the levee surface. The sacks are filled two-thirds full of earth, and should be well tramped or tamped into place. They are laid in alternate directions, those in the bottom layer being lengthwise of the levee, the next layer crosswise, etc. Gravel-filled sacks should be placed on the riverside slope of the topping if wave action becomes more severe than anticipated.

Lumber and Sack Topping

This is one of the most common emergency methods of raising low reaches in levees, especially when the height required is less than 3-feet. It is constructed as shown on Figure 8, and consists of a board fence erected on the levee crown about one foot from the riverside edge; backed with sacked earth or earth fill, placed on a surface stripped of sod, and scarified as described in ”Sandbag Topping” in Section 9.4. A row of 2 x 4-inch x 6-foot stakes is driven in as straight a line as practicable, to a minimum penetration of 2-feet, 6-inches. The stakes are spaced at 6-foot intervals for boards 12-feet long. A trench for a row of sandbags is dug adjacent to the landward edges of the stakes, with the riverside edge of the bottom being made as level as possible, in order to provide a secure and even seat for the bottom boards of the fence.

The bottom 1 x 12-inch x 12-foot boards are placed firmly on edge, end to end in the trench, and nailed to the stakes. The required additional rows of boards are nailed to the stakes with joints staggered. The fence should be braced as required, with 2 x 4-inch x 10-foot back braces nailed to 2 x 4-inch x 2-foot stakes as shown on Figure 8.

The bottom edge of the fence should be sealed with well-tamped earth fill on the riverside face. The landside backing is usually composed of earth-filled sacks, filled and laid as described in “Sacked Earth or Loose Earth” in

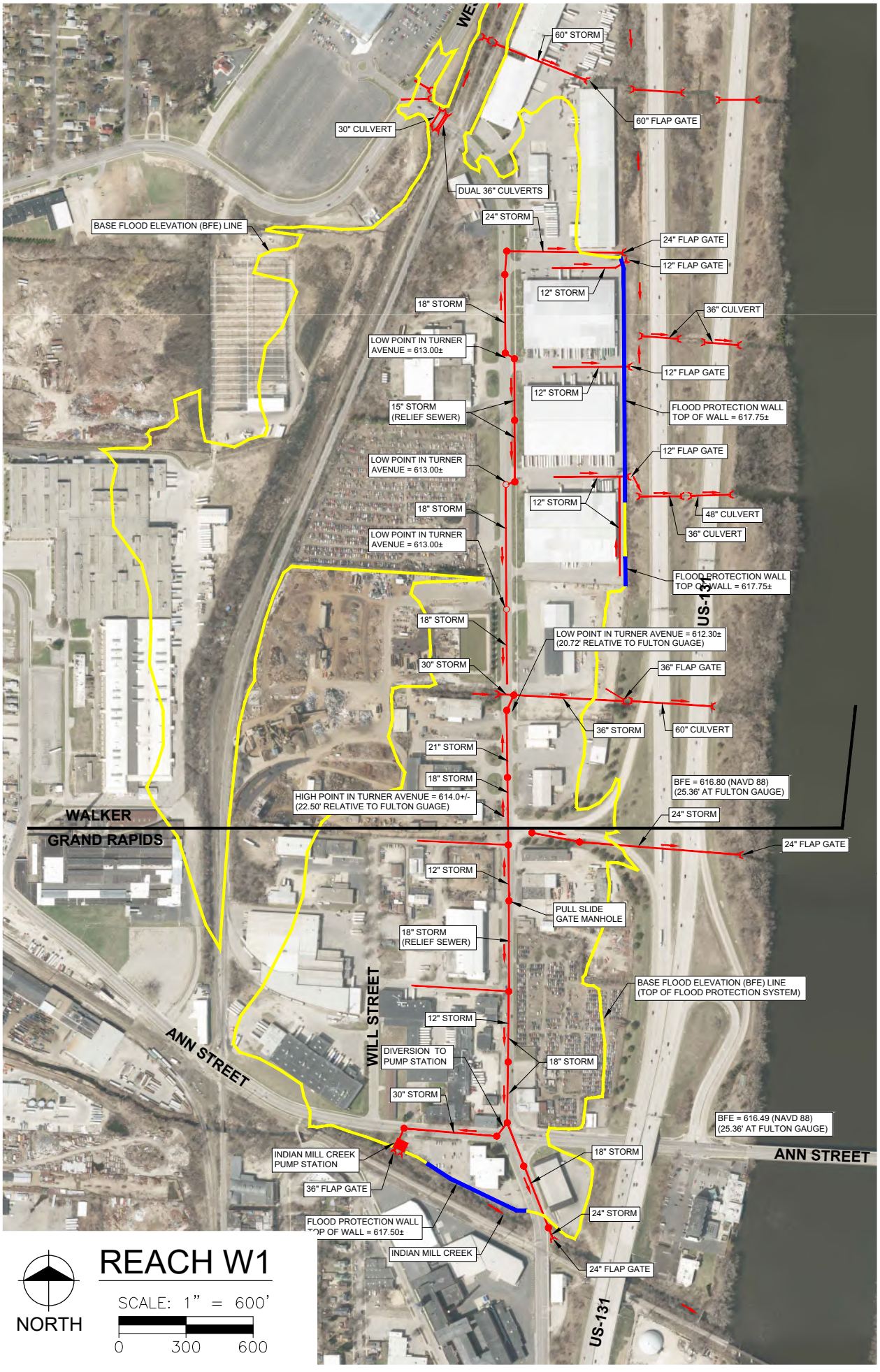
Section 9.2 and “Sandbag Topping” in Section 9.4. In some instances, it may be more practical to use tamped earth fill or sack material should be nailed to the landside face of the fence.

Caving Banks and Slides - Temporary Protection - Earth Embankments (Levees)

Caving banks and slides can cause considerable damage and create hazardous conditions which should be remedied immediately upon discovery. Slides, as distinguished from sloughs, are characterized by the shearing of a mass of the embankment on a slip plane. Slides are brought about generally by undercutting due to current scour over a period-of-time. This action is particularly dangerous if the undercutting reaches the base of the earth embankment (levee) proper, which may result in earth embankment (levee) failure. These conditions should be noted and brought to the attention of the Superintendent. As a temporary remedial measure against active caving of riverbanks, a rock filled crib as illustrated on Figure 1 is very effective when properly placed. This will serve to alleviate bank or levee damage until permanent corrective measures can be taken.

Cribs are usually 14 x 14-feet in plan by 10 to 14-inches in inside depth. The cribs are constructed of a double thickness of 1 x 4-inch x 14-foot lumber, equivalent to 2 x 4-inch pieces, lapped “rail fence” fashion at all corners and intersections. They are divided into four compartments of about equal areas by two perpendicular cross walls constructed in the same manner as the side walls. The floors and covers are built up of double 1 x 4-inch boards spaced about 9-inches center-to-center. Under the floor, and perpendicular to the direction of the floor boards, are five equally spaced pairs of 1 x 4-inch boards about 3-feet center-to-center. On top of the cover, perpendicular to the direction of the cover boards, are three pairs of top boards, one over each of the side walls and one over the central division wall. The compartments are filled with rock before covering. Each wall intersection of the fabricated crib is securely fastened by a loop of No. 9 wire.

Figures



REACH W1

SCALE: 1" = 600'

0 300 600

NORTH

©Copyright 2017 All Rights Reserved

PLOT INFO: Z:\2012\120330\LMP\CAD\REF\CITY OF WALKER EAP FIGURES.DWG LAYOUT: REACH W1 DATE: 4/10/2018 TIME: 4:55:49 PM USER: JRP

frc&h
engineers
scientists
architects
constructors
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Hard copy is intended to be 8.5"x11" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

City of Grand Rapids
Kent County, Michigan

FLOOD PROTECTION SYSTEM LAYOUT

PROJECT NO.
G120330

FIGURE NO.
1

Appendix 1

GRAND RIVER FLOOD PROTECTIVE SYSTEM
PLAN OF GENERAL IMPROVEMENTS

LIST OF DRAWINGS FOR FLOOD PROTECTION WORKS
WALKER, MICHIGAN

(All drawings prepared by City of Grand Rapids unless otherwise noted)

Floodwalls/Levees/Outfalls

West Bank – Ann Street to Upstream City Limits

GPF No.	No. of Sheets.	Title
1262	3	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Reconstruction of Turner Avenue from I-296 Ramp to 400' South of Ann Street and from I-296 Ramp to 750' North, Sheet 5, 7 and 9 of 15 (year unknown)
---	1	City of Grand Rapids, Michigan, Department of Public Service, Division of Engineering, Improvement in Edwin Street from Will Ave. to Turner Ave. (1972)
---	6	MDOT, NB US-131 Sta. 976+00 to Sta. 988+00, Job No. 56887A, prepared by URS (2006)
---	27	City of Grand Rapids, Design, Development and Enterprise Services and Kent County Drain Commission, Chapter 20 Drainage Commissioner, Improvements to Grand River Floodwall, Contract No. 2 (Freeboard and Embankment Protection Improvements, prepared by Fishbeck, Thompson, Carr & Huber, Inc. and Materials Testing Consultants, Inc. (2016)

Appendix 2

GRAND RAPIDS FLOOD PROTECTION SYSTEM POLICIES, PROCEDURES, AND INSPECTION CHECKLIST FORMS

POLICIES, PROCEDURES, AND INSPECTION REPORT FORMS

FOR

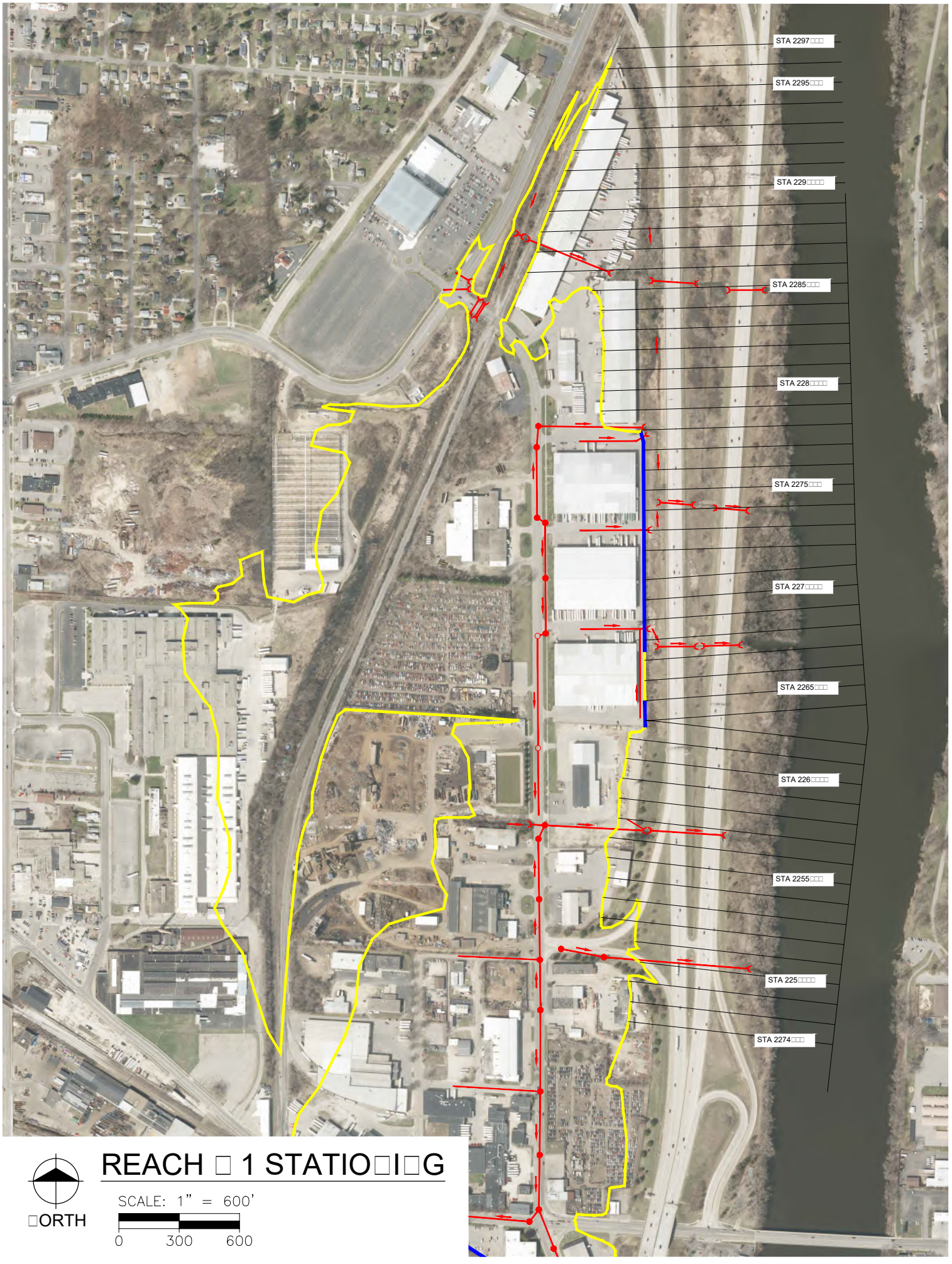
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

1. Forms similar to the sample inspection report forms contained herein can be used in submitting reports to the Superintendent who will evaluate the flood protection system condition and ability to protect Walker from floods on the Grand River. The forms cover inspection, maintenance, and operation of the flood protection works. All information desired and all remarks should be given precisely and accurately. Additional sheets and sketches should be added where necessary to clearly convey the submitted information.

2. Inspection of the features comprising the flood protection system should be made as indicated below.

3. Earth embankments should be inspected annually through the Office of the City Engineer, immediately following any flood in excess of 31,000 cfs (Stage = 19.34 feet) as measured at the U.S. Geological Survey (USGS) Station 04119000, Grand River at Grand Rapids, Michigan, or at such times deemed necessary by the City Engineer.

4. An annual report covering inspection, maintenance and operation of the flood protection works should be submitted in April to the City Manager. This report should include all logs of operation and dated copies of all inspection check lists made during the period covered by the reports.



REACH □ 1 STATIO□I□G

□ORTH

SCALE: 1" = 600'

0 300 600

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

SUMMARY OF LEVEE AND DRAINAGE STRUCTURES

Location:_____ **I.D. No.** _____

1. **Date of this Inspection report** _____
2. **Date of last inspection report** _____
3. **Levee:**
   a. **Unusual occurrences or remarks concerning levee inspection**

      _____
      _____
      _____
      _____
      _____

   b. **The following necessary repairs have been revealed by the levee inspection (enclose rough plan of anticipated repairs or explain)**

      _____
      _____
      _____
      _____
      _____
      _____

4. **Drainage Structures:**
   a. **Unusual occurrences or remarks concerning drainage structures inspection**

      _____
      _____
      _____
      _____
      _____

   b. **The following necessary repairs have been revealed by the drainage structures inspection (enclose plan of anticipated repairs or explain)**

      _____
      _____
      _____
      _____
      _____

5. **At what date (state specific date) will the responsible City division perform the above repairs?**

   _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

SUMMARY OF LEVEE AND DRAINAGE STRUCTURES

6. Remarks and Explanations

_____

_____

_____

_____

_____

_____

_____

_____

_____

No. of Additional Sheets _____

Signed: _____ **Date:** _____

Title: _____

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

	Location (Station)	Condition	Type of Maintenance Required
1. Settlement or loss of grade			
2. Bank caving (either side of levee)			
3. Rain, wave or current wash			
4. Seepage, sloughing, saturated areas or sand boils			
5. Have the areas identified in Item 4 been marked on the ground?			

*** Insert river station number or name of street, railroad, or other descriptive levee landmark.**

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

6. Low spots, ponding areas			
7. Crown of levee			
8. Riprap			
9. Access roads and road ramps, surfacing			
10. Grass or sod on crown, slopes and berms			

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

11. Weeds or undesirable vegetation			
12. Accumulation of drifts, trash or debris			
13. Damage due to fire			
14. Damage due to rodents			
15. Trespassing on right-of-way (encroachment, excavation, dumping or construction)			

INSPECTION CHECKLIST
FOR
FLOOD PROTECTION WORKS – WALKER, MICHIGAN

LEVEE

INSPECTION COVERS STATION* _____ TO _____

16. Miscellaneous

17. Remarks and explanations _____

_____

_____

_____

_____

_____

_____

No. of additional sheets _____

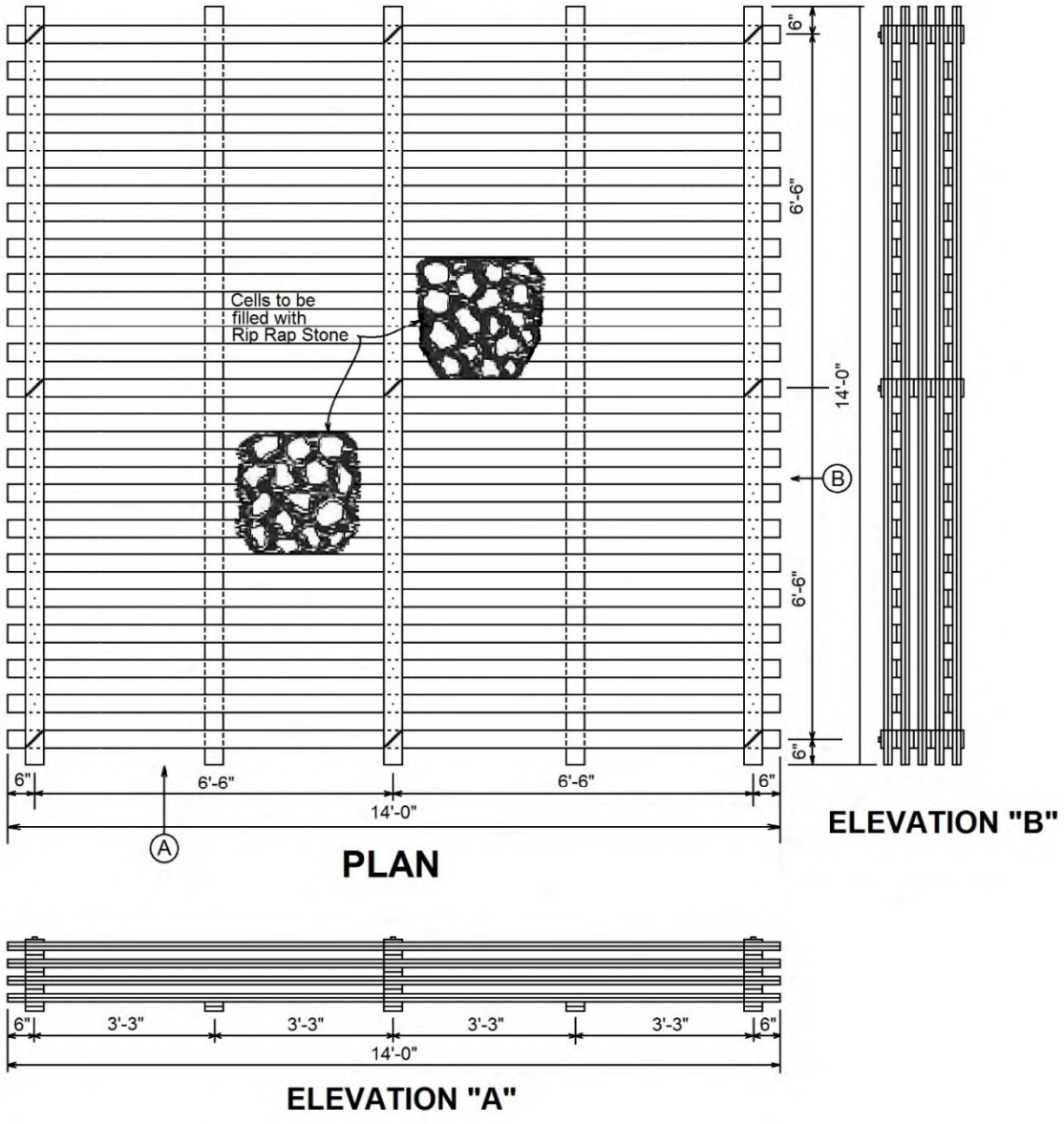
18. DATE OF LAST INSPECTION _____

19. DATE OF THIS INSPECTION _____

20. INSPECTOR _____

Appendix 3

GRAND RIVER FLOOD PROTECTIVE SYSTEM
FIGURES – EARTH EMBANKMENT (LEVEE) AND



NOTE:

Cribs constructed of double thicknesses of 1" X 4" X 14' lumber. Nail all intersections with 1-20d. nail. Each intersection of walls securely fastened by a loop of 1/4" strand, tightly twisted. If rock or concrete blocks are unobtainable, sacks filled with gravel or soil cement may be used.

BILL OF MATERIALS

Dimensions based on rough cut lumber

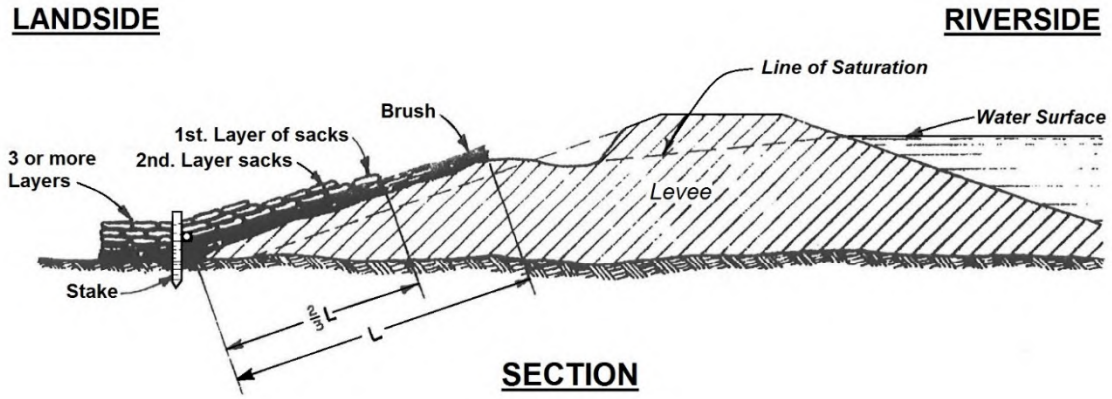
140 Pcs. 1" X 4" X 14' = 653 Bd. Ft.
12 Lbs. 20d. Common Nails
60 Ft. 1/4" Strand
1-1/2 Cu. Yds. Rip Rap Stone
Actual quantities. No allowance for waste.

FIGURE 1

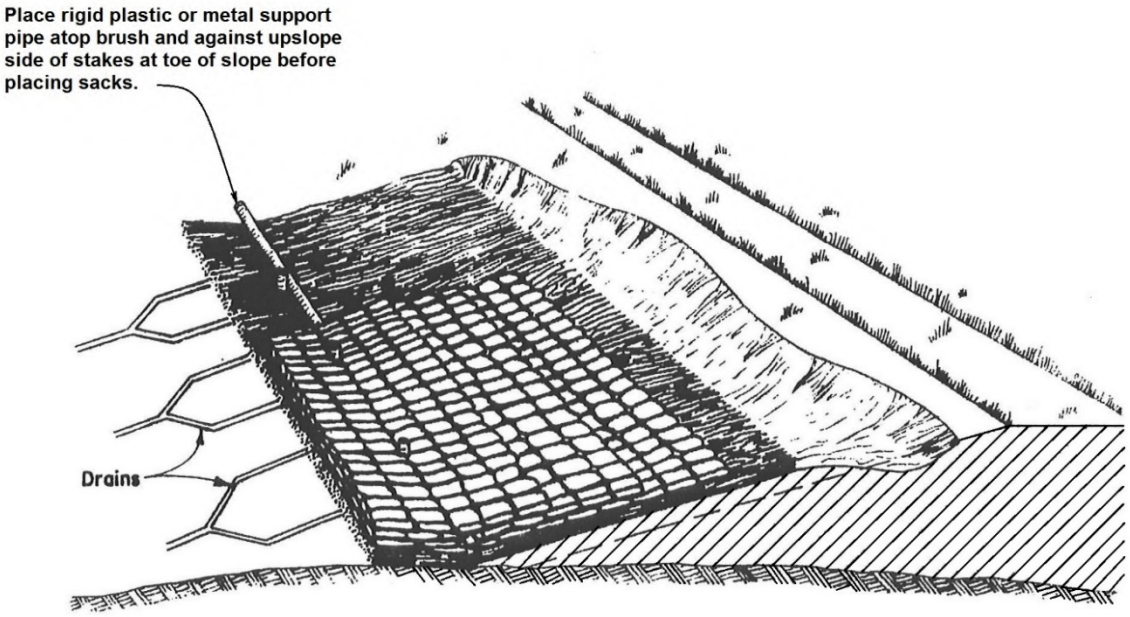
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE CAVING BANK PROTECTION

ROCK-FILLED CRIB



SECTION

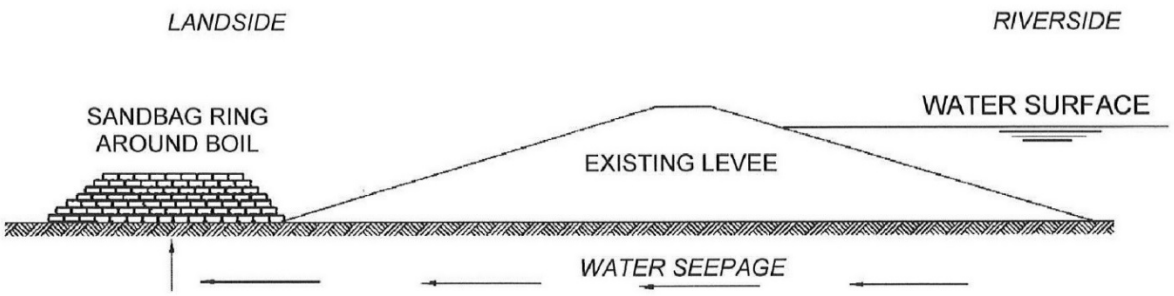


NOTE:
Cut V-Shaped drains no deeper than necessary and not more than 6" deep. Sandbags should be only 2/3 full.

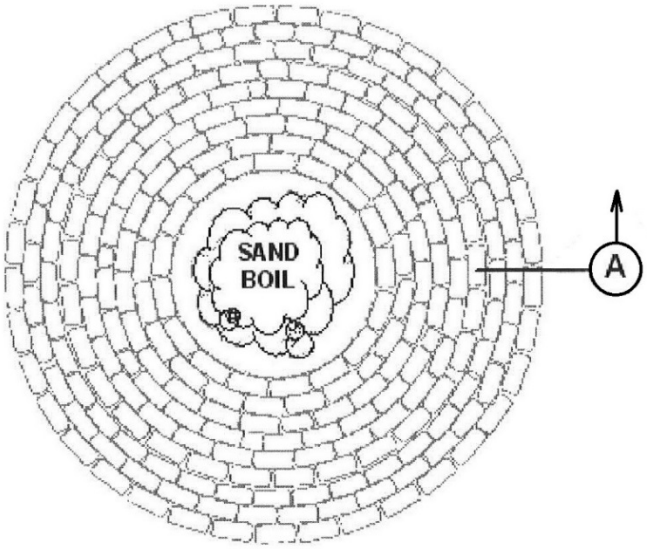
FIGURE 2
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
SLOUGHING

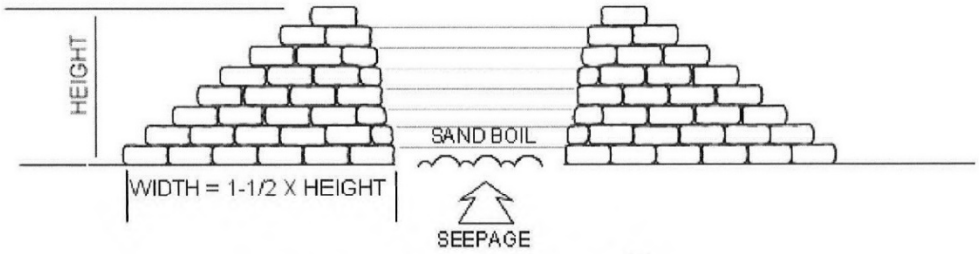
SANDBAG & BRUSH MAT



ELEVATION



PLAN VIEW



SECTIONAL ELEVATION — A

NOTES:

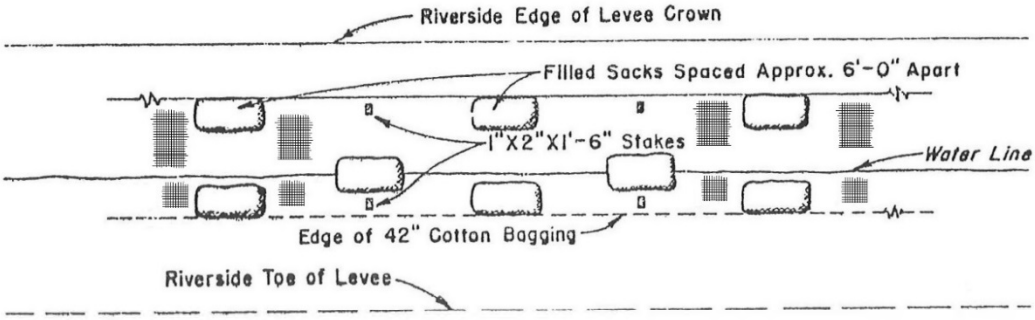
1. Do not sack a boil that does not eject soil material and whose flow is small.
2. Prepare base of sack ring by clearing debris, sod, loose soil or other objectionable material and scarify base.
3. Tamp sand bags into place.
4. Loose soil to be used between all sacks.
5. All sack joints to be staggered.
6. Bottom width to be no less than 1-1/2 times the height. Tie into levee if boil is near toe.
7. Height of sack ring should be only sufficient to create enough head to slow down flow through boil so that no more soil material is displaced and boil runs clear.
8. Never attempt to completely stop flow through boil.
9. Carry off water by omitting one sack in top layer or construct a "V"- shaped drain of boards or sheet metal to protect slope of sack ring.

FIGURE 3

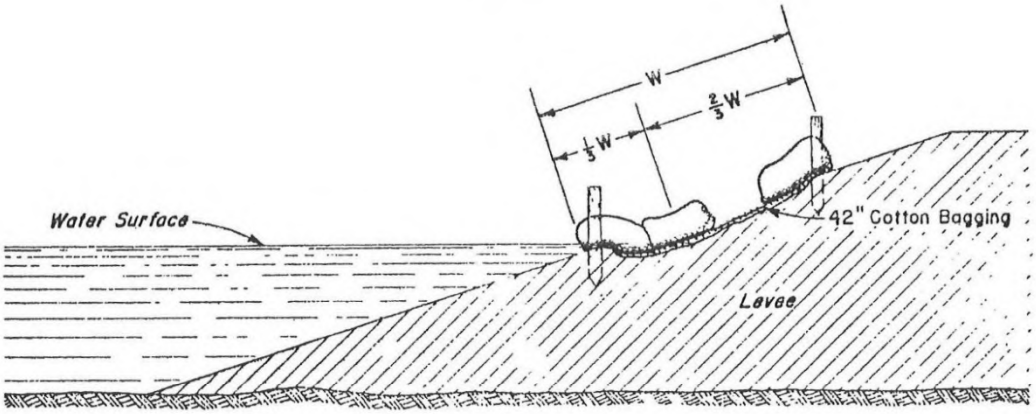
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
SAND BOIL

SACKED EARTH RING



PLAN



SECTION

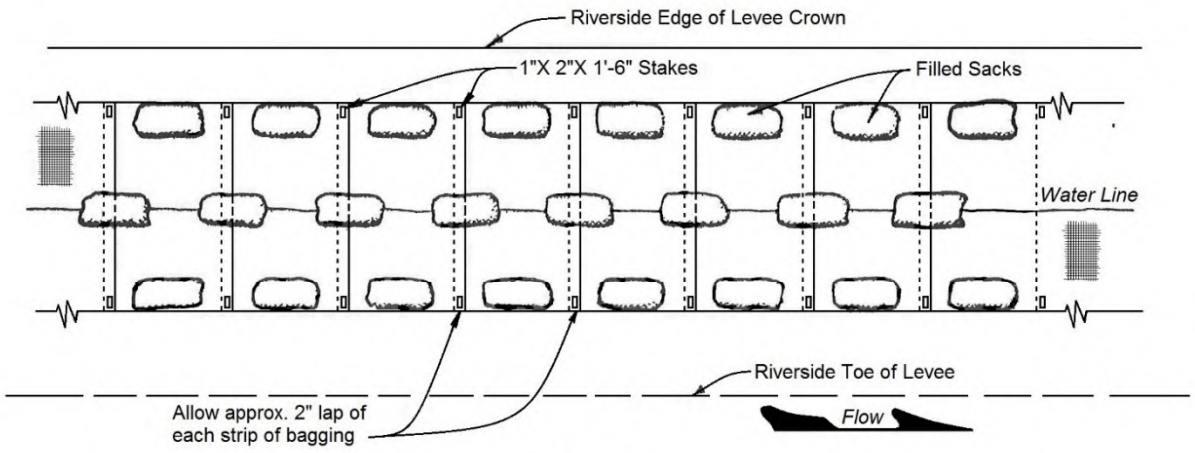
BILL OF MATERIAL TO CONSTRUCT 180 FEET OF PROTECTION		
LUMBER	BAGGING	SANDBAGS
60 - 1"X 2"X 1'-6" Stakes (Sharpened)	One roll regular (jute) Cotton Bagging 42" X 180'- 0"	90 - Filled Sacks

INSTRUCTIONS:
1. Lay 42" cotton bagging (jute) longitudinally along riverside slope of levee with approximate 2/3 width above water surface.
2. Weight bagging along edges and at water surface with filled sacks spaced approximately 6' apart. Drive stakes alternately between sacks along both edges of bagging.
3. If additional width is required, lace two or more widths of bagging together and lay as desired.
4. Plastic sheeting or burlap may be substituted for cotton bagging.

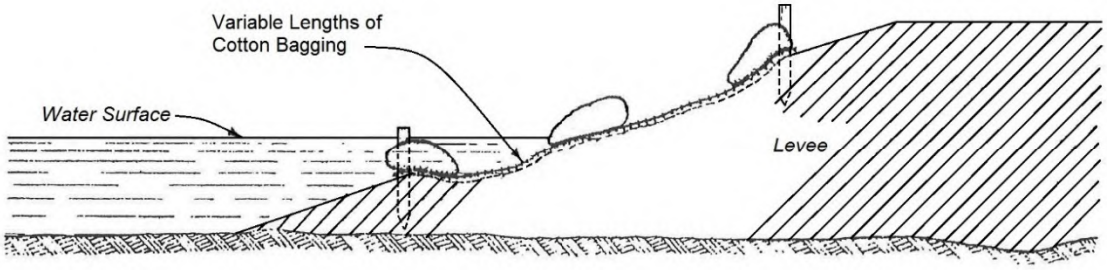
FIGURE 4
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

SANDBAG & COTTON BAGGING - NO. 1



PLAN



SECTION

Notes:

1. Lay lengths as required of Cotton Bagging approximately parallel with levee slope and across damaged section.
2. Lap strips with river current to prevent lifting.
3. Weight top and edges of bagging with filled sacks as shown above.
4. The filled sacks should be wired or tied to each strip before laying in place.
5. Stake the corners of each strip above the water surface
6. Plastic sheeting or burlap may be substituted for cotton bagging.

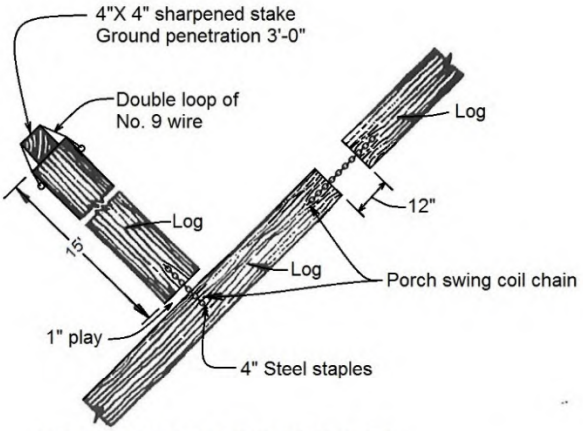
BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
120 pieces 1"X 2" x 1'-6" (Sharpened)
SANDBAGS
180 Filled Sacks Cotton Bagging as Required

FIGURE 5

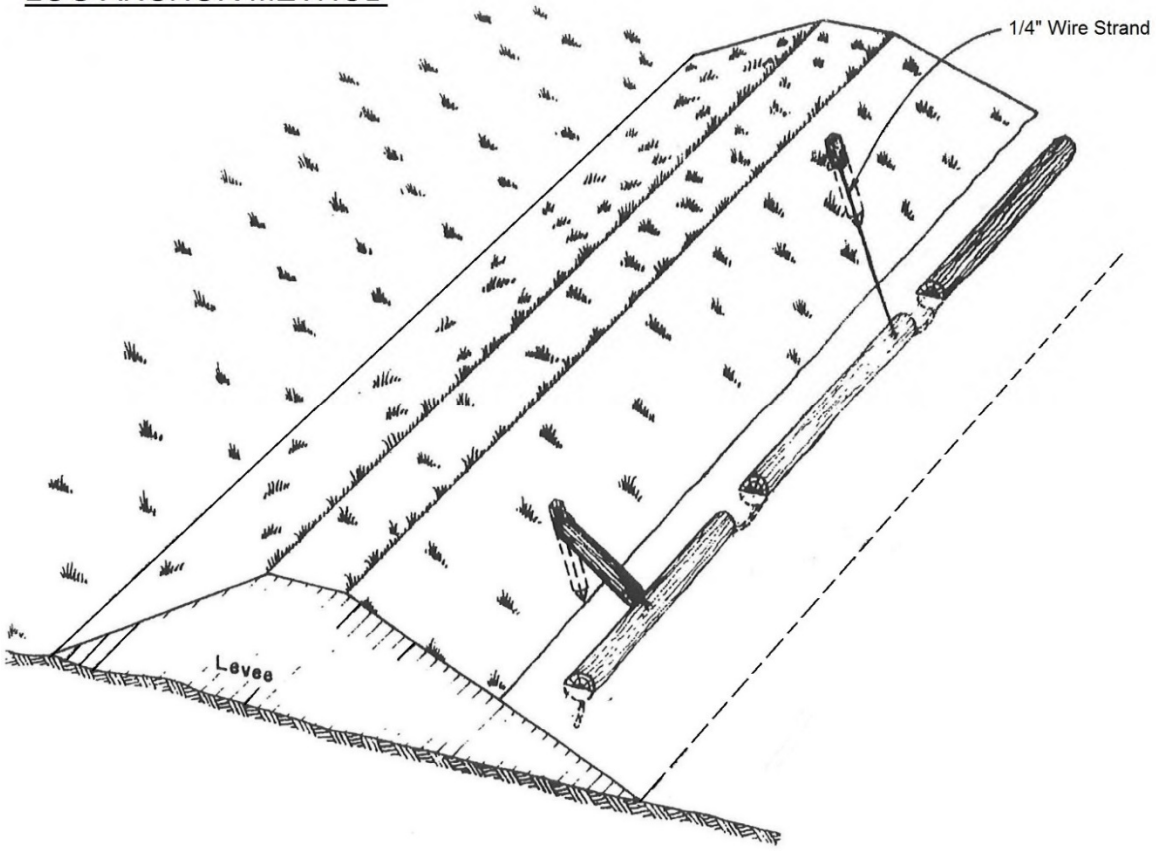
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE WAVE WASH PROTECTION

SANDBAG & COTTON BAGGING - NO. 2



LOG ANCHOR METHOD



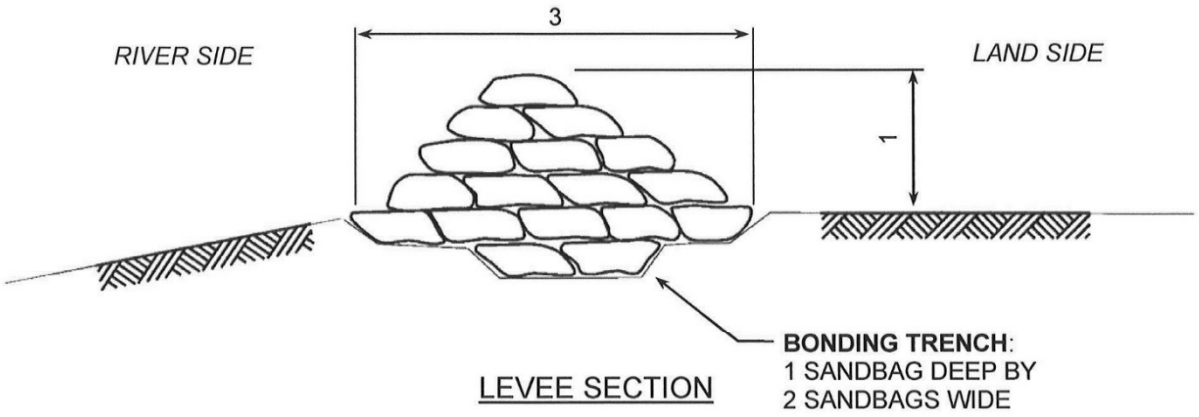
Notes:
1. Do not drive steel staples all the way in. Staples should protrude sufficiently to allow enough play for rotation of logs.
2. Substitute 3 doubled loops of No. 9 wire if porch swing coil chain is not available.
3. Anchor logs spaced a maximum of 50' apart.

FIGURE 6

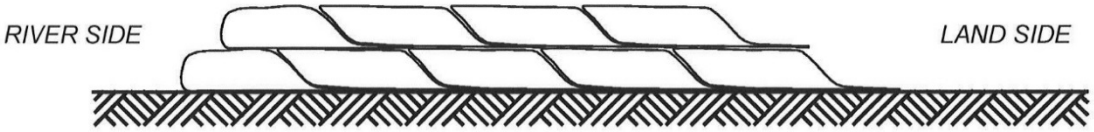
CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

LOG BOOM



LEVEE SECTION



METHOD OF LAPPING SACKS

LEVEE HEIGHT	NUMBER OF SAND BAGS REQUIRED FOR LENGTH OF LEVEE									
	50 FT	100 FT	175 FT	200 FT	250 FT	300 FT	350 FT	400 FT	450 FT	500 FT
1 Foot	300	600	1,050	1,200	1,500	1,800	2,100	2,400	2,700	3,000
2 Feet	1,050	2,100	3,675	4,200	5,250	6,300	7,350	8,400	9,450	10,500
3 Feet	2,250	4,500	7,875	9,000	11,250	13,500	15,750	18,000	20,250	22,500
4 Feet	3,900	7,800	13,650	15,600	19,500	23,400	27,300	31,200	35,100	39,000
5 Feet	6,000	12,000	21,000	24,000	30,000	36,000	42,000	48,000	54,000	60,000

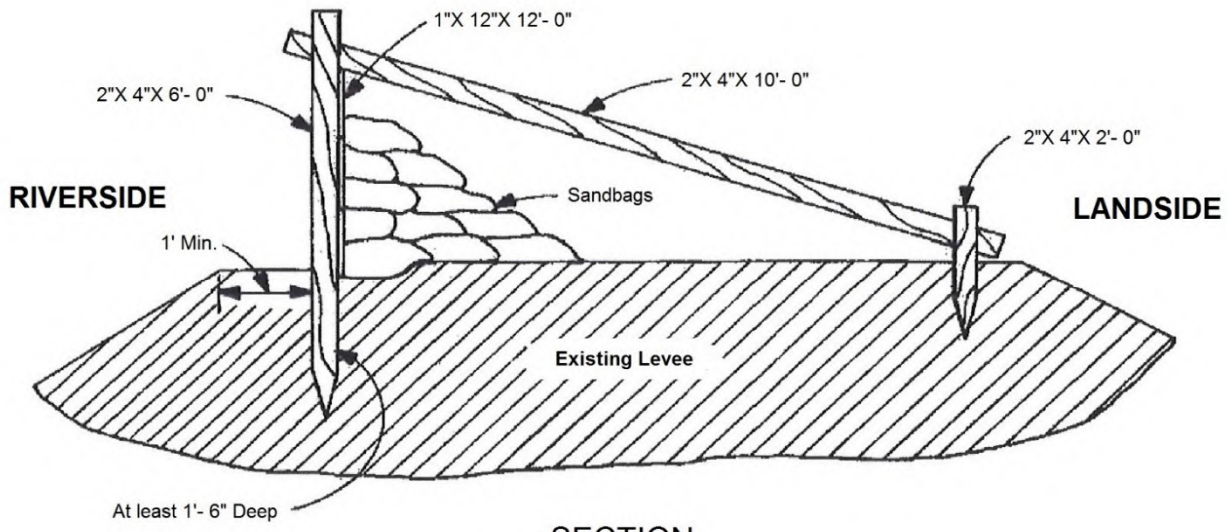
Notes:
1. Start upstream.
2. Strip sod before laying.
3. Alternate direction of sacks with bottom layer parallel to flow.
4. Next layer perpendicular to flow with open ends of sacks directed away from wet side.
5. Lap unfilled portion under next sack.
6. Tying of sewing sacks is not necessary.
7. Tamp thoroughly in place. Sacks should be approximately 1/2-full of sand or earth.
8. Width of sack levee should be 3 times the height.

FIGURE 7

CITY OF GRAND RAPIDS, MICHIGAN

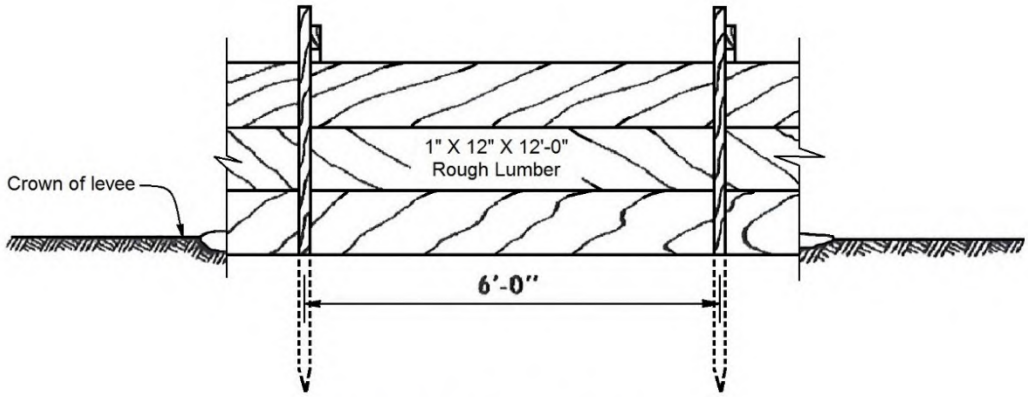
HIGH WATER MAINTENANCE OVER TOPPING

SANDBAG TOPPING



SECTION

* **Note:**
Earth fill may be substituted for sacked earth in times of emergency.



RIVERSIDE ELEVATION

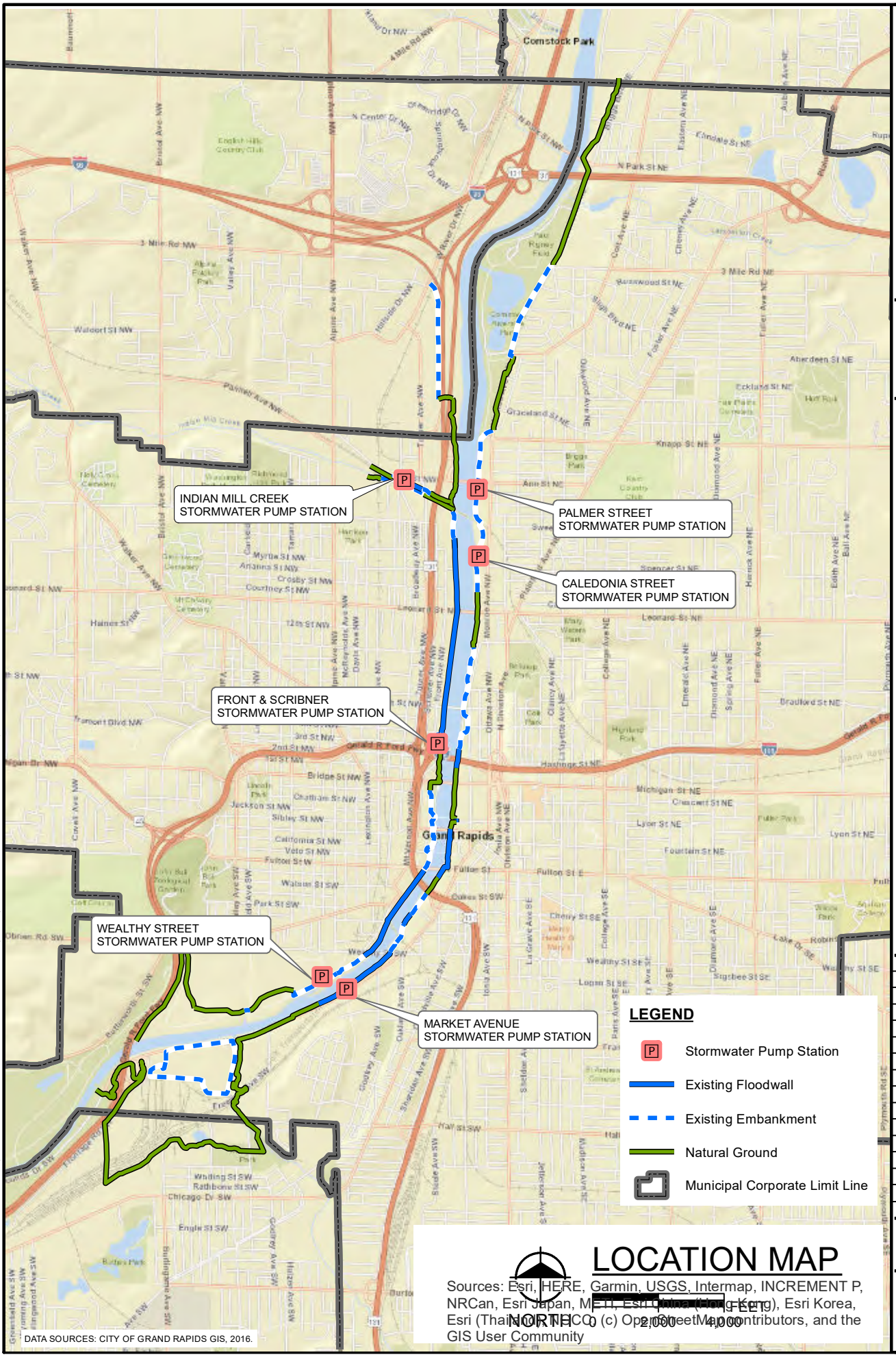
BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
25 pieces 1" X 12" X 12' 17 pieces 2" X 4" X 10' 17 pieces 2" X 4" X 6'** 17 pieces 2" X 4" X 2'** ** (Sharpened)
NAILS
1 lb. 8d nails 2 lbs. 16d nails
SANDBAGS
1100 bags

FIGURE 8

CITY OF GRAND RAPIDS, MICHIGAN

HIGH WATER MAINTENANCE
OVER TOPPING

LUMBER AND SACK TOPPING



LOCATION MAP

fishbeck

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

Hard copy is intended to be 8.5"x11" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

City of Grand Rapids
Kent County, Michigan

Grand River Flood Protection System

PROJECT NO.
G120330LMP

FIGURE NO.
9

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All Rights Reserved

PLOT INFO: Z:\2012\120330LMP\CAD\GIS\MapDoc\Flood Protection and Lift Station Location OMM (Walker).mxd Date: 1/24/2020 8:30:52 AM User: prbaskins

Appendix 4

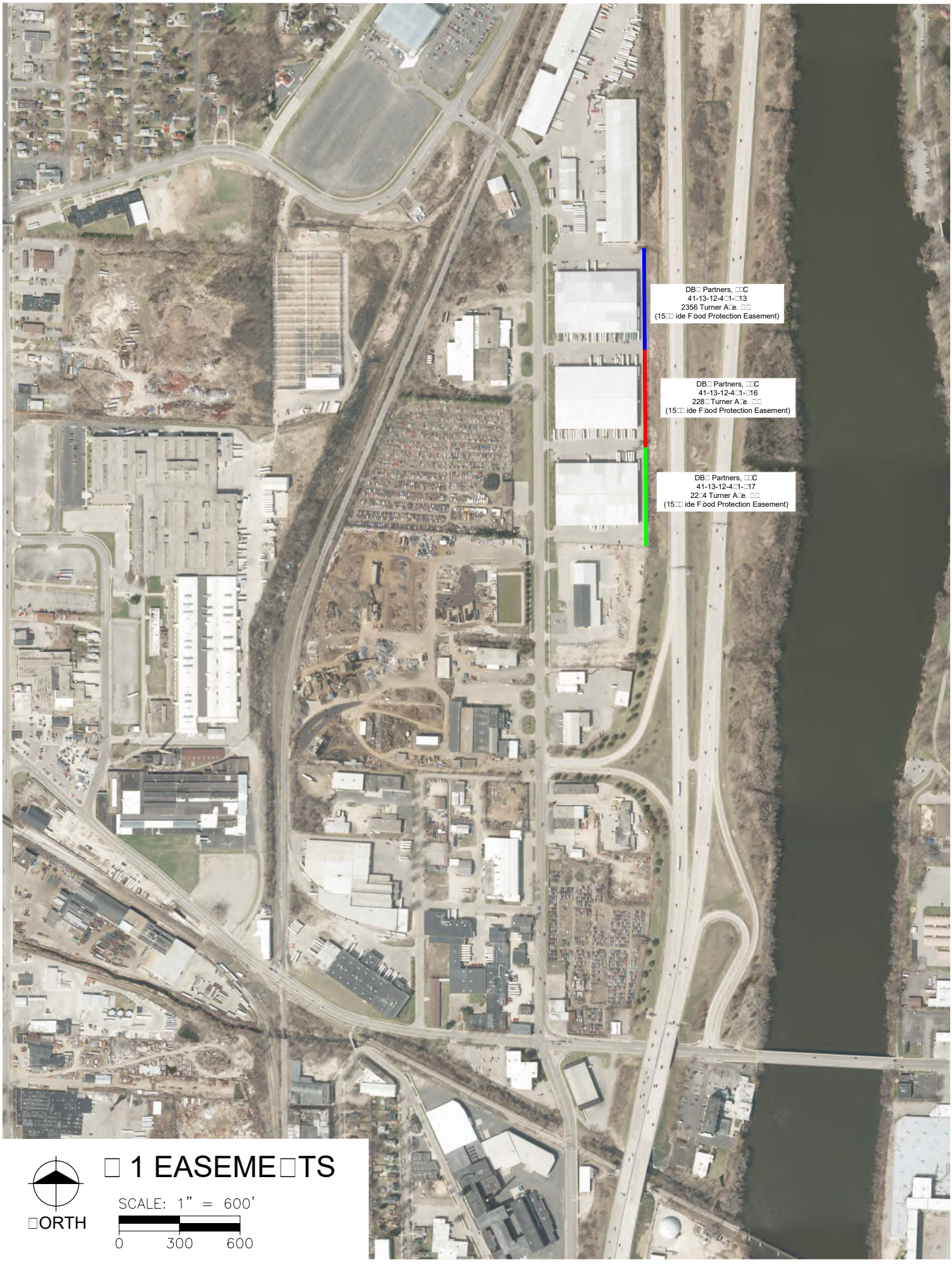
GRAND RIVER FLOOD PROTECTIVE SYSTEM OPERATIONS TO BE PERFORMED AT VARIOUS RIVER STAGES

Appendix 4
Operations to be Performed at Various River Stages

Item No.	Address/Item	Location of Item	Description of Item	Critical Elevation (when problem occurs)		Action Required	Materials Needed (during 100-year event)	Equipment Needed (to deliver and onsite)	Responsible Department
				USGS Flood Stage (at Grand Rapids gage) 100-year = 25.36'	NAVD 88 (at Location of Item)				
1	Road Closure	North Park Street west from West River Drive to Monroe Avenue	When the river rises, the street may become impassable	22.0	616.0	Barricade road if flooded to a depth of 3" or more	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
2	Road Closure	Turner Avenue between West River Drive and Southbound U.S. Route 131 ramps	When the river rises, the street may become impassable	20.0	611.4	Barricade road if flooded to a depth of 3" or more	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
3	Road Closure	Mill Creek Avenue between North Park Street and West River Drive	When the river rises, the street may become impassable	22.0	616.0	Barricade road if flooded to a depth of 3" or more	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
4	Road Closure (outside the GRFPS)	Veterans Memorial Drive between Maynard Avenue and Butterworth Street	When the river rises, the street may become impassable	12.0	593.5	Barricade road if flooded to a depth of 3" or more	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department
5	Road Closure (outside the GRFPS)	Riverbend Drive between Butterworth Sreet and Veterans Memorial Drive	When the river rises, the street may become impassable	12.0	593.7	Barricade road if flooded to a depth of 3" or more	Road Barricades, Traffic Cones, Warning Signs	None	Public Works Department

Appendix 5

GRAND RIVER FLOOD PROTECTIVE SYSTEM EASEMENTS


DB□ Partners, □□C
41-13-12-4□1-□13
2356 Turner A□e. □□
(15□□ ide F□ood Protection Easement)
DB□ Partners, □□C
41-13-12-4□1-□16
228□Turner A□e. □□
(15□□ ide F□ood Protection Easement)
DB□ Partners, □□C
41-13-12-4□1-□17
22□4 Turner A□e. □□
(15□□ ide F□ood Protection Easement)
□ 1 EASEME□TS
□ORTH
SCALE: 1" = 600'
0
300
600

FLOOD PROTECTION EASEMENT

DBV Partners, L.L.C., a Michigan limited liability company, of 1946 Turner Ave. NW, Grand Rapids, MI 49504 (the "Grantor"), in exchange for payment of $1.00, the receipt of which is acknowledged, quit-claims to the **City of Grand Rapids**, a Michigan municipal corporation, with offices at 300 Monroe Ave. NW, Grand Rapids, MI 49503 (the "City") a permanent easement in, on, over, under, and through the area described and depicted in the attached Exhibit B (the "Flood Protection Easement Area") for the purposes of surveying, designing, constructing, inspecting, repairing, replacing, improving, maintaining, altering, rehabilitating, monitoring, removing, using, and operating a floodwall, embankment, or other flood protection infrastructure, together with storm sewers or drains, flap gates, backflow preventers and other appurtenances thereto, subject to the following terms and conditions of this Flood Protection Easement (this "Easement"):

1. The City, including its officers, employees, contractors, engineers and other agents, shall have the right of ingress to and egress from the Flood Protection Easement Area through the Grantor's larger parcel described on the attached Exhibit A (the "Grantor's Property"), and any accretions thereto, over a route prearranged with the then property owner, in order to access the Flood Protection Easement Area for the purposes for which this Easement is provided. The then property owner shall not unreasonably delay, hinder, or condition such access or other City rights provided in this paragraph. Except in cases of an emergency, the City shall provide the then property owner (according to the City Assessor's property tax records) reasonable written notice of the City's intention to exercise its rights under this paragraph.

2. Upon the completion of any work performed pursuant to the City's rights under this Easement, the remainder of the Grantor's Property shall, to the extent it is damaged or disturbed by the work undertaken pursuant to this Easement, be restored to substantially the same condition it was in prior to such work at no cost to the Grantor or the then property owner.

3. The Grantor, its successors and assigns shall not and shall not suffer or permit any others to alter any improvements made or work performed pursuant to this Easement within the Flood Protection Easement Area. The Grantor, its successors and assigns shall not and shall not suffer or permit any others to construct, operate or maintain within the Flood Protection Easement Area any structure, except that which existed prior to the date of this Easement or improvements or additions to such an existing structure built in accordance with then applicable laws, ordinances, codes, rules or regulations, or structures or uses to which the City first consents in a written instrument recorded with the Kent County Register of Deeds.

4. Neither the Grantor nor the City (including their respective successors or assigns) shall grant an easement within the Flood Protection Easement Area to any other person or entity for any purpose, including, without limitation, any utility, without the prior consent of the other party to this Easement in a written instrument recorded with the Kent County Register of Deeds. However, the City, in its sole discretion, may assign this Easement or some or all of its rights, duties and obligations under this Easement to one or more parties who are engaged in providing some or all of the benefits to the general public as described in this Easement.

5. This Easement shall be perpetual and shall be binding upon the Grantor's successors, grantees, assigns, heirs and anyone else who may obtain an interest in the Grantor's Property from or through the Grantor.

6. The consent of Grantor's mortgagee is attached to this Easement.

The Grantor signed this Easement as of this 28th day of November, 2016.

DBV Partners, L.L.C.,
a Michigan limited liability company

By: Bruce Visser
* Bruce Visser
Its: Manager

MARIA VANDERWERF
Notary Public, State of Michigan, County of Kent
My Commission Expires August 26, 2019
Acting in the County of Kent

STATE OF MICHIGAN
COUNTY OF KENT

On Nov 28, 2016, Bruce Visser the Manager of **DBV Partners, L.L.C.**, a Michigan limited liability company, who is either personally known to me or who produced his/her driver's license as identification, personally signed this document in my presence.

Maria VanderWerf
* Maria VanderWerf
Notary Public, Kent County, MI
Acting in Kent County, MI
My commission expires: 8-26-19

Accepted by City Commission Proceeding No. 86333, dated Dec. 13, 2016.

Exempt from state and county transfer taxes pursuant to MCL 207.505(a) and MCL 207.526(a).

Prepared by:
Scott G. Smith
Dickinson Wright PLLC
200 Ottawa Ave NW, Ste 1000
Grand Rapids, MI 49503

Legal description by:
Michelle Nitengale
Fishbeck, Thompson, Carr & Huber, Inc.
1515 Arboretum Drive SW
Grand Rapids, MI 49546

After recording, return to:
Darlene O'Neal, Clerk
City of Grand Rapids
300 Monroe Ave NW
Grand Rapids, MI 49503

MORTGAGEE'S CONSENT TO FLOOD PROTECTION EASEMENT

The undersigned, Mercantile Bank Mortgage Company, LLC, of 310 Leonard St. NW, Grand Rapids MI 49501 (the "Lender"), being the mortgagee under that certain Mortgage dated October 27, 2011, recorded on October 31, 2011 as Instrument No. 20111102-0087183, Kent County Records, and assignee under that certain Assignment of Rents dated October 27, 2011, recorded on October 31, 2011 as Instrument No. 20111102-0087184, Kent County Records (collectively, the "Mortgage"), hereby consents to the granting of the Flood Protection Easement to which this Consent is attached (the "Easement") between DBV Partners, L.L.C., as grantor, and the City of Grand Rapids, a Michigan municipal corporation (the "City"), as grantee. The undersigned agrees that even though the Mortgage is prior in time to the interest of the City under the Easement, it and its successors and assigns shall recognize the rights of the City, its successors and assigns under the Easement. No foreclosure of the Mortgage or sale of the property or deed in lieu of foreclosure shall terminate the Easement or otherwise cut off or extinguish any of the City's easement rights under the Easement.

Dated this ___ day of _____, 2016.

MERCANTILE BANK MORTGAGE COMPANY, LLC

By:_____
Name:_____
Title:_____

STATE OF MICHIGAN)
)ss
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ____ day of_____, 2016, by _____, the _____ of MERCANTILE BANK MORTGAGE COMPANY, LLC, on behalf of said company.

_____

Notary Public, _____ County, MI
Acting in _____ County, MI
My commission expires: _____

GRAPIDS 60855-343 422899v1

GRANTOR'S PROPERTY
EXHIBIT A

PROPERTY OWNER: DBV PARTNERS, LLC

PROPERTY ADDRESS: 2204 TURNER AVENUE NW

PARCEL NUMBER: 41-13-12-401-017

PARCEL DESCRIPTION:
(AS FURNISHED TITLE COMMITMENT NO. 170873WMS PREPARED BY TRANSNATION TITLE AGENCY OF MICHIGAN DATED DECEMBER 15, 2015)

PART OF GOVERNMENT LOTS 3 AND 4, SECTION 12, TOWN 7 NORTH, RANGE 12 WEST, CITY OF WALKER, KENT COUNTY, MICHIGAN, DESCRIBED AS: BEGINNING ON THE NORTH-SOUTH 1/4 LINE AT A POINT BEING SOUTH 00 DEGREES 00 MINUTES 00 SECONDS WEST 1006.88 FEET FROM THE CENTER OF SAID SECTION 12; THENCE SOUTH 00 DEGREES 00 MINUTES 00 SECONDS WEST 471.96 FEET ALONG THE NORTH-SOUTH 1/4 LINE TO A POINT BEING SOUTH 00 DEGREES 00 MINUTES 00 SECONDS WEST 151.17 FEET FROM THE NORTHWEST CORNER OF SAID GOVERNMENT LOT 4; THENCE SOUTH 86 DEGREES 44 MINUTES 38 SECONDS EAST 544.70 FEET TO THE WEST RIGHT OF WAY LINE OF HIGHWAY US-131; THENCE NORTH 00 DEGREES 11 MINUTES 34 SECONDS WEST 502.90 FEET ALONG SAID RIGHT OF WAY LINE TO A LINE BEARING NORTH 90 DEGREES 00 MINUTES 00 SECONDS EAST FROM THE PLACE OF BEGINNING; THENCE SOUTH 90 DEGREES 00 MINUTES 00 SECONDS WEST 542.13 FEET TO THE PLACE OF BEGINNING.

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 ARBORETUM DRIVE SE
GRAND RAPIDS, MI 49546
616.575.3824 PHONE
616.464.3996 FAX

FLOOD PROTECTION EASEMENT
EXHIBIT B

FLOOD PROTECTION EASEMENT DESCRIBED AS:

THE EAST 15 FEET OF SUBJECT PARCEL LYING PARALLEL WITH AND COINCIDENT WITH THE WEST RIGHT-OF-WAY LINE OF US-131.

ALSO DESCRIBED AS: ALL THAT PART OF SUBJECT PARCEL LYING EASTERLY OF A LINE DESCRIBED AS: COMMENCING AT THE CENTER OF SECTION 12, T7N, R12W, CITY OF WALKER, KENT COUNTY, MICHIGAN; THENCE ALONG THE NORTH-SOUTH 1/4 LINE OF SAID SECTION, SOUTH 00°00'00" EAST 1006.88 FEET; THENCE NORTH 90°00'00" EAST 527.1 FEET TO THE POINT OF BEGINNING; THENCE PARALLEL WITH THE WEST RIGHT-OF-WAY LINE OF US-131, SOUTH 00°11'34" EAST 502.0 FEET TO THE POINT OF ENDING, SAID POINT BEING SOUTH 00°00'00" EAST 1478.84 FEET AND NORTH 90°00'00" EAST 529.7 FEET FROM THE CENTER OF SAID SECTION 12.

SAID PERMANENT EASEMENT CONTAINS 7,530 SQUARE FEET, MORE OR LESS.

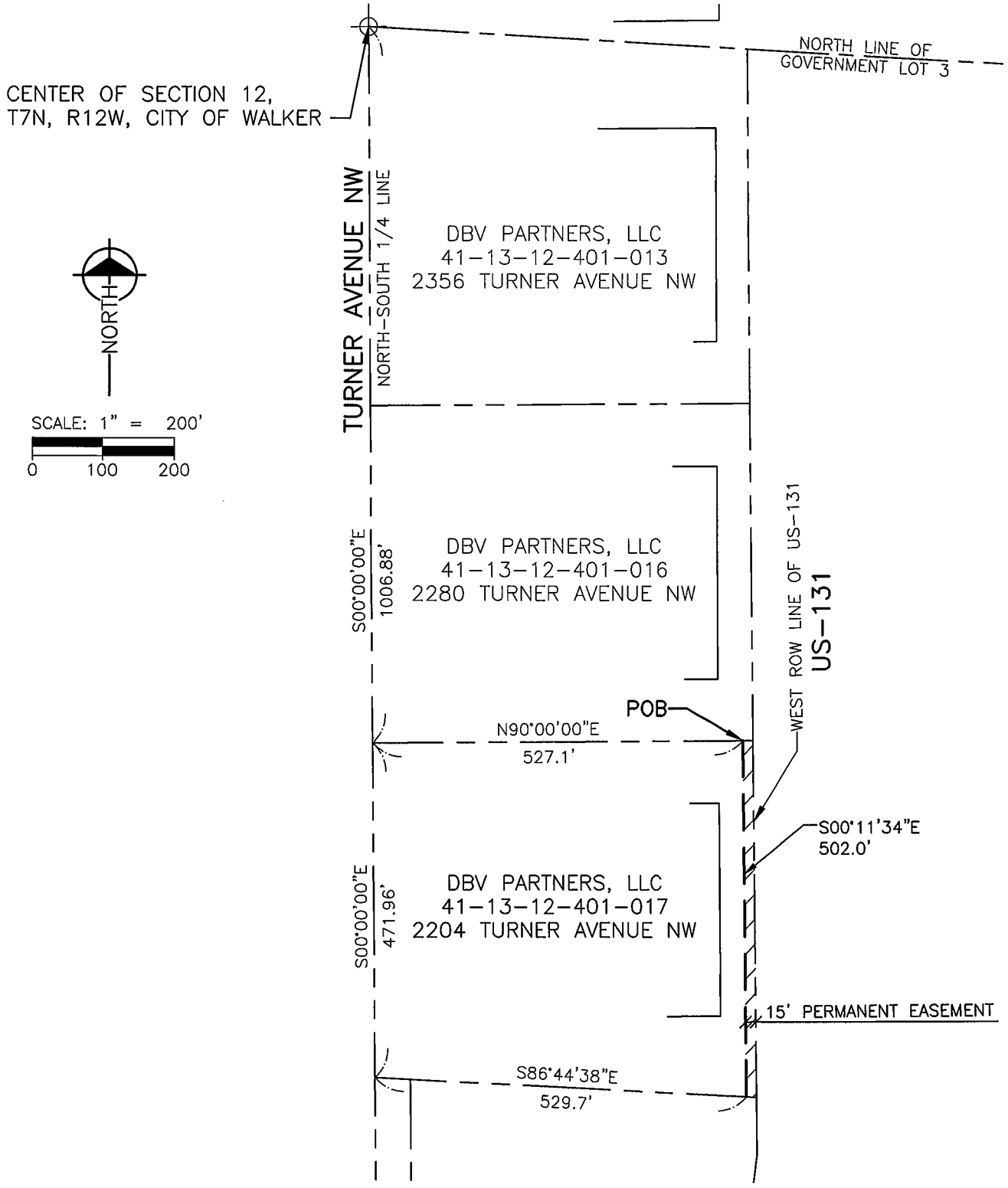
DESCRIPTION CORRECT

John S. Wiles P.S. #43075

BASIS OF BEARING FOR SAID EASEMENT:
WEST RIGHT-OF-WAY LINE OF US-131 PER TITLE COMMITMENT DESCRIPTION

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 ARBORETUM DRIVE SE
GRAND RAPIDS, MI 49546
616.575.3824 PHONE
616.464.3996 FAX

FLOOD PROTECTION EASEMENT
EXHIBIT B



BASIS OF BEARING FOR SAID EASEMENT:
WEST RIGHT-OF-WAY LINE OF US-131 PER
TITLE COMMITMENT DESCRIPTION

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 ARBORETUM DRIVE SE
GRAND RAPIDS, MI 49546
616.575.3824 PHONE
616.464.3996 FAX

FLOOD PROTECTION EASEMENT

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1. The City, including its officers, employees, contractors, engineers and other agents, shall have the right of ingress to and egress from the Flood Protection Easement Area through the Grantor's larger parcel described on the attached Exhibit A (the "Grantor's Property"), and any accretions thereto, over a route prearranged with the then property owner, in order to access the Flood Protection Easement Area for the purposes for which this Easement is provided. The then property owner shall not unreasonably delay, hinder, or condition such access or other City rights provided in this paragraph. Except in cases of an emergency, the City shall provide the then property owner (according to the City Assessor's property tax records) reasonable written notice of the City's intention to exercise its rights under this paragraph.

2. Upon the completion of any work performed pursuant to the City's rights under this Easement, the remainder of the Grantor's Property shall, to the extent it is damaged or disturbed by the work undertaken pursuant to this Easement, be restored to substantially the same condition it was in prior to such work at no cost to the Grantor or the then property owner.

3. The Grantor, its successors and assigns shall not and shall not suffer or permit any others to alter any improvements made or work performed pursuant to this Easement within the Flood Protection Easement Area. The Grantor, its successors and assigns shall not and shall not suffer or permit any others to construct, operate or maintain within the Flood Protection Easement Area any structure, except that which existed prior to the date of this Easement or improvements or additions to such an existing structure built in accordance with then applicable laws, ordinances, codes, rules or regulations, or structures or uses to which the City first consents in a written instrument recorded with the Kent County Register of Deeds.

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5. This Easement shall be perpetual and shall be binding upon the Grantor's successors, grantees, assigns, heirs and anyone else who may obtain an interest in the Grantor's Property from or through the Grantor.

6. The consent of Grantor's mortgagee is attached to this Easement.

The Grantor signed this Easement as of this 28th day of November, 2016.

DBV Partners, L.L.C.,
a Michigan limited liability company

By: Bruce Visser
* Bruce Visser
Its: Manager

MARIA VANDERWERF
Notary Public, State of Michigan, County of Kent
My Commission Expires August 26, 2019
Acting in the County of Kent

STATE OF MICHIGAN
COUNTY OF KENT

On Nov. 28, 2016, Bruce Visser the Manager of **DBV Partners, L.L.C.**, a Michigan limited liability company, who is either personally known to me or who produced his/her driver's license as identification, personally signed this document in my presence.

Maria Vanderwerf
* Maria Vanderwerf
Notary Public, Kent County, MI
Acting in Kent County, MI
My commission expires: 8-26-19

Accepted by City Commission Proceeding No. 86333, dated Dec. 13, 2016.

Exempt from state and county transfer taxes pursuant to MCL 207.505(a) and MCL 207.526(a).

Prepared by:
Scott G. Smith
Dickinson Wright PLLC
200 Ottawa Ave NW, Ste 1000
Grand Rapids, MI 49503

Legal description by:
Michelle Nitengale
Fishbeck, Thompson, Carr & Huber, Inc.
1515 Arboretum Drive SW
Grand Rapids, MI 49546

After recording, return to:
Darlene O'Neal, Clerk
City of Grand Rapids
300 Monroe Ave NW
Grand Rapids, MI 49503

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Dated this ___ day of _____, 2016.

MERCANTILE BANK MORTGAGE COMPANY, LLC

By:_____
Name:_____
Title:_____

STATE OF MICHIGAN)
)ss
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ____ day of_____, 2016, by _____, the _____ of MERCANTILE BANK MORTGAGE COMPANY, LLC, on behalf of said company.

_____

Notary Public, _____ County, MI
Acting in _____ County, MI
My commission expires: _____

GRAPIDS 60855-343 422896v1

GRANTOR'S PROPERTY
EXHIBIT A

PROPERTY OWNER: DBV PARTNERS, LLC

PROPERTY ADDRESS: 2280 TURNER AVENUE NW

PARCEL NUMBER: 41-13-12-401-016

PARCEL DESCRIPTION:
(AS FURNISHED TITLE COMMITMENT NO. 170871WMS PREPARED BY TRANSNATION TITLE AGENCY OF MICHIGAN DATED DECEMBER 15, 2015)

PART OF GOVERNMENT LOT 3, SECTION 12, TOWN 7 NORTH, RANGE 12 WEST, CITY OF WALKER, KENT COUNTY, MICHIGAN, DESCRIBED AS: BEGINNING ON THE NORTH-SOUTH 1/4 LINE AT A POINT BEING SOUTH 00 DEGREES 00 MINUTES 00 SECONDS WEST 1006.88 FEET FROM THE CENTER OF SAID SECTION 12; THENCE NORTH 00 DEGREES 00 MINUTES 00 SECONDS EAST 475.00 FEET ALONG THE NORTH-SOUTH 1/4 LINE; THENCE NORTH 90 DEGREES 00 MINUTES 00 SECONDS EAST 540.53 FEET TO THE WEST RIGHT OF WAY LINE OF HIGHWAY US-131; THENCE SOUTH 00 DEGREES 11 MINUTES 34 SECONDS EAST 475.00 FEET ALONG SAID RIGHT OF WAY; THENCE SOUTH 90 DEGREES 00 MINUTES 00 SECONDS WEST 542.13 FEET TO THE PLACE OF BEGINNING.

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 ARBORETUM DRIVE SE
GRAND RAPIDS, MI 49546
616.575.3824 PHONE
616.464.3996 FAX

FLOOD PROTECTION EASEMENT
EXHIBIT B

FLOOD PROTECTION EASEMENT DESCRIBED AS:

THE EAST 15 FEET OF SUBJECT PARCEL LYING PARALLEL WITH AND COINCIDENT WITH THE WEST RIGHT-OF-WAY LINE OF US-131.

ALSO DESCRIBED AS: ALL THAT PART OF SUBJECT PARCEL LYING EASTERLY OF A LINE DESCRIBED AS: COMMENCING AT THE CENTER OF SECTION 12, T7N, R12W, CITY OF WALKER, KENT COUNTY, MICHIGAN; THENCE ALONG THE NORTH-SOUTH 1/4 LINE OF SAID SECTION, SOUTH 00°00'00" EAST 531.88 FEET; THENCE NORTH 90°00'00" EAST 525.5 FEET TO THE POINT OF BEGINNING; THENCE PARALLEL WITH THE WEST RIGHT-OF-WAY LINE OF US-131, SOUTH 00°11'34" EAST 475.0 FEET TO THE POINT OF ENDING, SAID POINT BEING SOUTH 00°00'00" EAST 1006.88 FEET AND NORTH 90°00'00" EAST 527.1 FEET FROM THE CENTER OF SAID SECTION 12.

SAID PERMANENT EASEMENT CONTAINS 7,125 SQUARE FEET, MORE OR LESS.

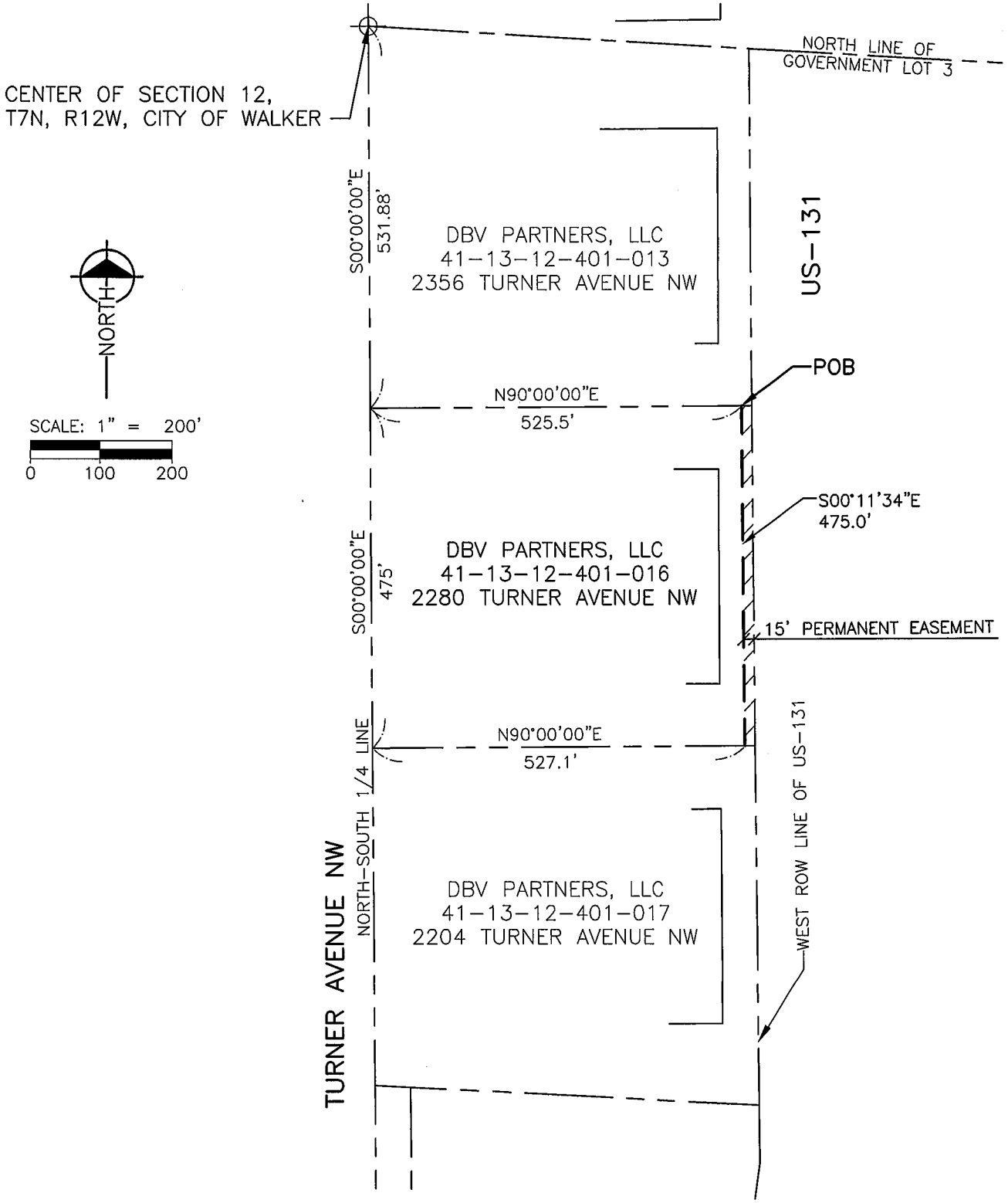
DESCRIPTION CORRECT

John S. Wiles P.S. #43075

BASIS OF BEARING FOR SAID EASEMENT: WEST RIGHT-OF-WAY LINE OF US-131 PER TITLE COMMITMENT DESCRIPTION

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 ARBORETUM DRIVE SE
GRAND RAPIDS, MI 49546
616.575.3824 PHONE
616.464.3996 FAX

FLOOD PROTECTION EASEMENT
EXHIBIT B



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WEST RIGHT-OF-WAY LINE OF US-131 PER
TITLE COMMITMENT DESCRIPTION

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1515 ARBORETUM DRIVE SE
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FLOOD PROTECTION EASEMENT

DBV Partners, L.L.C., a Michigan limited liability company, of 1946 Turner Ave. NW, Grand Rapids, MI 49504 (the "Grantor"), in exchange for payment of $1.00, the receipt of which is acknowledged, quit-claims to the **City of Grand Rapids**, a Michigan municipal corporation, with offices at 300 Monroe Ave. NW, Grand Rapids, MI 49503 (the "City") a permanent easement in, on, over, under, and through the area described and depicted in the attached Exhibit B (the "Flood Protection Easement Area") for the purposes of surveying, designing, constructing, inspecting, repairing, replacing, improving, maintaining, altering, rehabilitating, monitoring, removing, using, and operating a floodwall, embankment, or other flood protection infrastructure, together with storm sewers or drains, flap gates, backflow preventers and other appurtenances thereto, subject to the following terms and conditions of this Flood Protection Easement (this "Easement"):

1. The City, including its officers, employees, contractors, engineers and other agents, shall have the right of ingress to and egress from the Flood Protection Easement Area through the Grantor's larger parcel described on the attached Exhibit A (the "Grantor's Property"), and any accretions thereto, over a route prearranged with the then property owner, in order to access the Flood Protection Easement Area for the purposes for which this Easement is provided. The then property owner shall not unreasonably delay, hinder, or condition such access or other City rights provided in this paragraph. Except in cases of an emergency, the City shall provide the then property owner (according to the City Assessor's property tax records) reasonable written notice of the City's intention to exercise its rights under this paragraph.

2. Upon the completion of any work performed pursuant to the City's rights under this Easement, the remainder of the Grantor's Property shall, to the extent it is damaged or disturbed by the work undertaken pursuant to this Easement, be restored to substantially the same condition it was in prior to such work at no cost to the Grantor or the then property owner.

3. The Grantor, its successors and assigns shall not and shall not suffer or permit any others to alter any improvements made or work performed pursuant to this Easement within the Flood Protection Easement Area. The Grantor, its successors and assigns shall not and shall not suffer or permit any others to construct, operate or maintain within the Flood Protection Easement Area any structure, except that which existed prior to the date of this Easement or improvements or additions to such an existing structure built in accordance with then applicable laws, ordinances, codes, rules or regulations, or structures or uses to which the City first consents in a written instrument recorded with the Kent County Register of Deeds.

4. Neither the Grantor nor the City (including their respective successors or assigns) shall grant an easement within the Flood Protection Easement Area to any other person or entity for any purpose, including, without limitation, any utility, without the prior consent of the other party to this Easement in a written instrument recorded with the Kent County Register of Deeds. However, the City, in its sole discretion, may assign this Easement or some or all of its rights, duties and obligations under this Easement to one or more parties who are engaged in providing some or all of the benefits to the general public as described in this Easement.

5. This Easement shall be perpetual and shall be binding upon the Grantor's successors, grantees, assigns, heirs and anyone else who may obtain an interest in the Grantor's Property from or through the Grantor.

6. The consent of Grantor's mortgagee is attached to this Easement.

The Grantor signed this Easement as of this 28th day of November, 2016.

DBV Partners, L.L.C.,
a Michigan limited liability company

By: Bruce Visser
* Bruce Visser
Its: Manager

MARIA VANDERWERF
Notary Public, State of Michigan, County of Kent
My Commission Expires August 26, 2019
Acting in the County of Kent

STATE OF MICHIGAN
COUNTY OF KENT

On Nov. 28, 2016, Bruce Visser the Manager of **DBV Partners, L.L.C.**, a Michigan limited liability company, who is either personally known to me or who produced his/her driver's license as identification, personally signed this document in my presence.

Maria Vanderwerf
* Maria Vanderwerf
Notary Public, Kent County, MI
Acting in Kent County, MI
My commission expires: 8-26-19

Accepted by City Commission Proceeding No. 86333, dated Dec. 13, 2016.

Exempt from state and county transfer taxes pursuant to MCL 207.505(a) and MCL 207.526(a).

Prepared by:
Scott G. Smith
Dickinson Wright PLLC
200 Ottawa Ave NW, Ste 1000
Grand Rapids, MI 49503

Legal description by:
Michelle Nitengale
Fishbeck, Thompson, Carr & Huber, Inc.
1515 Arboretum Drive SW
Grand Rapids, MI 49546

After recording, return to:
Darlene O'Neal, Clerk
City of Grand Rapids
300 Monroe Ave NW
Grand Rapids, MI 49503

MORTGAGEE'S CONSENT TO FLOOD PROTECTION EASEMENT

The undersigned, Mercantile Bank Mortgage Company, LLC, of 310 Leonard St. NW, Grand Rapids MI 49501 (the "Lender"), being the mortgagee under that certain Mortgage dated October 27, 2011, recorded on October 31, 2011 as Instrument No. 20111102-0087183, Kent County Records, and assignee under that certain Assignment of Rents dated October 27, 2011, recorded on October 31, 2011 as Instrument No. 20111102-0087184, Kent County Records (collectively, the "Mortgage"), hereby consents to the granting of the Flood Protection Easement to which this Consent is attached (the "Easement") between DBV Partners, L.L.C., as grantor, and the City of Grand Rapids, a Michigan municipal corporation (the "City"), as grantee. The undersigned agrees that even though the Mortgage is prior in time to the interest of the City under the Easement, it and its successors and assigns shall recognize the rights of the City, its successors and assigns under the Easement. No foreclosure of the Mortgage or sale of the property or deed in lieu of foreclosure shall terminate the Easement or otherwise cut off or extinguish any of the City's easement rights under the Easement.

Dated this ___ day of _____, 2016.

MERCANTILE BANK MORTGAGE COMPANY, LLC

By:_____
Name:_____
Title:_____

STATE OF MICHIGAN)
)ss
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ____ day of_____, 2016, by _____, the _____ of MERCANTILE BANK MORTGAGE COMPANY, LLC, on behalf of said company.

_____

Notary Public, _____ County, MI
Acting in _____ County, MI
My commission expires: _____

GRAPIDS 60855-343 401159v1

GRANTOR'S PROPERTY
EXHIBIT A

PROPERTY OWNER: DBV PARTNERS, LLC

PROPERTY ADDRESS: 2356 TURNER AVENUE NW

PARCEL NUMBER: 41-13-12-401-013

PARCEL DESCRIPTION:
(AS FURNISHED TITLE COMMITMENT NO. 170869WMS PREPARED BY TRANSNATION TITLE AGENCY OF MICHIGAN DATED DECEMBER 15, 2015)

PART OF GOVERNMENT LOT 3, SECTION 12, TOWN 7 NORTH, RANGE 12 WEST, CITY OF WALKER, KENT COUNTY, MICHIGAN, DESCRIBED AS: BEGINNING ON THE NORTH-SOUTH ONE-QUARTER LINE AT A POINT BEING SOUTH 00 DEGREES 00 MINUTES 00 SECONDS WEST 531.88 FEET FROM THE CENTER OF SAID SECTION 12; THENCE NORTH 00 DEGREES 00 MINUTES 00 SECONDS EAST 531.88 FEET TO THE CENTER OF SAID SECTION; THENCE SOUTH 86 DEGREES 08 MINUTES 03 SECONDS EAST 540.10 FEET ALONG THE NORTH LINE OF SAID GOVERNMENT LOT 3 TO THE WEST RIGHT OF WAY LINE OF HIGHWAY US-131; THENCE SOUTH 00 DEGREES 11 MINUTES 34 SECONDS EAST 495.47 FEET ALONG SAID RIGHT OF WAY LINE TO A LINE BEARING NORTH 90 DEGREES 00 MINUTES 00 SECONDS EAST FROM THE PLACE OF BEGINNING; THENCE SOUTH 90 DEGREES 00 MINUTES 00 SECONDS WEST 540.53 FEET TO THE PLACE OF BEGINNING.

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 ARBORETUM DRIVE SE
GRAND RAPIDS, MI 49546
616.575.3824 PHONE
616.464.3996 FAX

FLOOD PROTECTION EASEMENT
EXHIBIT B

FLOOD PROTECTION EASEMENT DESCRIBED AS:

THE EAST 15 FEET OF SUBJECT PARCEL LYING PARALLEL WITH AND COINCIDENT WITH THE WEST RIGHT-OF-WAY LINE OF US-131.

ALSO DESCRIBED AS: ALL THAT PART OF SUBJECT PARCEL LYING EASTERLY OF A LINE DESCRIBED AS: COMMENCING AT THE CENTER OF SECTION 12, T7N, R12W, CITY OF WALKER, KENT COUNTY, MICHIGAN; THENCE ALONG THE NORTH LINE OF GOVERNMENT LOT 3, SOUTH 86°08'03" EAST 525.1 FEET TO THE POINT OF BEGINNING; THENCE PARALLEL WITH THE WEST RIGHT-OF-WAY LINE OF US-131, SOUTH 00°11'34" EAST 496.5 FEET TO THE POINT OF ENDING, SAID POINT BEING SOUTH 00°00'00" EAST 531.88 FEET AND NORTH 90°00'00" EAST 525.5 FEET FROM THE CENTER OF SAID SECTION 12.

SAID PERMANENT EASEMENT CONTAINS 7,447.5 SQUARE FEET, MORE OR LESS.

DESCRIPTION CORRECT

John S. Wiles P.S. #43075

BASIS OF BEARING FOR SAID EASEMENT:
WEST RIGHT-OF-WAY LINE OF US-131 PER TITLE COMMITMENT DESCRIPTION

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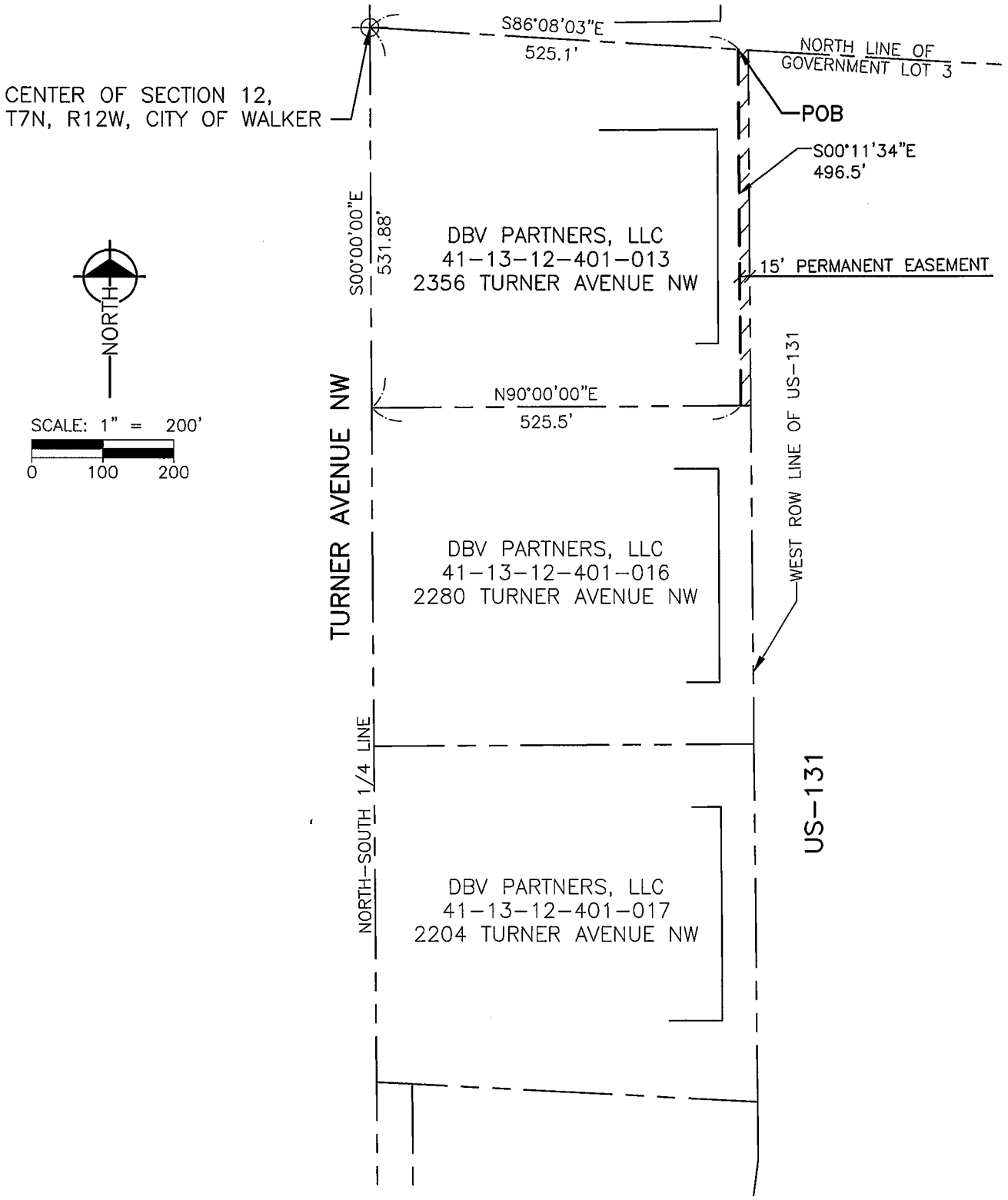
EXHIBIT B



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Appendix 6

GRAND RIVER FLOOD PROTECTIVE SYSTEM
ASBUILT DRAWINGS

UTILITIES - CONTACT INFORMATION

PUBLIC

CITY OF GRAND RAPIDS TRAFFIC SIGNALS
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3847

CITY OF GRAND RAPIDS STREET LIGHTING
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3281

CITY OF GRAND RAPIDS WATER SYSTEM
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 456-4096

CITY OF GRAND RAPIDS
SANITARY AND STORM SEWER MAINTENANCE
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 456-3561

PRIVATE

CONSUMERS ENERGY (ELECTRIC)
PO BOX 201
GRAND RAPIDS, MI 49501-0201
(616) 530-4244

AT&T (TELEPHONE)
ROOM 5 (PROJECTS N. OF FRANKLIN ST.)
2ND FLOOR (PROJECTS S. OF FRANKLIN ST.)
955 36TH ST. SE
GRAND RAPIDS, MI 49508
(616) 246-7203 (PROJECTS N. OF FRANKLIN ST.)
(616) 246-7210 (PROJECTS S. OF FRANKLIN ST.)

DTE ENERGY (NATURAL GAS)
444 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(800) 947-5000

COMCAST (CABLE TV)
955 CENTURY AVE. SW
GRAND RAPIDS, MI 49503
(616) 245-5039

VERIZON BUSINESS (FIBER OPTICS)
2855 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 224-4944

CENTURY TEL (FIBER OPTICS)
320 N. WASHINGTON SQUARE
LANSING, MI 48933
(989) 239-8110

CHOICEONE (FIBER OPTICS)
44 GRANDVILLE AVE. SW, STE. 400
GRAND RAPIDS, MI 49503
(616) 988-7100

US SIGNAL COMPANY, LLC (FIBER OPTICS)
20 MONROE AVE. NW
GRAND RAPIDS, MI 49503
(616) 988-7031

LDMI
3355 EAGLE PARK DR. NE, STE. 102
GRAND RAPIDS, MI 49525
(616) 493-5364

CALL 811 FOR MISS DIG

FOR PROTECTION OF UNDERGROUND UTILITIES AND IN CONFORMANCE WITH PUBLIC ACT 53, 1974, THE CONTRACTOR SHALL CALL 811 A MINIMUM OF THREE (3) FULL WORKING DAYS (EXCLUDING SATURDAYS, SUNDAYS AND HOLIDAYS) PRIOR TO EXCAVATING IN THE VICINITY OF UTILITY LINES. ALL "MISS DIG" PARTICIPATING MEMBERS WILL THUS BE ROUTINELY NOTIFIED. THIS DOES NOT RELIEVE THE CONTRACTOR OF THE RESPONSIBILITY OF NOTIFYING UTILITY OWNERS WHO MAY NOT BE A PART OF THE "MISS DIG" ALERT SYSTEM.

GENERAL NOTES

1) MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE 1993 EDITION OF THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, EXCEPT AS OTHERWISE INDICATED ON THESE PLANS OR IN THE SUPPLEMENTAL SPECIAL SPECIFICATIONS.

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

CITY OF GRAND RAPIDS

GRAND RAPIDS, MICHIGAN

DESIGN, DEVELOPMENT AND ENTERPRISE SERVICES

AND

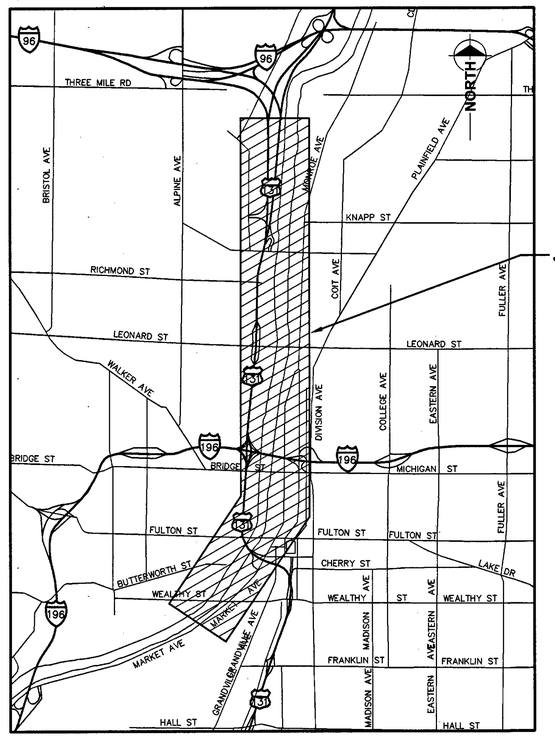
KENT COUNTY DRAIN COMMISSION CHAPTER 20 DRAINAGE COMMISSIONER

IMPROVEMENTS

TO

GRAND RIVER FLOODWALL CONTRACT NO. 1

(BACKFLOW PREVENTION)



JOB SITE

PROJECT LOCATION

41-14- 065240

BID SET

BID SET NO.	DATE	BID SET NO.	DATE

REVISIONS

REV NO.	DATE	SHEET NUMBER(S)	APPROVED BY

AS-BUILT RECORD

CONTRACTOR	GEORGETOWN CONSTRUCTION INC.
FIELD ENGINEER	FTC&H
INSPECTED BY	FTC&H
AS-BUILT BY	FTC&H
AS-BUILT DATE	12/2014
BORINGS BY	N/A
WATER PIPE MANUFACTURER	N/A
SANITARY PIPE MANUFACTURER	N/A
STORM PIPE MANUFACTURER	M&E MANUFACTURING

PERMITS

M.D.E.Q. WATER SYSTEM PERMIT NO.:		OTHER: PART 301/31 JOINT PERMIT	NO.: 13-41-0118-P
M.D.E.Q. WASTEWATER SYSTEM PERMIT NO.:		OTHER:	NO.:
M.D.O.T. RIGHT-OF-WAY PERMIT NO.:	41131-023923-14-041514	OTHER:	NO.:

CITY COMMISSION PROC. NO. 83285 DATE 3.11.2014

MDOT AGREEMENT ☐ CONTRACT AWARDED ☒

FINANCIAL AGREEMENT ☐ SHPO AGREEMENT ☐

GRANT AGREEMENT ☐ COST SHARING AGREEMENT ☐

PUBLIC UTILITIES EASEMENT (SEE EASEMENT DESCRIPTION SHEET)

ADDITIONAL CITY COMMISSION PROCEEDINGS

PROCEEDING NO. DATE PURPOSE

INDEX OF SHEETS

1 TITLE SHEET
2 UPSTREAM SEWER WORK LOCATION MAP

OUTFALL LOCATIONS

3 WEALTHY ST. TO THE BLUE BRIDGE
4 BRIDGE ST. TO LEONARD ST.
5 G.T. RAILROAD TO ANN ST.
6 RIVERSIDE PARK
7 MISCELLANEOUS DETAILS

UPSTREAM SEWER WORK LOCATIONS

8 A AND B
9 C AND D
10 E AND F
11 G AND H
12 I AND J
13 K AND L
14 M AND N
15 O AND P

DESIGNED & SURVEYED BY: fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

FTC&H
PROFESSIONAL PERSON IN RESPONSIBLE CHARGE OF THIS PROJECT

SHEETS: 1 - 15

NAME OF LICENSEE: JEREMY N. KRAMER

NUMBER: 53043

SIGNATURE

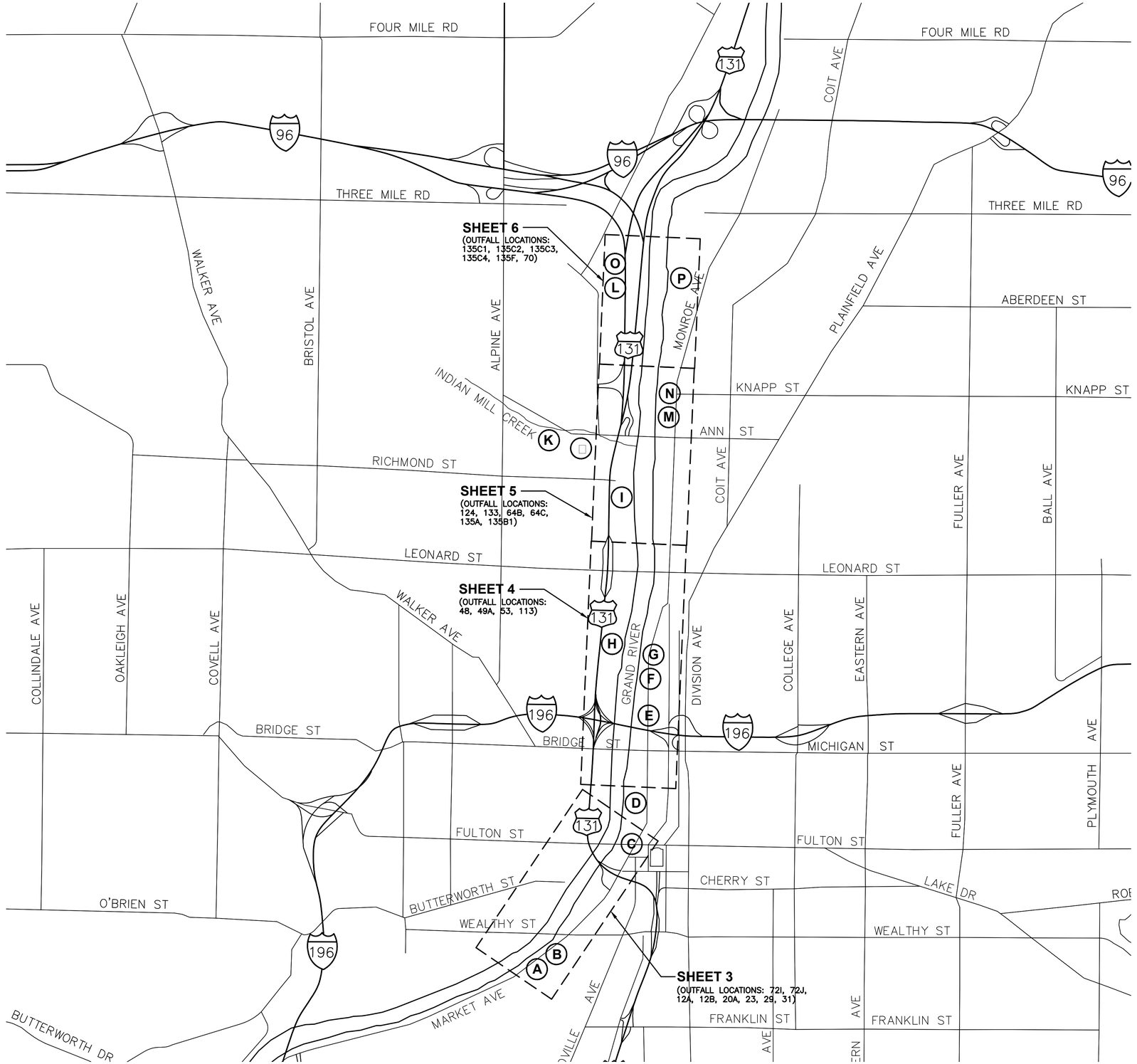
STATE OF MICHIGAN — JEREMY N. KRAMER — ENGINEER — No. 53043 — LICENSED PROFESSIONAL ENGINEER

City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO
GRAND RIVER FLOODWALL CONTRACT NO. 1
(BACKFLOW PREVENTION)

Drawn by RML Notes in
Check: Field JM/JB Office RDV
Approved Mark De Clercq City Engineer 2/24/14 Date
APPROVAL OF SHEET(S) 1 15 ONLY

Project No.	GPF No.	Sheet No.
13057	5269	1 of 15



NORTH

NO SCALE

LEGEND

WORK LOCATION	WORK DETAIL
A	SEE SHEET 8
B	SEE SHEET 8
C	SEE SHEET 9
D	SEE SHEET 9
E	SEE SHEET 10
F	SEE SHEET 10
G	SEE SHEET 11
H	SEE SHEET 11
I	SEE SHEET 12
□	SEE SHEET 12
K	SEE SHEET 13
L	SEE SHEET 13
M	SEE SHEET 14
N	SEE SHEET 14
O	SEE SHEET 15
P	SEE SHEET 15

UPSTREAM SEWER WORK LOCATION MAP

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY: fishbeck, thompson, carr & huber, inc.
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City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO

GRAND RIVER FLOODWALL CONTRACT NO. 1

(BACKFLOW PREVENTION)

AS-BUILT
12/2014

Drawn by	GPF No.	Sheet No.
Check: Field RML / JB/JH / Check: Office RDV	526□	2 of 15

PLOT INFO: Z:\2012\120330BFP\CAD\CD\AS-BUILTS\C022-22_G1203308FP_AS_BUILT.DWG LAYOUT: 2 DATE: 12/9/2014 TIME: 9:06:03 AM USER: CDO

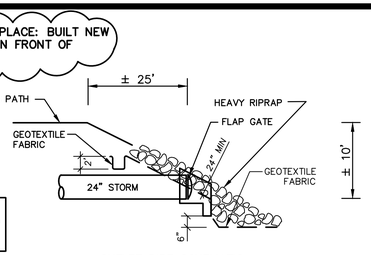


REMOVE EXISTING HEADWALL, 12"–36"

LEFT IN PLACE: BUILT NEW OUTLET IN FRONT OF EXISTING

PLACE CONCRETE HEADWALL FOR 24" PIPE, WITH 24" FLAP GATE PER DETAIL SHEET 7

REMOVAL OF EXISTING RIP RAP INCLUDED IN PROPOSED HEADWALL (TYP)



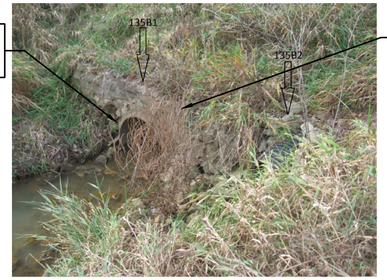
OUTLET PIPE SCHEMATIC CROSS SECTION

OUTLET PIPE 135A DETAIL

NO SCALE

PLACE CONCRETE HEADWALL FOR 36" PIPE, WITH 36" FLAP GATE PER DETAIL SHEET 7

REMOVAL OF EXISTING RIP RAP INCLUDED IN PROPOSED HEADWALL (TYP)



REMOVE EXISTING HEADWALL, 12"–36"

OUTLET PIPE 135B1 DETAIL

NO SCALE



AERIAL VIEW

SCALE 1"=200' – NORTH

MATCH EXISTING GRADE UPSTREAM AND DOWNSTREAM OF OUTFALL, APPROX. 3/4 SLOPE

REMOVE TREE, 8–18 INCH

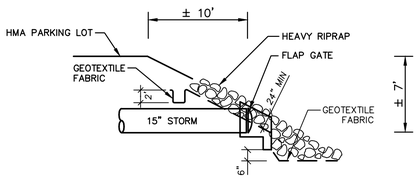
REMOVE TREE, 1–7 INCH (TYPICAL OF 2 THIS LOCATION) (INCLUDED IN HEADWALL)

PLACE CONCRETE HEADWALL FOR 15" PIPE, WITH 15" FLAP GATE PER DETAIL SHEET 7

REMOVAL OF EXISTING RIP RAP INCLUDED IN PROPOSED HEADWALL (TYP)

REMOVE EXISTING HEADWALL, 12"–36"





OUTLET PIPE SCHEMATIC CROSS SECTION

OUTLET PIPE 133 DETAIL

NO SCALE

PLACE 12" FLAP GATE FOR EXISTING HEADWALL

PLACE 12" FLAP GATE FOR EXISTING HEADWALL



OUTLET PIPE 64B DETAIL

NO SCALE



OUTLET PIPE 64C DETAIL

NO SCALE

AS-BUILT
12/2014

OUTFALL LOCATIONS (G.T. RAILROAD TO ANN ST.)

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY
fishbeck, thompson, carr & huber, inc.
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City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS
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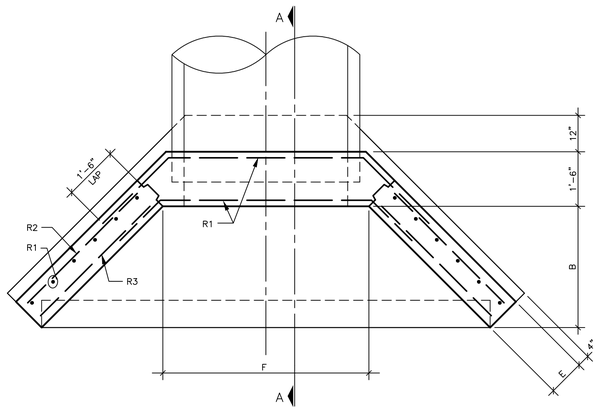
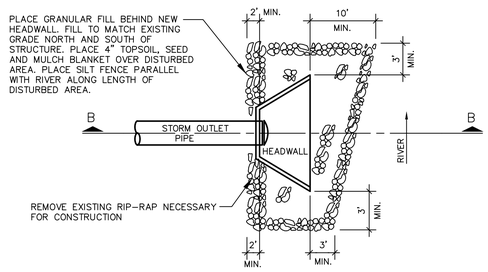
(BACKFLOW PREVENTION)

Drawn by	GPF No.	Sheet No.
RML	526	5 of 15
Check: Field JB/JH		
Check: Office RDV		

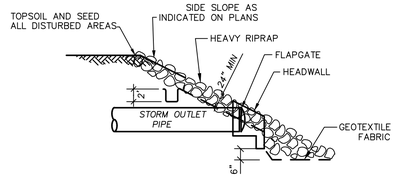
PLOT INFO: Z:\2012\120330BFP\CAD\CD\AS-BUILTS\C002-22_G120330BFP_AS_BUILT.DWG LAYOUT: 5 DATE: 12/9/2014 TIME: 9:08:31 AM USER: CDO



PLAN VIEW



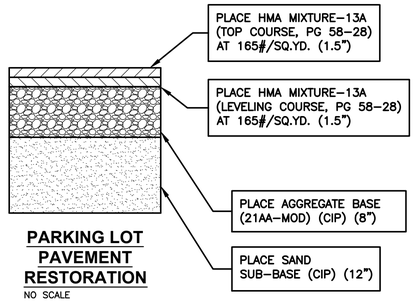
PLAN VIEW



SECTION B-B

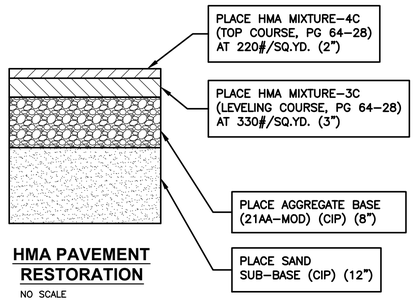
HEADWALL RIP RAP

NO SCALE



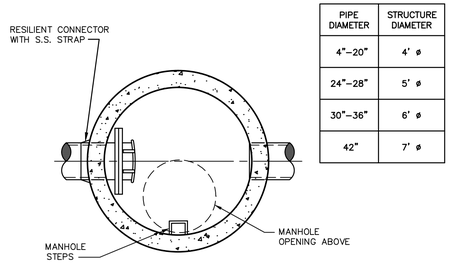
PARKING LOT PAVEMENT RESTORATION

NO SCALE

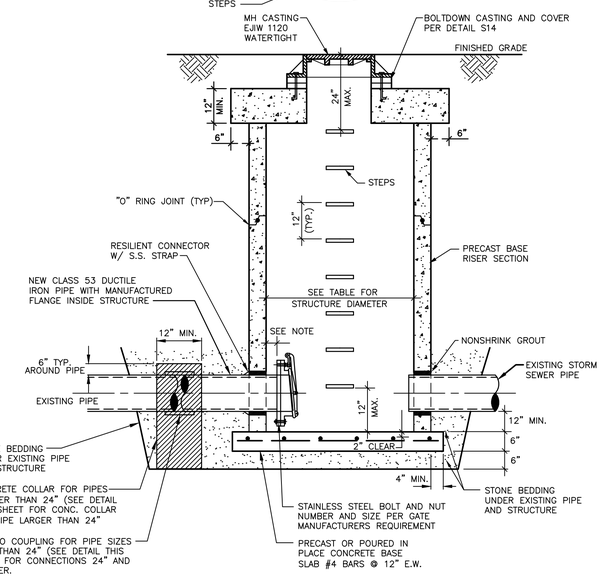


HMA PAVEMENT RESTORATION

NO SCALE



PIPE DIAMETER	STRUCTURE DIAMETER
4"-20"	4' ø
24"-28"	5' ø
30"-36"	6' ø
42"	7' ø



NOTE: MINIMIZE DIMENSION TO WALL. VERIFY THAT GATE CAN FREELY SWING OPEN.

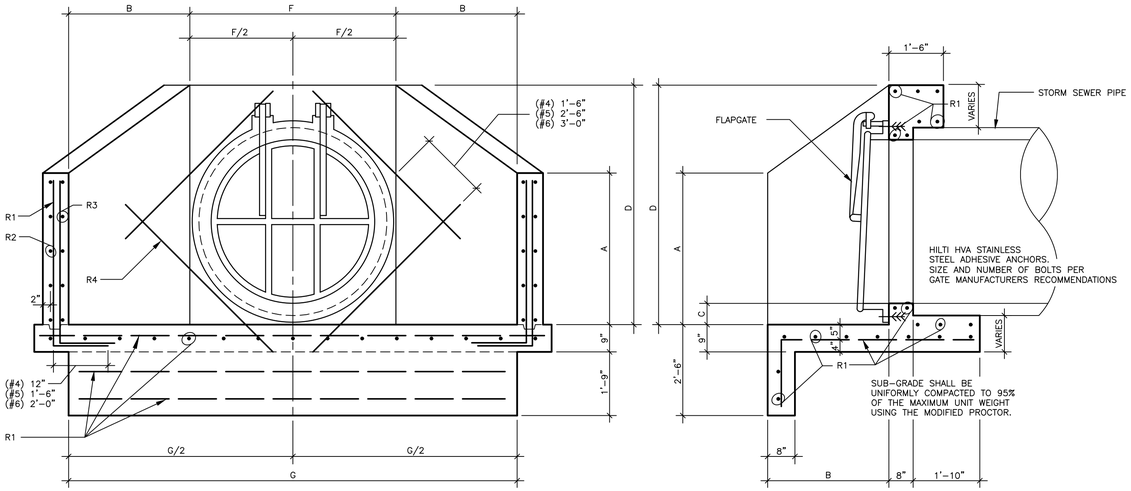
FLAP GATE MANHOLE

NO SCALE

CONCRETE PAVEMENT RESTORATION

NO SCALE

MISCELLANEOUS DETAILS



FRONT ELEVATION

SECTION A-A

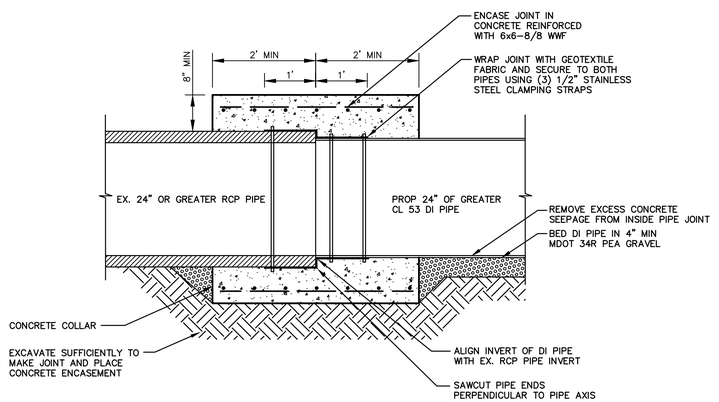
STRUCTURAL STEEL SCHEDULE									
MARK	SEWER DIAMETER								
	15" OR LESS	24"	30"	36"	42"	48"	54"	60"	72"
R1	#4	#4	#4	#4	#4	#5	#5	#6	#6
R2	#4	#4	#4	#4	#4	#4	#4	#4	#4
R3	*	*	*	#4	#4	#4	#4	#4	#4
R4	#4	#4	#5	#5	#5	#5	#5	#6	#6

1. ALL REINFORCEMENT SPACES @12" ON CENTER.
2. * OMIT THIS LAYER OF HORIZONTAL REINFORCEMENT.
3. PROVIDE 2" CLEARANCE FOR REBAR.

STORM SEWER DIMENSION SCHEDULE									
MARK	SEWER DIAMETER								
	15" OR LESS	24"	30"	36"	42"	48"	54"	60"	72"
A	6"	1'-3"	1'-10"	2'-4"	3'-1"	4'-0"	4'-8"	5'-0"	6'-8"
B	2'-6"	2'-6"	2'-6"	2'-7"	2'-7"	3'-0"	3'-4"	3'-7"	4'-5"
C	5"	5"	6"	6"	7"	7"	8"	9"	9"
D	2'-6"	3'-3"	3'-10"	4'-4"	5'-1"	6'-0"	6'-8"	7'-0"	8'-8"
E	8"	8"	8"	10"	10"	10"	10"	10"	10"
F	2'-1"	2'-11"	3'-6"	4'-2"	4'-8"	5'-3"	5'-10"	6'-5"	7'-6"
G	7'-1"	7'-11"	8'-6"	9'-4"	9'-10"	11'-3"	12'-6"	13'-7"	16'-4"

CONCRETE HEADWALL AND FLAP GATE

NO SCALE



RCP TO DI □OINT TRANSITION DETAIL

NO SCALE

ALL WORK FOR TRANSITIONS FROM ONE PIPE MATERIAL TO ANOTHER ACCORDING TO THIS DETAIL IS INCLUDED IN THE BID ITEM FOR THE FLAPGATE MANHOLE (NEW AND EXISTING).

AS-BUILT
12/2014

REV. NO.	DESCRIPTION

DESIGNED & SEALED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

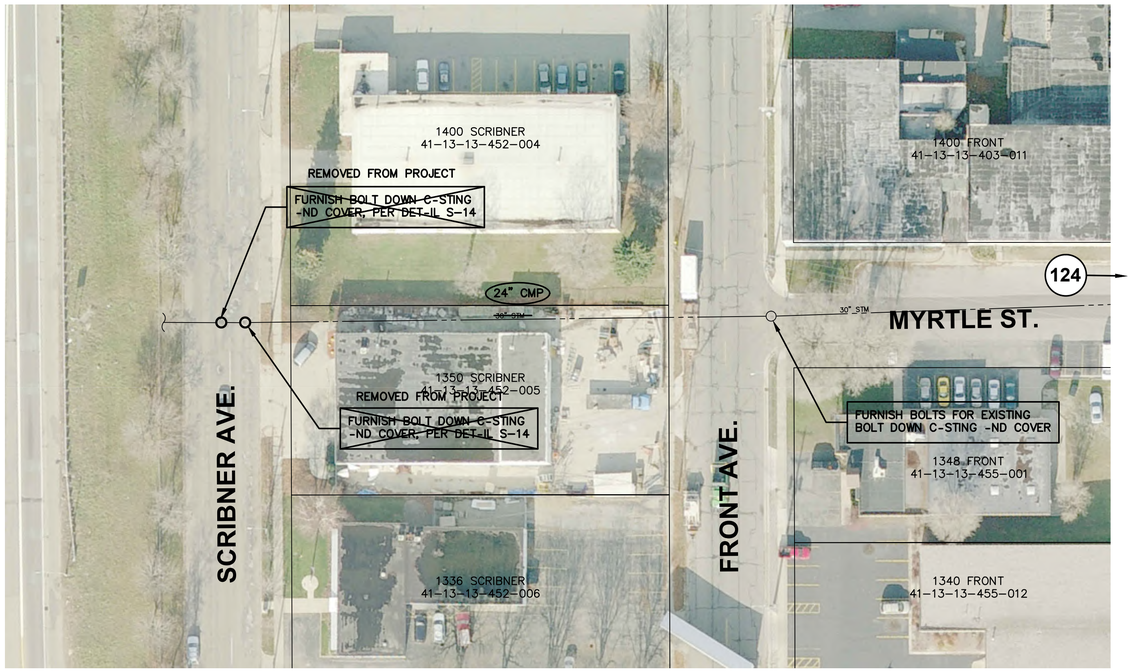
Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS
TO
GRAND RIVER FLOODWALL CONTRACT NO. 1
(BACKFLOW PREVENTION)

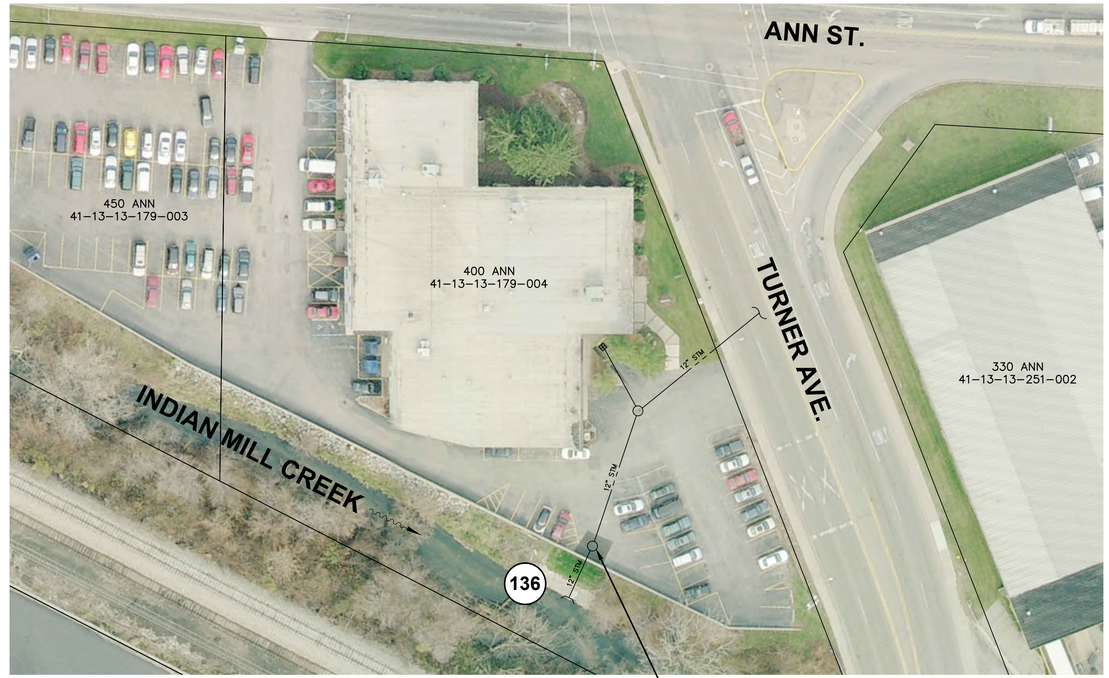
Drawn by	GPF No.	Sheet No.
RML	526□	7 of 15
Check: Field JB/JH		
Check: Office RDV		

PLOT INFO: Z:\2012\I200336FP\CAD\CD\AS-BUILTS\C002-22_G1203336FP_AS_BUILT.DWG LAYOUT: 7 DATE: 12/8/2014 TIME: 11:41:05 AM USER: CDO



FRONT AND MYRTLE - LOCATION I
(OUTFALL 124)
SCALE 1"=40'

NORTH



TURNER AND ANN - LOCATION
(OUTFALL 136)
SCALE 1"=40'

NORTH

UPSTREAM SEWER WORK LOCATIONS (I AND)

GENER-L NOTES

1. S-WCUT -ND REMOVE P-VEMENT -S NECESS-RY FOR CONSTRUCTION.
2. ENGINEER -ND CONTR-CTOR TO M-RK OUT -ND -GREE TO REMOV-L LIMITS PRIOR TO ST-RT OF CONSTRUCTION. -LL REMOV-LS -RE INCLUDED IN OTHER BID ITEMS UNLESS OTHERWISE NOTED.
3. RESTOR-TION ITEMS -RE INCLUDED IN C-STING -ND COVER REPL-CEMENT.

AS-BUILT
12/2014

REV. NO.	DESCRIPTION

DESIG:ED & S:R:E:ED B:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
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TO
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(BACKFLOW PREVENTION)

Drawn by	GPF No.	Sheet No.
RML	526	12 of 15
Check: Field JB/JH		
Check: Office RDV		

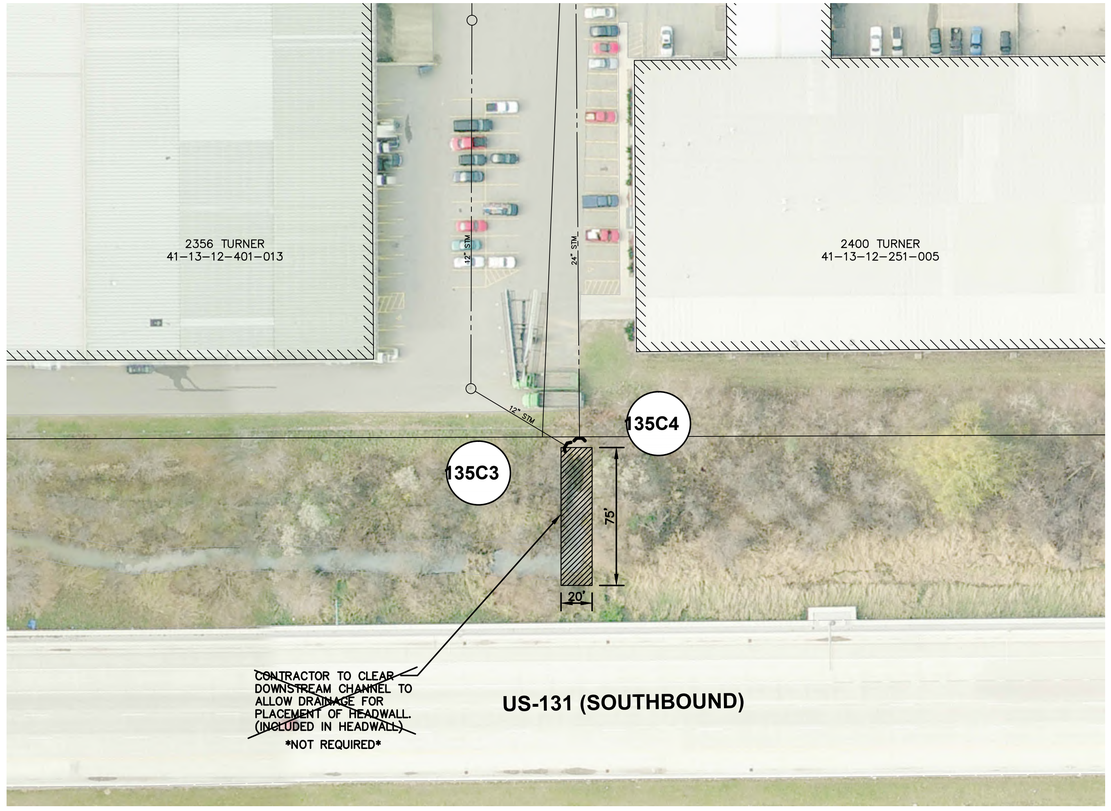
PLOT INFO: Z:\2012\1203308FP\CAD\CD\AS-BUILTS\C002-22_G1203308FP_AS_BUILT.DWG LAYOUT: 12 DATE: 12/9/2014 TIME: 9:15:04 AM USER: CDO



HAMILTON AND BROADWAY - LOCATION K
(OUTFALL 138)
SCALE 1"=40'

NORTH

NOTE: EXISTING FLAPGATE IN MH TO NORTH (CLOSEST TO OUTLET) GATE PROVIDED BOLT DOWN CASTING: BOTH LOCATIONS



TURNER - LOCATION L
(OUTFALL 135C3 AND 135C4)
SCALE 1"=40'

NORTH

GENERAL NOTES

1. SAWCUT AND REMOVE PAVEMENT AS NECESSARY FOR CONSTRUCTION.
2. ENGINEER AND CONTRACTOR TO MARK OUT AND AGREE TO REMOVAL LIMITS PRIOR TO START OF CONSTRUCTION. ALL REMOVALS ARE INCLUDED IN OTHER BID ITEMS UNLESS OTHERWISE NOTED.
3. RESTORATION ITEMS ARE INCLUDED IN CASTING AND COVER REPLACEMENT.

AS-BUILT
12/2014

UPSTREAM SEWER WORK LOCATIONS (K AND L)

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY: fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
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phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

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IMPROVEMENTS
TO
GRAND RIVER FLOODWALL CONTRACT NO. 1
(BACKFLOW PREVENTION)

Drawn by	GPF No.	Sheet No.
RML	526	13 of 15
Check: Field JB/JH		
Check: Office RDV		

PLOT INFO: Z:\2012\120330BFP\CAD\CD\AS-BUILTS\C002-22_G120330BFP_AS_BUILT.DWG LAYOUT: 13 DATE: 12/9/2014 TIME: 9:15:40 AM USER: CDO

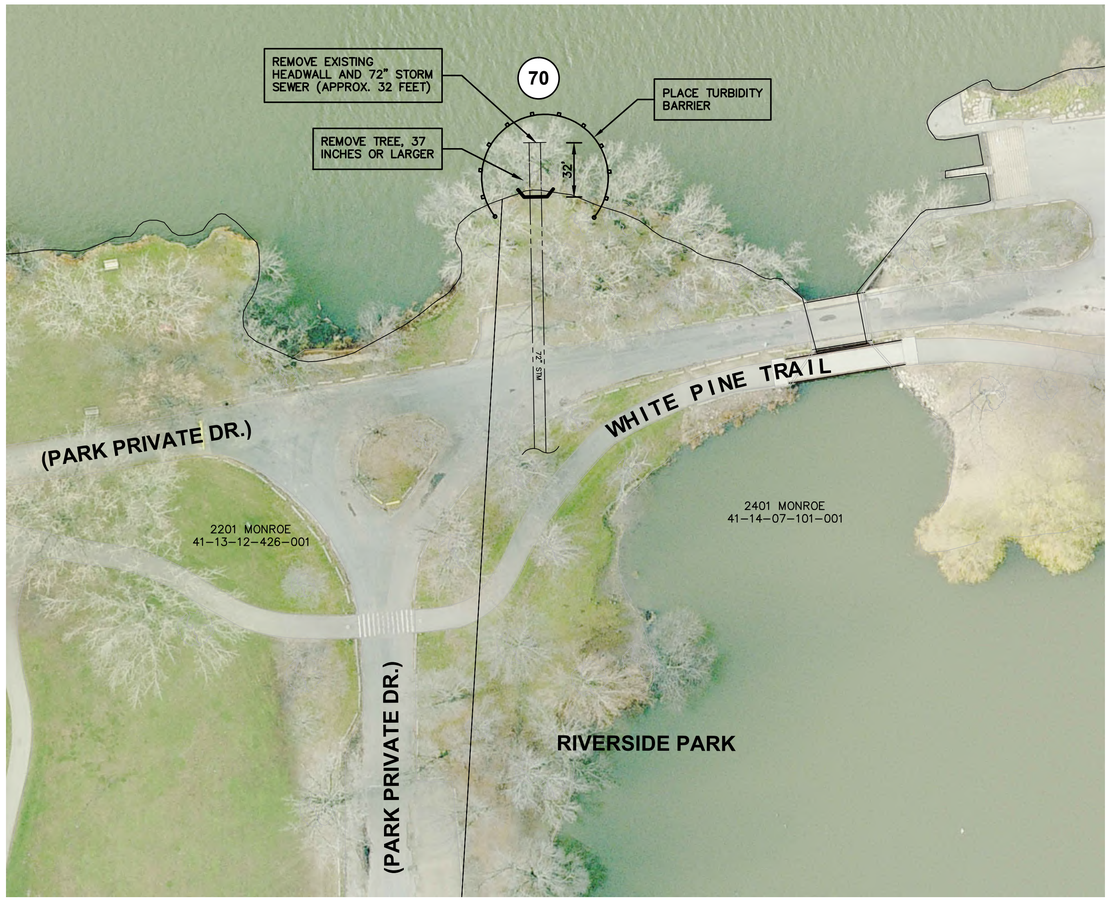


TURNER - LOCATION O
(OUTFALL 135F)
SCALE 1"=40'

NORTH



PLACE CONCRETE HEADWALL FOR 60" PIPE, WITH 60" FLAP GATE PER DETAIL SHEET 7



GUILD ENTRANCE

RIVERSIDE PARK - LOCATION P
(OUTFALL 70)
SCALE 1"=40'

NORTH



REMOVE 32' OF 72" CONCRETE PIPE TO MATCH BANKS NORTH AND SOUTH OF OUTFALL

PLACE CONCRETE HEADWALL FOR 72" PIPE, WITH 72" FLAP GATE PER DETAIL 7

GENERAL NOTES

1. SAWCUT AND REMOVE PAVEMENT AS NECESSARY FOR CONSTRUCTION.
2. ENGINEER AND CONTRACTOR TO MARK OUT AND AGREE TO REMOVAL LIMITS PRIOR TO START OF CONSTRUCTION. ALL REMOVALS ARE INCLUDED IN OTHER BID ITEMS UNLESS OTHERWISE NOTED.
3. RESTORATION ITEMS ARE INCLUDED IN CASTING AND COVER REPLACEMENT.

AS-BUILT
12/2014

UPSTREAM SEWER WORK LOCATIONS (O AND P)

REV. NO.	DESCRIPTION

DESIGNED & SEALED BY:
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City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS
TO
GRAND RIVER FLOODWALL CONTRACT NO. 1
(BACKFLOW PREVENTION)

Drawn by	GPF No.	Sheet No.
RML	526	15 of 15
Check: Field JB/JH		
Check: Office RDV		

PLOT INFO: Z:\2012\1203308FP\CAD\CD\AS-BUILTS\C002-22_G1203308FP_AS_BUILT.DWG LAYOUT: 15 DATE: 12/9/2014 TIME: 9:17:04 AM USER: CDO

UTILITIES - CONTACT INFORMATION

PUBLIC

CITY OF GRAND RAPIDS TRAFFIC SIGNALS
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3847

CITY OF GRAND RAPIDS STREET LIGHTING
509 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(616) 456-3281

CITY OF GRAND RAPIDS WATER SYSTEM
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 456-4096

CITY OF GRAND RAPIDS
SANITARY AND STORM SEWER MAINTENANCE
1900 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 456-3581

PRIVATE

CONSUMERS ENERGY (ELECTRIC)
PO BOX 201
GRAND RAPIDS, MI 49501-0201
(616) 530-4244

AT&T (TELEPHONE)
ROOM 6 (PROJECTS N. OF FRANKLIN ST.)
2ND FLOOR (PROJECTS S. OF FRANKLIN ST.)
955 36TH ST. SE
GRAND RAPIDS, MI 49508
(616) 246-7203 (PROJECTS N. OF FRANKLIN ST.)
(616) 246-7210 (PROJECTS S. OF FRANKLIN ST.)

DTE ENERGY (NATURAL GAS)
444 WEALTHY ST. SW
GRAND RAPIDS, MI 49503
(800) 947-5000

COMCAST (CABLE TV)
955 CENTURY AVE. SW
GRAND RAPIDS, MI 49503
(616) 245-5039

VERIZON BUSINESS (FIBER OPTICS)
2855 OAK INDUSTRIAL DR. NE
GRAND RAPIDS, MI 49505
(616) 224-4944

CENTURY TEL (FIBER OPTICS)
320 N. WASHINGTON SQUARE
LANSING, MI 48933
(989) 239-8110

CHOICEONE (FIBER OPTICS)
44 GRANDVILLE AVE. SW, STE. 400
GRAND RAPIDS, MI 49503
(616) 988-7100

US SIGNAL COMPANY, LLC (FIBER OPTICS)
20 MONROE AVE. NW
GRAND RAPIDS, MI 49503
(616) 988-7031

LDMI
3355 EAGLE PARK DR. NE, STE. 102
GRAND RAPIDS, MI 49525
(616) 493-5364

CALL 811 FOR MISS DIG

FOR PROTECTION OF UNDERGROUND UTILITIES AND IN CONFORMANCE WITH PUBLIC ACT 53, 1974, THE CONTRACTOR SHALL CALL 811 A MINIMUM OF THREE (3) FULL WORKING DAYS (EXCLUDING SATURDAYS, SUNDAYS AND HOLIDAYS) PRIOR TO EXCAVATING IN THE VICINITY OF UTILITY LINES. ALL "MISS DIG" PARTICIPATING MEMBERS WILL THUS BE ROUTINELY NOTIFIED. THIS DOES NOT RELIEVE THE CONTRACTOR OF THE RESPONSIBILITY OF NOTIFYING UTILITY OWNERS WHO MAY NOT BE A PART OF THE "MISS DIG" ALERT SYSTEM.

GENERAL NOTES

1) MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE 1993 EDITION OF THE CITY OF GRAND RAPIDS STANDARD CONSTRUCTION SPECIFICATIONS, EXCEPT AS OTHERWISE INDICATED ON THESE PLANS OR IN THE SUPPLEMENTAL SPECIAL SPECIFICATIONS.

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

CITY OF GRAND RAPIDS

GRAND RAPIDS, MICHIGAN

DESIGN, DEVELOPMENT AND ENTERPRISE SERVICES

AND

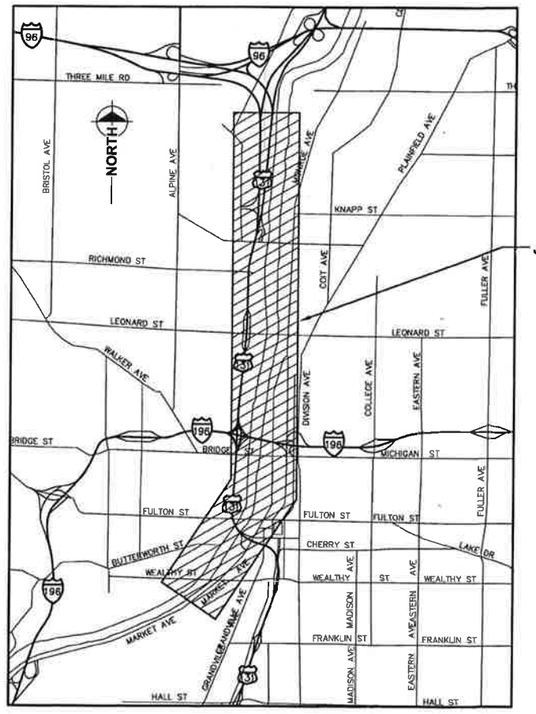
KENT COUNTY DRAIN COMMISSION CHAPTER 20 DRAINAGE COMMISSIONER

IMPROVEMENTS

TO

GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)



PROJECT LOCATION

AS-BUILT
12/2017

INDEX OF SHEETS

1 TITLE SHEET
2 LOCATION MAP

WEST SIDE

3 700 WEALTHY STREET
4 240 FRONT AVENUE
5 240 - 210 FRONT AVENUE
6 50 FRONT AVENUE
7 417 WATSON STREET
8-9 624 FRONT AVENUE (FISH LADDER PARK)
10 1781 BROADWAY AVE (INDIAN MILL CREEK)
11-12 2204 - 2280 TURNER AVENUE

EAST SIDE

13 449 MARKET AVENUE
14 509 WEALTHY STREET
15 201 MARKET AVENUE
16-17 647 MONROE AVENUE
18-19 OUTFALL ABANDONMENTS
20-22 MISCELLANEOUS DETAILS
23 QUANTITIES

BID SET

BID SET NO.	DATE	BID SET NO.	DATE

REVISIONS

REV NO.	DATE	SHEET NUMBER(S)	APPROVED BY
1	7/27/16	3	TRP

AS-BUILT RECORD

CONTRACTOR	Diversco
FIELD ENGINEER	FTCH
INSPECTED BY	FTCH
AS-BUILT BY	FTCH
AS-BUILT DATE	12/2017
BORINGS BY	MTC
WATER PIPE MANUFACTURER	NA
SANITARY PIPE MANUFACTURER	NA
STORM PIPE MANUFACTURER	NA

PERMITS

M.D.E.Q. WATER SYSTEM PERMIT NO.:	OTHER: NO.:
M.D.E.Q. WASTEWATER SYSTEM PERMIT NO.:	OTHER: NO.:
M.D.O.T. RIGHT-OF-WAY PERMIT NO.:	OTHER: NO.:

CITY COMMISSION PROC. NO. 86029 DATE 8/23/16
MDOT AGREEMENT ☐ CONTRACT AWARDED ☒
FINANCIAL AGREEMENT ☐ SHPO AGREEMENT ☐
GRANT AGREEMENT ☐ COST SHARING AGREEMENT ☐
PUBLIC UTILITIES EASEMENT (SEE EASEMENT DESCRIPTION SHEET)

ADDITIONAL CITY COMMISSION PROCEEDINGS

PROCEEDING NO.	DATE	PURPOSE
88694	4/25/17	CXT
86763	5/23/17	CE.BAS

DESIGNED & SURVEYED BY: fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
Grand Rapids, Michigan 49546
phone (616)575-3824, fax (616)464-3996
engineers • scientists • architects • constructors

Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

FTC&H
PROFESSIONAL PERSON IN RESPONSIBLE CHARGE OF THIS PROJECT

SHEETS: 1 - 23

NAME OF LICENSEE: JOSEPH R. PLATTE

NUMBER: 43898

SIGNATURE: Joseph R. Platte

STATE OF MICHIGAN — JOSEPH R. PLATTE — ENGINEER — No. 43898 — LICENSED PROFESSIONAL ENGINEER

City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

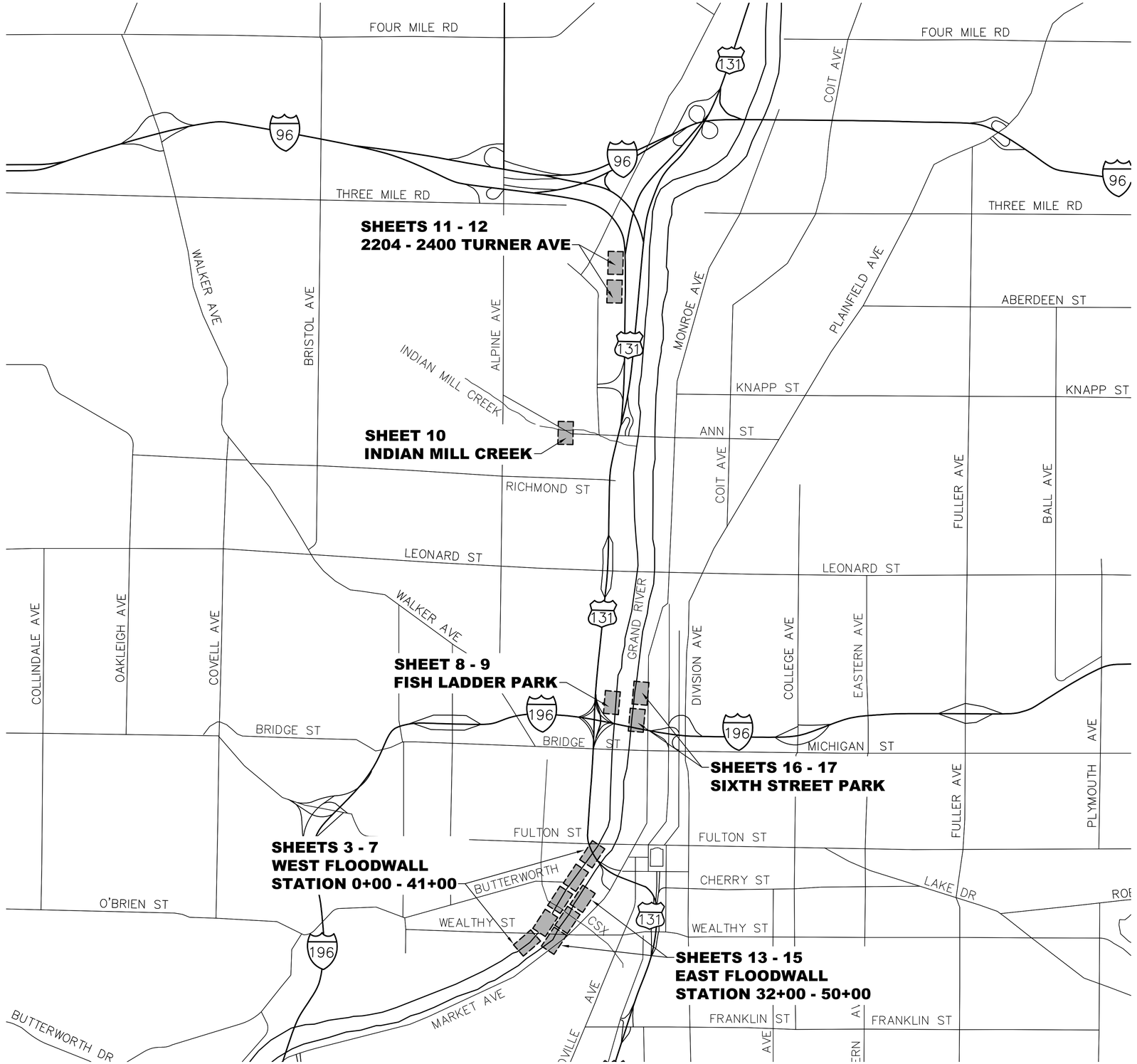
IMPROVEMENTS TO
GRAND RIVER FLOODWALL CONTRACT NO. 2
(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

Drawn by NRT Notes In
Check: Field Office

Approved Mark A. DeClerq 7-5-16
City Engineer Date

APPROVAL OF SHEET(S) 1 - 23 ONLY

Project No.	GPF No.	Sheet No.
14034	5426	1 of 23



NORTH

NO SCALE

LOCATION MAP

REV. NO.	DESCRIPTION

DESIGNED & SURVEYED BY:
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City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO GRAND RIVER FLOODWALL CONTRACT NO. 2

(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

AS-BUILT
12/2017

Drawn by _____	GPF No.	Sheet No.
Check: Field _____	5426	2 of ___
Check: Office _____		

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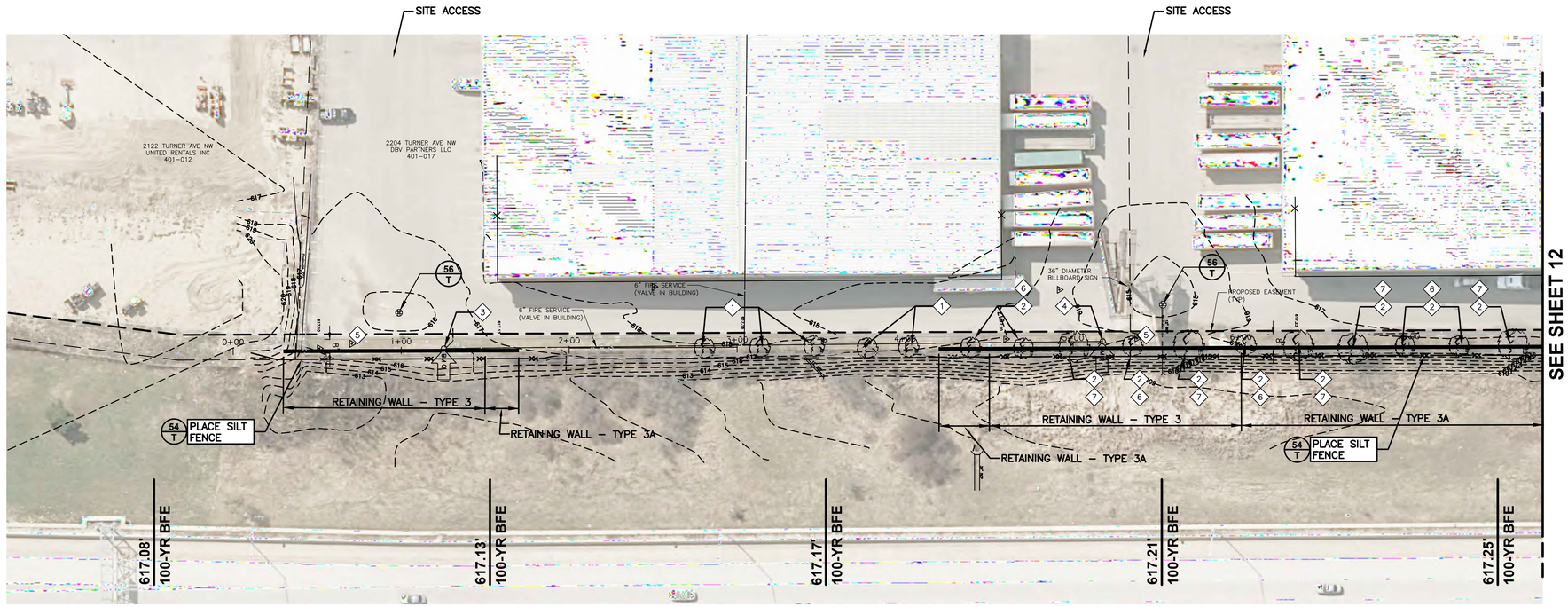


REMOVE EXISTING CHAIN LINK FENCE; PLACE MDOT "FENCE, CHAIN LINK, 48 INCH" PER MDOT R-98-B SERIES DETAILS.
STATIONS 0+30 TO 1+50
STATIONS 4+50 TO 6+00

ESTIMATED EARTHWORK QUANTITIES ON MDOT PROPERTY

15 CYDS. CUT 15 CYDS FILL.

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), STEAM, TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

BENCHMARK

BENCHMARK Q ELEV. 617.84
ESE FLANGE BOLT ON HYDRANT UNDER E IN EJIW, 30 FEET SOUTH AND 36 FEET EAST OF SE CORNER OF 2204 TURNER AVENUE BUILDING

BENCHMARK R ELEV. 618.10
ESE FLANGE BOLT OF HYDRANT UNDER E IN EJIW, 27 FEET EAST AND 12 FEET SOUTH OF BILLBOARD BETWEEN 2204 AND 2280 TURNER AVENUE BUILDINGS

NORTH

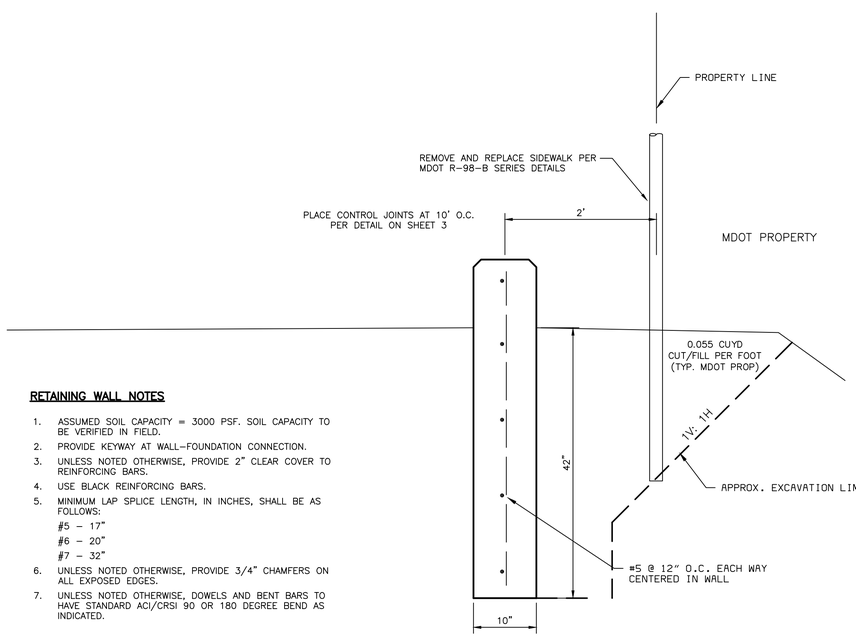
SCALE
PLAN: 1"=40'

KEY NOTES

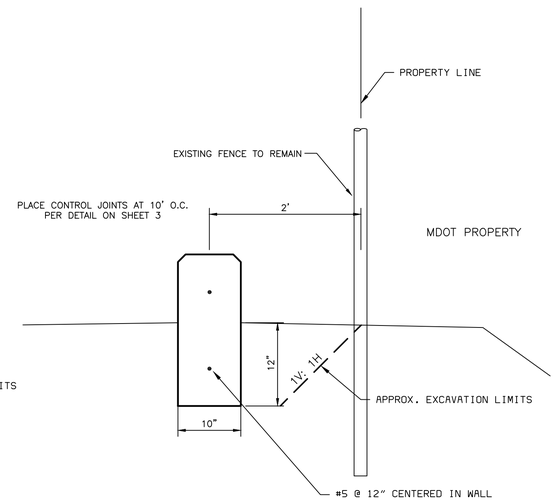
1. PROTECT EXISTING TREES.
2. REMOVE EXISTING TREE.
3. RELOCATE EXISTING FIRE HYDRANT BY OFF SETTING 50' OF 6" WATERMAIN 3 FEET TO THE WEST.
4. RELOCATE EXISTING FIRE HYDRANT BY OFF SETTING 80' OF 6" WATERMAIN 2 FEET TO THE WEST. THE ENGINEER WILL DETERMINE IN FIELD WHETHER OR NOT RELOCATION IS NECESSARY.
5. RESTORE ALL DISTURBED AREAS WITH 4" TOPSOIL, SEED,AND MULCH (TYP).
6. PLACE CRATAEGUS CRUS-GALLI 'CRUZAM', 3 INCH
7. PLACE AMELANCHIER CANADENSIS 'TRAZAM', 2-1/2 INCH

SOIL EROSION AND SEDIMENTATION CONTROL

1. SEE SHEET 20 FOR SOIL EROSION AND SEDIMENTATION CONTROL NOTES AND DETAILS.
2. PREDOMINANT SOILS TYPE: URBAN LAND (NRCS WEB SOIL SURVEY)
3. PROXIMITY TO GRAND RIVER: 700 FEET
4. CONTRACTOR TO IDENTIFY: LIMITS OF EARTH CHANGE; METHOD FOR PREVENTING THE TRACKING OF SEDIMENT ONTO PAVEMENT; SCHEDULING PLAN FOR IMPLEMENTATION, INSTALLATION AND MAINTENANCE OF SESC MEASURES AND BMPS.
5. CONTRACTOR TO IDENTIFY: METHOD FOR PREVENTING CONCRETE DUST AND DEBRIS FROM ENTERING THE RIVER; METHOD/LOCATION FOR CONCRETE WASHOUT DISPOSAL.



CONCRETE RETAINING WALL - TYPE 3
(2204-2280 TURNER AVE.)
SCALE: 1"=1'



CONCRETE RETAINING WALL - TYPE 3A
(2204-2280 TURNER AVE.)
SCALE: 1"=1'

RETAINING WALL NOTES

1. ASSUMED SOIL CAPACITY = 3000 PSF. SOIL CAPACITY TO BE VERIFIED IN FIELD.
2. PROVIDE KEYWAY AT WALL-FOUNDATION CONNECTION.
3. UNLESS NOTED OTHERWISE, PROVIDE 2" CLEAR COVER TO REINFORCING BARS.
4. USE BLACK REINFORCING BARS.
5. MINIMUM LAP SPLICE LENGTH, IN INCHES, SHALL BE AS FOLLOWS:
   #5 – 17"
   #6 – 20"
   #7 – 32"
6. UNLESS NOTED OTHERWISE, PROVIDE 3/4" CHAMFERS ON ALL EXPOSED EDGES.
7. UNLESS NOTED OTHERWISE, DOWELS AND BENT BARS TO HAVE STANDARD ACI/CRSI 90 OR 180 DEGREE BEND AS INDICATED.

STATION	100 YEAR FLOOD ELEVATION	EXISTING TOP OF FLOOD PROTECTION	PROPOSED TOP OF FLOOD PROTECTION	FREEBOARD	WALL DETAIL
0+00	617.09	620.48	617.75	0.66'	
0+32	617.10	619.57	617.75	0.65'	NA
0+50	617.10	616.57	617.75	0.65'	TYPE 3
1+00	617.11	616.41	617.75	0.64'	TYPE 3
1+50	617.12	616.93	617.75	0.63'	TYPE 3
1+70	617.13	617.39	617.75	0.62'	TYPE 3A
2+00	617.13	617.55	617.55	0.42'	NA
3+00	617.15	618.25	618.25	1.10'	NA
4+00	617.17	617.65	617.70	0.53'	NA
4+20	617.18	617.45	617.75	0.57'	NA
4+50	617.19	617.10	617.75	0.56'	TYPE 3A
5+00	617.19	616.47	617.75	0.56'	TYPE 3
5+50	617.21	615.90	617.75	0.54'	TYPE 3
6+00	617.22	616.27	617.75	0.53'	TYPE 3
6+50	617.23	616.81	617.75	0.52'	TYPE 3A
7+00	617.24	617.10	617.75	0.51'	TYPE 3A
7+50	617.25	617.20	617.75	0.50'	TYPE 3A
8+00	617.26	617.21	617.75	0.49'	TYPE 3A

WEST SIDE
2204-2280 TURNER AVENUE

REV. NO.	DESCRIPTION
9/28/2016	CHANGED SELECTED WALL CROSS-SECTIONS FROM TYPE 3 TO TYPE 3A
9/30/2016	REVISED DRAWING TO INCLUDE ADDITIONAL INFORMATION FOR MDOT ROW PERMIT
11/15/2016	REVISED DRAWING TO INCLUDE ADDITIONAL INFORMATION FOR MDOT ROW PERMIT

DESIGNED & SURVEYED BY:
fishbeck, thompson, carr & huber, inc.
1515 Arboretum Dr. SE
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phone (616)575-3824, fax (616)464-3996
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Materials Testing Consultants, Inc.
693 Plymouth Ave. NE, Grand Rapids, MI 49505
Phone (616)456-5469, Fax (616)456-5784

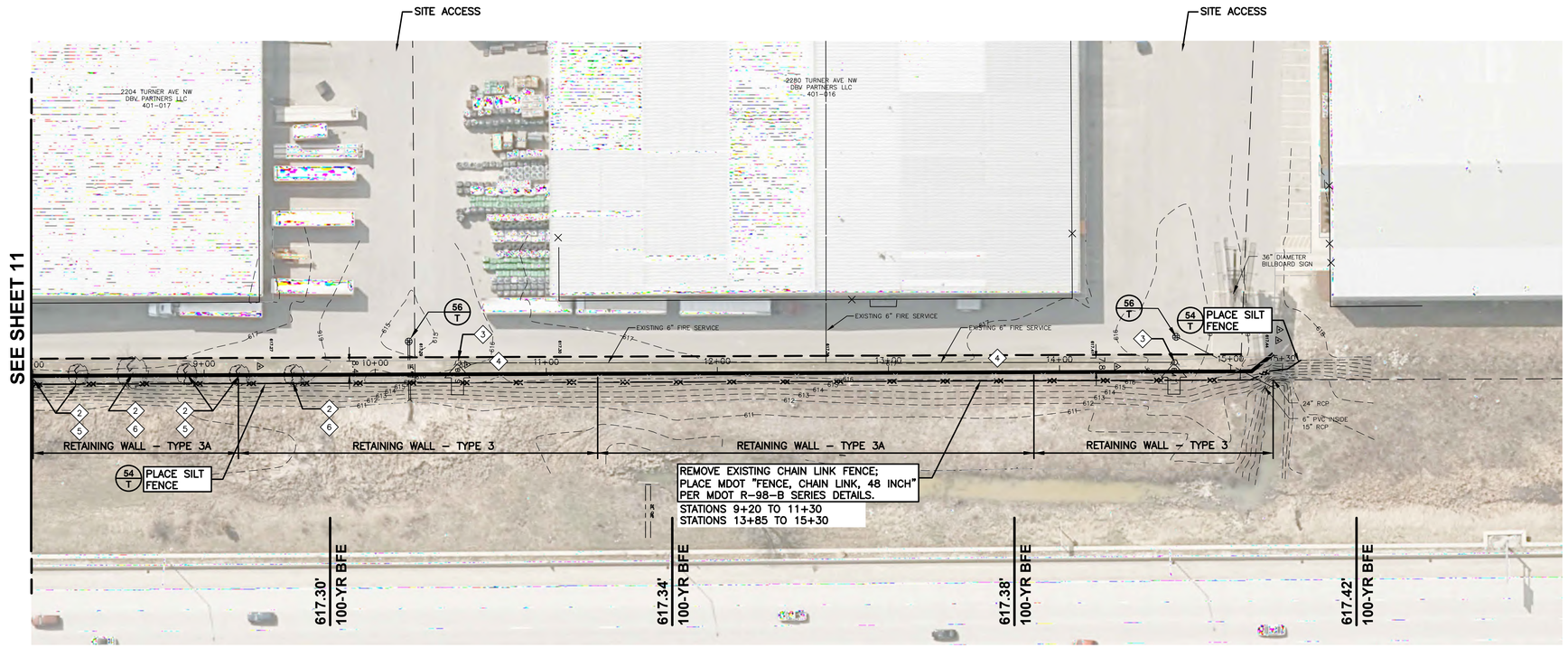
City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO
GRAND RIVER FLOODWALL CONTRACT NO. 2
(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

AS-BUILT
12/2017

Drawn by NRT	GPF No.	Sheet No.
Check: Field	5426	11 of 23
Check: Office		

PLOT INFO: Z:\2012\1203320FB\CAD\CD2\00_ASBUILTS\11_1203320FB_REV_ASBUILT.DWG LAYOUT: 11 DATE: 4/3/2018 TIME: 1:59:54 PM USER: JRP



SEE SHEET 11

BENCHMARK

BENCHMARK S ELEV. 616.55
ESE FLANGE BOLT OF HYDRANT UNDER E IN EJIW,
55 FEET SOUTH AND 33 FEET EAST OF SE CORNER
OF 2356 TURNER AVENUE BUILDING

BENCHMARK T ELEV. 616.70
ESE FLANGE BOLT OF HYDRANT UNDER E IN EJIW,
55 FEET NORTH AND 37 FEET EAST OF NE CORNER
OF 2356 TURNER AVENUE BUILDING

NORTH

SCALE
PLAN: 1"=40'

KEY NOTES

1. PROTECT EXISTING TREES.
2. REMOVE EXISTING TREE.
3. PROTECT EXISTING FIRE HYDRANT IN PLACE.
4. RESTORE ALL DISTURBED AREAS WITH 4" TOPSOIL, SEED, AND MULCH (TYP).
5. PLACE CRATAEGUS CRUS-GALLI 'CRUZAM', 3 INCH
6. PLACE AMELANCHIER CANADENSIS 'TRAZAM', 2-1/2 INCH

SOIL EROSION AND SEDIMENTATION CONTROL

1. SEE SHEET 20 FOR SOIL EROSION AND SEDIMENTATION CONTROL NOTES AND DETAILS.
2. PREDOMINANT SOILS TYPE: URBAN LAND (NRCS WEB SOIL SURVEY)
3. PROXIMITY TO GRAND RIVER: 700 FEET
4. CONTRACTOR TO IDENTIFY: LIMITS OF EARTH CHANGE; METHOD FOR PREVENTING THE TRACKING OF SEDIMENT ONTO PAVEMENT; SCHEDULING PLAN FOR IMPLEMENTATION, INSTALLATION AND MAINTENANCE OF SESC MEASURES AND BMPS.
5. CONTRACTOR TO IDENTIFY: METHOD FOR PREVENTING CONCRETE DUST AND DEBRIS FROM ENTERING THE RIVER; METHOD/LOCATION FOR CONCRETE WASHOUT DISPOSAL.

STATION	100 YEAR FLOOD ELEVATION	EXISTING TOP OF FLOOD PROTECTION	PROPOSED TOP OF FLOOD PROTECTION	FREEBOARD	WALL DETAIL
8+00	617.25	617.26	~~617.75~~ 617.76	0.50'	
9+00	617.28	616.96	~~617.75~~ 617.83	0.47'	TYPE 3A
9+20	617.28	616.71	~~617.75~~ 617.79	0.47'	TYPE 3A
10+00	617.30	615.50	617.75	0.45'	TYPE 3
11+00	617.32	616.45	~~617.75~~ 617.58	0.43'	TYPE 3
11+20	617.32	616.35	617.75	0.43'	TYPE 3
12+00	617.34	617.05	~~617.75~~ 617.58	0.41'	TYPE 3A
13+00	617.36	617.20	617.75	0.39'	TYPE 3A
13+85	617.37	616.75	617.75	0.38'	TYPE 3A
14+00	617.38	616.65	~~617.75~~ 617.66	0.37'	TYPE 3
15+00	617.40	616.80	617.75	0.35'	TYPE 3
15+25	617.41	617.55	617.75	0.34'	TYPE 3
15+30	617.41	617.60	~~617.75~~ 617.66	0.34'	TYPE 3

ESTIMATED EARTHWORK QUANTITIES ON MDOT PROPERTY

20 CYDS. CUT 20 CYDS FILL.

THE UNDERGROUND LOCATIONS SHOWN FOR NATURAL GAS (GAS), STEAM, TELEPHONE (TEL), ELECTRICAL POWER (PWR), CABLE TV (CTV) AND FIBER OPTIC LINES (FIBER) ARE APPROXIMATE. THE CITY OF GRAND RAPIDS ASSUMES NO RESPONSIBILITY FOR THEIR ACCURATE REPRESENTATION IN THIS DRAWING. MISS DIG MUST BE CONTACTED PRIOR TO CONSTRUCTION TO LOCATE THESE UTILITIES.

AS-BUILT
12/2017

WEST SIDE
2204-2280 TURNER AVENUE

REV. NO.	DESCRIPTION
9/28/2016	CHANGED SELECTED WALL CROSS-SECTIONS FROM TYPE 3 TO TYPE 3A
9/30/2016	REVISED DRAWING TO INCLUDE ADDITIONAL INFORMATION FOR MDOT ROW PERMIT

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City of Grand Rapids
Design, Development, and Enterprise Services
Engineering Department

IMPROVEMENTS TO
GRAND RIVER FLOODWALL CONTRACT NO. 2
(FREEBOARD AND EMBANKMENT PROTECTION IMPROVEMENTS)

Drawn by NRT
Check: Field
Check: Office

GPF No. 5426

Sheet No. 12 of 23

PLOT INFO: Z:\2012\120330FB\CAD\C02\00_ASBUILTS\12_120330FB_REV_ASBUILT.DWG LAYOUT: 12 DATE: 4/3/2018 TIME: 2:08:39 PM USER: JRP

US-131 CURVE 2
URVE DATA
58' 46" (RT)
17' 11"
0.000.00'
70.96'
41.91'
.73'
965+17.57 X=12,773,315.213Y=549,804.8552
966+88.53 X=12,773,323.465Y=549,975.6136
968+59.47 X=12,773,334.635Y=550,146.2060
ER = N.C.

			FINAL R.O.W.
AUTH	DATE	NO.	REVISION

EROSION AND SEDIMENTATION CONTROL ITEMS			FED/STATE
KEY	NAME	PAY ITEM	QUANTITY
(26)	GEOTEXTILE SILT FENCE	Erosion Control, Silt Fence	480 Ft
(24)*	SANDBAGS	Erosion Control, Sand Bag	400 Ea
(29)	INLET PROTECTION FABRIC DROP	Erosion Control, Inlet Protection, Fabric Drop	4 Ea

* TO BE USED AS DIRECTED BY THE ENGINEER

ENVIRONMENTAL NOTE:
- UPON CONSTRUCTION OF THE CULVERT END SECTIONS, THE CONTRACTOR SHALL INSTALL 100 FEET OF SILT FENCE IN EACH QUADRANT OF THE CULVERT. AT THE END OF EACH WORK DAY, ALL AREAS OF DISTURBED EARTH SHALL BE PROTECTED BY SILT FENCE.

SECTION 12
T7N, R12W
CITY OF WALKER

SB US-131

GUARDRAIL QUANTITIES - NB US-131 LT

FED/STATE
1 Ea Guardrail Approach Terminal, Type 2T
1 Ea Guardrail Anch, Bridge, Det T1
2 Ea Guardrail Reflector

INSTALL NEW CULVERT WITH END SECTIONS
FED/STATE
193 Ft Culv, Cl V, 42 Inch, Jacked In Place
2 Ea Culv End Sect, Conc, 42 Inch
2 Ea Dr Marker Post

GUARDRAIL, TYPE T & BRIDGE APPROACH CURB AND GUTTER
CONC BARRIER, SINGLE FACE, TYPE B
VALLEY GUTTER, CONC
SLOPE STAKE LINE
EX NB US-131 SURVEY ℄
PROP TRUSS SIGN (SEE SIGNING PLANS)
PROP 42" CONC
PROP 18" CONC
PROP 12" CONC
PROP 8" CONC
EX ROW VARIES
NB US-131 CONST ℄
PROP WALL (SEE WALL DETAILS)
GUARDRAIL, TYPE T & BRIDGE APPROACH CURB AND GUTTER
300' RAMP LANE TAPER
+31.49
+31.49
END ANN ST ON RAMP STA 121+75.20 = NB US-131 STA 965+84.92 24.00' RT
POT=121+75.20
PI=965+71.57
PI=966+88.53
PI=968+59.47
12'
48"
VARIES
964 965 966 967 968 969 970 971 972 973 974 975

GUARDRAIL QUANTITIES - NB US-131 RT

FED/STATE
1 Ea Guardrail Approach Terminal, Type 2T
1 Ea Guardrail Anch, Bridge, Det T1
2 Ea Guardrail Reflector

SECTION 12
T7N, R12W
CITY OF WALKER

CONSTRUCTION QUANTITIES - THIS SHEET

FED/STATE
6025 Syd Conc Pavt, Nonreinf, 11 Inch, High Performance
675 Syd Conc Pavt, Misc, Nonreinf, 11 inch, High Performance
4020 Ft Joint, Contraction, Cp
1920 Ft Joint, Contraction, C3p
3200 Syd Shoulder, Nonreinf Conc, High Performance
540 Syd Shoulder, Cl II, 6 Inch
9900 Syd Aggregate Base - Modified, 6 Inch
3600 Ft Underdrain, Subbase, 6 Inch
240 Ft Underdrain Outlet, 6 Inch
3 Ea Underdrain, Outlet Ending, 6 Inch
1333 Ft Conc Barrier, Single Face, Type B
1333 Ft Valley Gutter, Conc
111 Ft Curb and Gutter, Bridge Approach

STRUCT NO.	STATION	OFFSET*	RIM ELEV*	Dr Structure, -- inch dia		Dr Structure Cover		Sewer, Cl II, -- inch, Tr Det B		Sewer, Cl II, -- inch, Tr Det D	
				24"	48"	TYPE	Lb	12"	18"	12"	18"
				Ea	Ea			Ft	Ft	Ft	Ft
18	NB US 131 STA 970+71.16	22.00 RT	622.74		1	VG	610	68			
19	NB US 131 STA 970+71.16	46.00 LT	622.74		1	VG	610				239
20	NB US 131 STA 973+10.39	46.00 LT	621.78		1	VG	610	68			
21	NB US 131 STA 973+10.39	22.00 RT	621.78		1	VG	610				300
	FED/STATE TOTALS				4		2440	136			539

* RIM ELEV AND OFFSETS ARE MEASURED TO CENTER OF STRUCTURE

CONSTRUCTION SHEET

URS

NB US-131 STA 964+00 TO STA 976+00

NB US-131

DATE: 09/01/06
DATE: 09/05/06
WORKED ON BY: SB
CHECKED BY: NGB
FILE: 56887_131_96400.DGN

965+00 966+00 967+00 968+00 969+00 970+00 971+00 972+00 973+00 974+00 975+00 976+00

1:4 FS OR FLATTER

+70.50 +87.50 CONC CURB & GUTTER, BRIDGE APPROACH: 1:4 FS
VALLEY GUTTER, CONC W/ CONC BARRIER, SINGLE FACE, TYPE B: TRANS FROM 1:4 FS OR FLATTER TO 1:2 FS

+00.00 VALLEY GUTTER, CONC W/ CONC BARRIER, SINGLE FACE, TYPE B: 1:2 FS

NORMAL CROWN

+75.00 TRANS FROM 1:2 FS TO 1:6 FS OR FLATTER +75.00 1:6 FS OR FLATTER

+50.00 +00.00 TRANS FROM 1:6 FS OR FLATTER TO 1:4 FS

+13.21 +80.04 CONC CURB & GUTTER, BRIDGE APPROACH: 1:4 FS 1:4 FS +50.00

+50.00 VALLEY GUTTER, CONC W/ CONC BARRIER, SINGLE FACE, TYPE B: TRANS FROM 1:4 FS TO 1:2 FS

+50.00 VALLEY GUTTER, CONC W/ CONC BARRIER, SINGLE FACE, TYPE B: 1:2 FS

1:6 FS OR FLATTER TO 1:2 FS

29/18 +71.16 PROP 4' CB

PROP FL ELEV 619.57 12" E

29/20 +10.39 PROP 4' CB

PROP FL ELEV 618.43 12" E

EX FL ELEV 606.09 36" E

PROP FL ELEV 605.43 42" E

EX FL ELEV 605.02 60" W
605.02 60" E

625 620 615 610

EX GROUND PROFILE LT 75'
EX GROUND POINTS LT 100'
PROP DITCH PROFILE LT

-0.400%

EXISTING GROUND PROFILE
PROP PLAN GRADE

29/19 +71.16 PROP 4' CB

29/21 +10.39 PROP 4' CB

PROP 18" @ 0.48%

PROP 18" @ 0.48%

PROP FL ELEV
618.74 18" N
619.24 12" W

PROP FL ELEV
617.60 18" N
617.60 18" S
618.10 12" W

PROP FL ELEV 604.96 42" W

EX FL ELEV 604.96 36" W

EX FL ELEV 603.99 60" W

625 620 615 610 605

EX GROUND PROFILE RT 50'
EX GROUND POINTS RT 100'
PROP DITCH PROFILE RT

EARTHWORK QUANTITIES - THIS SHEET

FED/STATE

1476 Cyd Embankment, CIP, Special
4786 Cyd Excavation, Earth*
4824 Cyd Subbase, CIP

*Includes: 856 Cyd Topsoil Stripping

AUTH	DATE	NO.	REVISION
			FINAL R.O.W.

URS
Surface Transportation
Grand Rapids - Farmington Hills - Traverse City

NB US-131 STA 964+00 TO STA 976+00

DATE	SCALE	CONT. SEC.	JOB NO.	DESIGN UNIT
09/07/06	HORZ. 1" = 40' VERT. 1" = 4'	41131	56887A	GREEN

MDOT Michigan Department of Transportation

CHECKED BY: NCB DATE: 09/05/06 WORKED ON BY: SB

DATE: 09/01/06

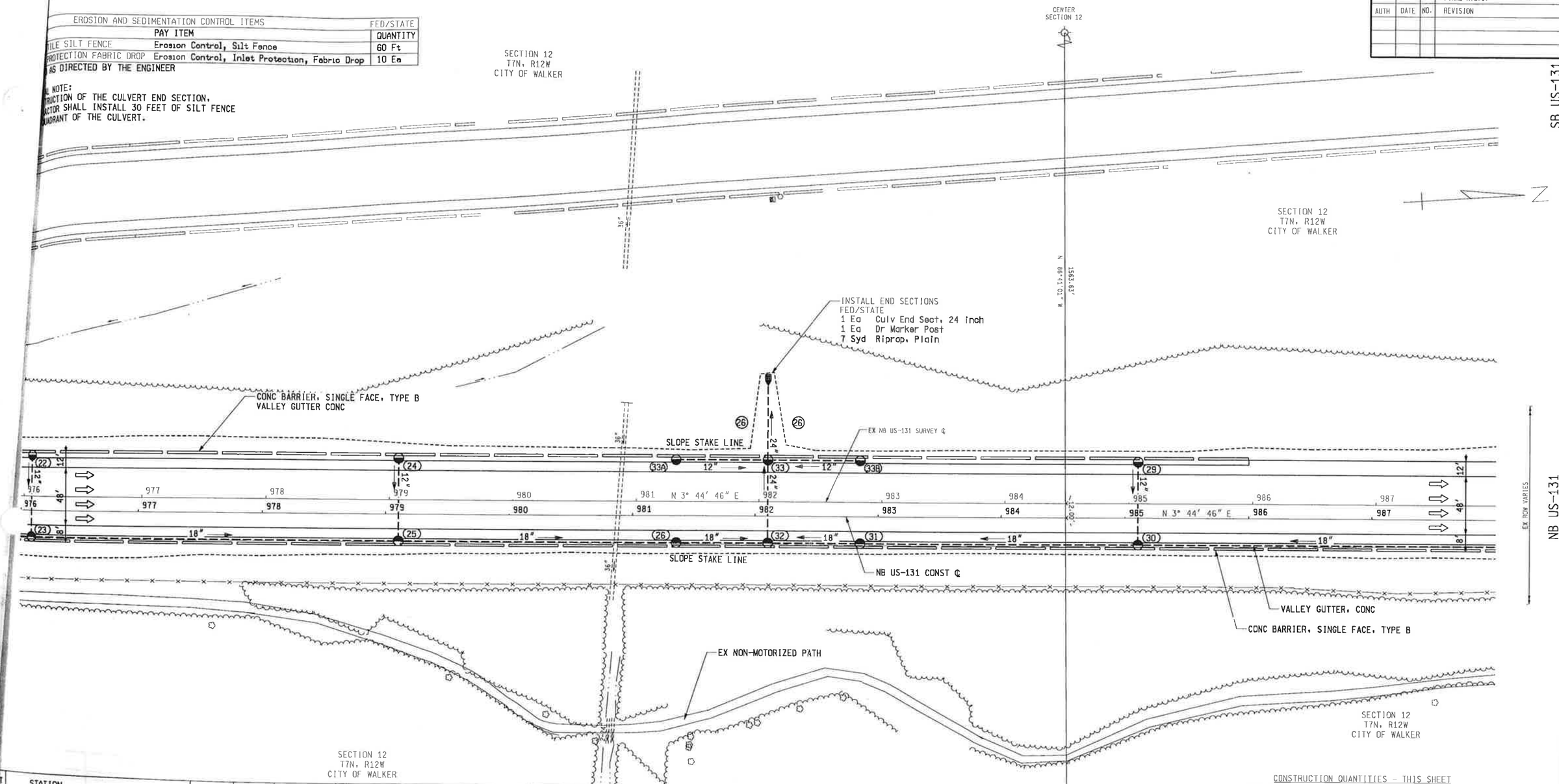
56887_131_96400.PRF

EROSION AND SEDIMENTATION CONTROL ITEMS		FED/STATE
	PAY ITEM	QUANTITY
TILE SILT FENCE	Erosion Control, Silt Fence	60 Ft
PROTECTION FABRIC DROP	Erosion Control, Inlet Protection, Fabric Drop	10 Ea

AS DIRECTED BY THE ENGINEER

L NOTE:
TRUCTION OF THE CULVERT END SECTION,
ACTOR SHALL INSTALL 30 FEET OF SILT FENCE
UADRANT OF THE CULVERT.

AUTH	DATE	NO.	FINAL R.O.W. REVISION



STATION	OFFSET*	RIM ELEV*	Dr Structure, -- inch dia 24" Ea	Dr Structure, -- inch dia 48" Ea	Dr Structure Cover TYPE	Dr Structure Cover Lb	Sewer, Cl II, -- inch, Tr Det B 12" Ft	Sewer, Cl II, -- inch, Tr Det B 18" Ft	Sewer, Cl II, -- inch, Tr Det B 24" Ft	Sewer, Cl II, -- inch, Tr Det D 12" Ft	Sewer, Cl II, -- inch, Tr Det D 18" Ft
NB US 131 STA 976+10.39	46.00 LT	620.58		1	VG	610	68				
NB US 131 STA 976+10.39	22.00 RT	620.58		1	VG	610					300
NB US 131 STA 979+10.39	46.00 LT	619.46		1	VG	610	68				
NB US 131 STA 979+10.39	22.00 RT	619.46		1	VG	610					225
NB US 131 STA 981+35.39	22.00 RT	619.06		1	VG	610		75			
NB US 131 STA 985+10.39	46.00 LT	619.46		1	VG	610	68				
NB US 131 STA 985+10.39	22.00 RT	619.46		1	VG	610					225
NB US 131 STA 982+85.39	22.00 RT	619.06		1	VG	610		75			
NB US 131 STA 982+10.39	22.00 RT	619.03		1	VG	610			64		
NB US 131 STA 982+10.39	46.00 LT	619.03		1	VG	610			61		
NB US 131 STA 981+35.39	46.00 LT	619.06		1	VG	610	75				
NB US 131 STA 982+85.39	46.00 LT	619.06		1	VG	610	75				
FED/STATE TOTALS				12		7320	354	150	125		750

RIM ELEV AND OFFSETS ARE MEASURED TO CENTER OF STRUCTURE
SEE FREEWAY LIGHTING PLANS FOR LIGHTING REMOVAL, PLACEMENT AND DETAILS

CONSTRUCTION QUANTITIES - THIS SHEET

FED/STATE	
6400 Syd	Conc Pavt, Nonreinf, 11 inch, High Performance
3840 Ft	Joint, Contraction, Cp
1920 Ft	Joint, Contraction, C3p
3200 Syd	Shoulder, Nonreinf Conc, High Performance
540 Syd	Shoulder, Cl II, 6 inch
9600 Syd	Aggregate Base - Modified, 6 inch
3600 Ft	Underdrain, Subbase, 6 inch
240 Ft	Underdrain Outlet, 6 inch
6 Ea	Underdrain, Outlet Ending, 6 inch
2200 Ft	Conc Barrier, Single Face, Type B
2200 Ft	Valley Gutter, Conc

CONSTRUCTION SHEET

URS Surface Transportation Grand Rapids, Farmington Hills, Traverse City

MDOT Michigan Department of Transportation

NB US-131 STA 976+00 TO STA 988+00

DATE	SCALE	CONT. SEC.	JOB NO.	DESIGN UNIT	SHEET NO. R.O.W	SHEET NO. CONST.
09/07/06	1"=40'	41131	56887A	GREEN		61

SB US-131

NB US-131

DATE: 09/01/06 WORKED ON BY: SB DATE: 09/05/06 CHECKED BY: NGB FILE NAME: 56887_131_97600.DGN

VALLEY GUTTER, CONC W/ CONC BARRIER, SINGLE FACE, TYPE B; 1:2 FS

(29) 24 — +10.39 PROP 4" CB
(29) 33A — +35.39 PROP 4" CB
(29) 33 — +10.39 PROP 4" CB
(29) 33B — +85.39 PROP 4" CB
(29) 29 — +10.39 PROP 4" CB

PROP 12" @ 0.48%
PROP 12" @ 0.48%

PROP FL ELEV
615.55 12" E

PROP FL ELEV
613.14 12" N

EX FL ELEV
603.69 36" E

PROP FL ELEV
612.42 24" E
612.78 12" N
612.78 12" S

PROP FL ELEV
612.60 24" W
612.60 24" E

PROP FL ELEV
613.14 12" S

PROP FL ELEV
615.55 12" E

K = 1062
850' V.C.
-0.400% +0.400%
EL. 618.82
+10.39

625
620
615
610
625
620
615

EX GROUND PROFILE LT 75'
EX GROUND POINTS LT 100'
PROP DITCH PROFILE LT

EXISTING GROUND PROFILE
PROP PLAN GRADE

(29) 25 — +10.39 PROP 4" CB
(29) 26 — +35.39 PROP 4" CB
(29) 32 — +10.39 PROP 4" CB
(29) 31 — +85.39 PROP 4" CB
(29) 30 — +10.39 PROP 4" CB

PROP 18" @ 0.48%
PROP 18" @ 0.48%
PROP 18" @ 0.48%
PROP 18" @ 0.48%
PROP 18" @ 0.48%

PROP FL ELEV
614.72 18" N
614.72 18" S
615.22 12" W

EX FL ELEV
604.87 24" E

EX FL ELEV
604.62 24" E

PROP FL ELEV
613.64 18" N
613.64 18" S

EX FL ELEV
603.47 36" W

PROP FL ELEV
612.78 24" W
613.28 18" S
613.28 18" N

PROP FL ELEV
613.64 18" N
613.64 18" S

PROP FL ELEV
614.72 18" N
614.72 18" S
615.22 12" W

620.49 621.06 620.74 620.86 620.58 620.65 620.38 620.46 620.22 620.28 620.08 620.13 619.94 619.99 619.83 619.88 619.77 619.79 619.72 619.73 619.71 619.69 619.70 619.67 619.70 619.68 619.72 619.71 619.78 619.76 619.86 619.84 619.96 619.94 620.07 620.07 620.21 620.21 620.36 620.39 620.53 620.58 620.73 620.78 620.95 620.98 621.16 621.18

977+00 978+00 979+00 980+00 981+00 982+00 983+00 984+00 985+00 986+00 987+00 988+00

625
620
615
610
605
600

EX GROUND PROFILE RT 50'
EX GROUND POINTS RT 100'
PROP DITCH PROFILE RT

EARTHWORK QUANTITIES - THIS SHEET

FED/STATE

438	Cyd	Embankment, CIP, Special
6078	Cyd	Excavation, Earth*
4190	Cyd	Subbase, CIP

*Includes: 617 Cyd Topsoil Stripping

AUTH	DATE	NO.	REVISION
			FINAL R.O.W.

URS
Surface Transportation
Grand Rapids Farmington Hills
Traverse City

NB US-131 STA 976+00 TO STA 988+00

DATE	SCALE	CONT. SEC.	JOB NO.	DESIGN UNIT
09/07/06	HORZ. 1" = 40' VERT. 1" = 4"	41131	56887A	GREEN

DATE: 09/01/06
DATE: 09/05/06
WORKED ON BY: SB
CHECKED BY: NGB

MDOT Michigan Department of Transportation

SHEET NO.	
R.O.W	CONST.
	62

FILE NAME: 56887_131_97600.PRF

			FINAL R.O.W.
AUTH	DATE	NO.	REVISION

EROSION AND SEDIMENTATION CONTROL ITEMS		FED/STATE
NAME	PAY ITEM	QUANTITY
SANDBAGS	Erosion Control, Sand Bag	150 Ea
GEOTEXTILE SILT FENCE	Erosion Control, Silt Fence	1100 Ft
INLET PROTECTION FABRIC DROP	Erosion Control, Inlet Protection, Fabric Drop	7 Ea

TO BE USED AS DIRECTED BY THE ENGINEER

ENVIRONMENTAL NOTES:
1. @ US-131 STA 990+50 TO 1000+00 (LT) PRIOR TO THE START OF CONSTRUCTION THE CONTRACTOR SHALL INSTALL SILT FENCE AS DIRECTED BY THE ENGINEER.
2. @ US-131 STA 998+50 TO 1000+00 (RT) PRIOR TO THE START OF CONSTRUCTION THE CONTRACTOR SHALL INSTALL SILT FENCE AS DIRECTED BY THE ENGINEER.

SECTION 12
T7N, R12W
CITY OF WALKER

GUARDRAIL QUANTITIES - NB US-131 LT
FED/STATE
1 Ea Guardrail Approach Terminal, Type 2T
1 Ea Guardrail Anch, Bridge, Det T1

INSTALL NEW CULVERT WITH END SECTIONS
FED/STATE
171 Ft Culv, Cl V, 72 Inch, Jacked in Place
2 Ea Culv End Sect, Conc, 72 inch
2 Ea Dr Marker Post

BEGIN NW RAMP STA 995+93.25
= NB US-131 STA 995+93.09 24.00' LT

INSTALL NEW CULVERT AND END SECTION
FED/STATE
1 Ea Culv End Sect, 18 inch
1 Ea Dr Marker Post
7 Syd Riprap, Plain

CONC BARRIER, SINGLE FACE, TYPE B

2' GORE POINT
NB US-131 STA 997+43.24
NW RAMP STA 997+43.25

GUARDRAIL, TYPE T & BRIDGE APPROACH CURB AND GUTTER

SLOPE STAKE LINE

EX NB US-131 SURVEY ℄

NW RAMP CONST ℄

VALLEY GUTTER, CONC

EX 60" ABANDONED CULVERT

PROP 72" CONC

PC-999+98.99

EX ROW VARIES

989 990 991 992 993 994 995 996 997 998 N 2° 58' 56" E 999

SLOPE STAKE LINE

NB US-131 CONST ℄

PROP TRUSS SIGN

CONC BARRIER, SINGLE FACE, TYPE B

VALLEY GUTTER, CONC

SECTION 12
T7N, R12W
CITY OF WALKER

STRUCT NO.	STATION	OFFSET*	RIM ELEV*	Dr Structure, -- inch dia		Dr Structure Cover		Sewer, Cl II, -- inch, Tr Det B			Sewer, Cl II, -- inch, Tr Det D			Dr Structure, Add Depth of -- inch dia, 8 feet to 15 feet
				24"	48"			12"	15"	18"	12"	15"	18"	48"
				Ea	Ea	TYPE	Lb	Ft	Ft	Ft	Ft	Ft	Ft	Ft
27	NB US 131 STA 991+10.39	22.00 RT	621.78		1	VG	610						300	
34	NB US 131 STA 988+10.39	22.00 RT	620.58		1	VG	610						300	
36	NB US 131 STA 994+10.39	22.00 RT	622.98		1	VG	610				200			
37	NB US 131 STA 999+10.26	22.00 RT	624.98		1	VG	610				300			
48	NB US 131 STA 996+10.26	22.00 RT	623.78		1	VG	610		68					0.3
49	NB US 131 STA 997+24.72	47.75 LT	624.20		1	VG	610					115		
	NB US 131 STA 996+10.26	46.22 LT	623.78		1	VG	610			25				1.0
	FED/STATE	TOTALS			7		4270		68	25	500	115	600	2

* RIM ELEV AND OFFSETS ARE MEASURED TO CENTER OF STRUCTURE

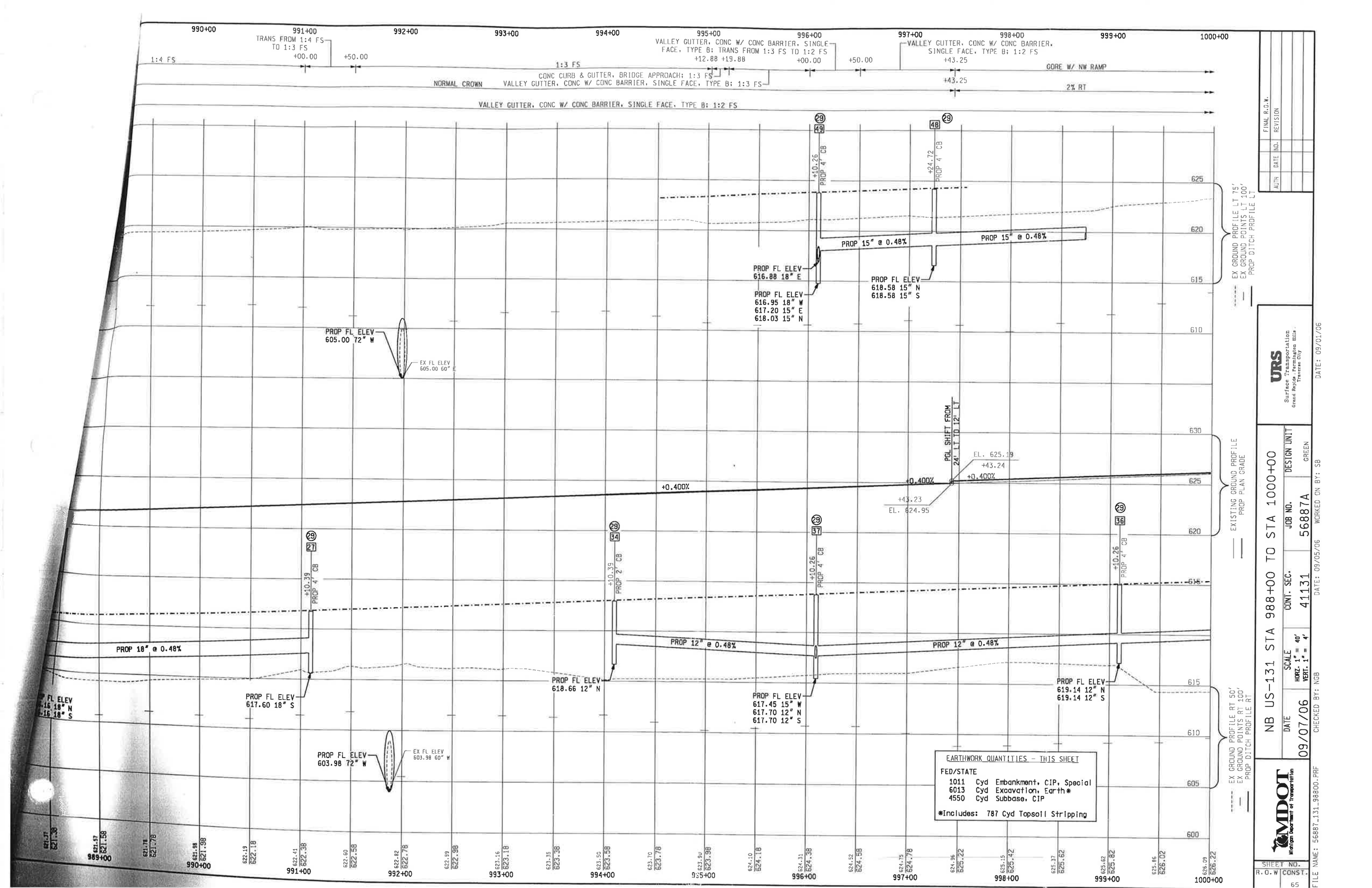
CONSTRUCTION QUANTITIES - THIS SHEET
FED/STATE
6400 Syd Conc Pavt, Nonreinf, 11 inch, High Performance
100 Syd Conc Pavt, Misc, Nonreinf, 11 inch, High Performance
3840 Ft Joint, Contraction, Cp
1980 Ft Joint, Contraction, C3p
3200 Syd Shoulder, Nonreinf Conc, High Performance
1678 Ft Valley Gutter, Conc
1678 Ft Conc Barrier, Single Face, Type B
540 Syd Shoulder, Cl II, 6 inch
9700 Syd Aggregate Base - Modified, 6 inch
3600 Ft Underdrain, Subbase, 6 inch
240 Ft Underdrain Outlet, 6 inch
6 Ea Underdrain, Outlet Ending, 6 inch
67 Ft Curb and Gutter, Bridge Approach

CONSTRUCTION SHEET

NB US-131 STA 988+00 TO STA 1000+00

NB US-131

DATE: 09/01/06
DATE: 09/05/06 WORKED ON BY: SB
CHECKED BY: NGB
56887.131.98800.DGN



FINAL R.O.W.

AUTH	DATE	NO.	REVISION

URS
Surface Transportation
Grand Rapids Farmington Hills
Traverse City

NB US-131 STA 988+00 TO STA 1000+00

DATE	SCALE	CONT. SEC.	JOB NO.	DESIGN UNIT
09/07/06	HORZ. 1" = 40' VERT. 1" = 4'	41131	56887A	GREEN

MDOT
Michigan Department of Transportation

SHEET NO.	
R.O.W	CONST.
	65

DATE: 09/01/06
DATE: 09/05/06
WORKED ON BY: SB
CHECKED BY: NGB
FILE NAME: 56887_131_98800.PRF

NOTICE OF AUTHORIZATION

Permit Number: WRP043093 v.1 **Date Issued: December 20, 2024**
Site Name: 41-220 Front Ave NW-Grand Rapids **Expiration Date: December 20, 2029**

The Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division, P.O. Box 30458, Lansing, Michigan 48909-7958, under provisions of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended; specifically:

☒ Part 31, Floodplain Regulatory Authority of the Water Resources Protection.

☒ Part 301, Inland Lakes and Streams.

☒ Part 303, Wetlands Protection.

Authorized activity:

Removal of four (4) low-head dams and construction of several in-stream rock structures in the Grand River for the purposes of restoring rapids, improving public safety, improving habitat, and enhancing access and use. The proposed work would permanently impact approximately 2,750 linear feet of the Grand River channel by dredging approximately 14,244 cubic yards of material and placing approximately 32,110 cubic yards of fill below the Ordinary High-Water Mark (OHWM). The project would permanently impact the 100-year floodplain (El. 612.0 FT NAVD 88) of the Grand River by dredging approximately 1,448 cubic yards of material and placing approximately 724 cubic yards of fill within the floodplain and floodway. The proposed work would also permanently impact 0.01 acres emergent wetlands by dredging approximately 61 cubic yards of material and placing 73 cubic yards of fill within existing wetland areas.

To be conducted at property located in: Kent County, Waterbody: Grand River
Section 24, Town 07N, Range 12W, City of Grand Rapids

Permittee:
Tim Burkman
300 Monroe Avenue Northwest
City of Grand Rapids - Engineering Department
Grand Rapids, Michigan 49503

Lucas A. Trumble, P.E.
Dam Safety Unit
Water Resources Division
517-420-8923

This notice must be displayed at the site of work.
Laminating this notice or utilizing sheet protectors is recommended.
Please refer to the above permit number with any questions or concerns.

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Approved
Issued On:12/20/2024
Expires On:12/20/2029

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION
PERMIT

Issued To:

Tim Burkman
300 Monroe Avenue Northwest
Engineering Department
Grand Rapids, Michigan 49503

Permit No: **WRP043093 v.1**
Submission No.: **HQ2-Y2FM-WS9TA**
Site Name: **41-220 Front Ave NW-Grand Rapids**
Issued: **December 20, 2024**
Revised:
Expires: **December 20, 2029**

This permit is being issued by the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division, under the provisions of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA); specifically:

- ☒ **Part 301, Inland Lakes and Streams**
- ☒ **Part 303, Wetlands Protection**
- ☐ **Part 315, Dam Safety**
- ☒ **Part 31, Water Resources Protection (Floodplain Regulatory Authority)**
- ☐ **Part 323, Shorelands Protection and Management**
- ☐ **Part 325, Great Lakes Submerged Lands**
- ☐ **Part 353, Sand Dunes Protection and Management**

EGLE certifies that the activities authorized under this permit are in compliance with the State Coastal Zone Management Program and certifies without conditions under the Federal Clean Water Act, Section 401 that the discharge from the activities authorized under this permit will comply with Michigan's water quality requirements in Part 31, Water Resources Protection, of the NREPA and associated administrative rules, where applicable.

Permission is hereby granted, based on permittee assurance of adherence to State of Michigan requirements and permit conditions, to:

Authorized Activity:

Removal of four (4) low-head dams and construction of several in-stream rock structures in the Grand River for the purposes of restoring rapids, improving public safety, improving habitat, and enhancing access and use. The proposed work would permanently impact approximately 2,750 linear feet of the Grand River channel by dredging approximately 14,244 cubic yards of material and placing approximately 33,107 cubic yards of fill below the Ordinary High-Water Mark (OHWM). The project would permanently impact the 100-year floodplain (El. 612.0 FT NAVD 88) of the Grand River by dredging approximately 1,448 cubic yards of material and

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placing approximately 724 cubic yards of fill within the floodplain and floodway. The proposed work would also permanently impact 0.01 acres emergent wetlands by dredging approximately 61 cubic yards of material and placing 73 cubic yards of fill within existing wetland areas.

Waterbody Affected: Grand River
Property Location: Kent County, City of Grand Rapids Township, Town 07N, Range 12W, Section 24

Authority granted by this permit is subject to the following limitations:

A. Initiation of any work on the permitted project confirms the permittee's acceptance and agreement to comply with all terms and conditions of this permit.
B. The permittee, in exercising the authority granted by this permit, shall not cause unlawful pollution as defined by Part 31 of the NREPA.
C. This permit shall be kept at the site of the work and available for inspection at all times during the duration of the project or until its date of expiration.
D. All work shall be completed in accordance with the approved plans and specifications submitted with the application and/or plans and specifications attached to this permit.
E. No attempt shall be made by the permittee to forbid the full and free use by the public of public waters at or adjacent to the structure or work approved.
F. It is made a requirement of this permit that the permittee give notice to public utilities in accordance with 2013 PA 174 (Act 174) and comply with each of the requirements of Act 174.
G. This permit does not convey property rights in either real estate or material, nor does it authorize any injury to private property or invasion of public or private rights, nor does it waive the necessity of seeking federal assent, all local permits, or complying with other state statutes.
H. This permit does not prejudice or limit the right of a riparian owner or other person to institute proceedings in any circuit court of this state when necessary to protect his rights.
I. Permittee shall notify EGLE within one (1) week after the completion of the activity authorized by this permit by completing and forwarding the attached preaddressed postcard to the office addressed thereon.
J. All dredged or excavated materials shall be disposed of in an upland site (outside of floodplains, unless exempt under Part 31 of the NREPA, and wetlands).
K. In issuing this permit, EGLE has relied on the information and data that the permittee has provided in connection with the submitted application for permit. If, subsequent to the issuance of a permit, such information and data prove to be false, incomplete, or inaccurate, EGLE may modify, revoke, or suspend the permit, in whole or in part, in accordance with the new information.
L. The permittee shall indemnify and hold harmless the State of Michigan and its departments, agencies, officials, employees, agents, and representatives for any and all claims or causes of action arising from acts or omissions of the permittee, or employees, agents, or representative of the permittee, undertaken in connection with this permit. The permittee's obligation to indemnify the State of Michigan applies only if the state: (1) provides the permittee or its designated representative written notice of the claim or cause of action within 30 days after it is received by the state, and (2) consents to the permittee's participation in the proceeding on the claim or cause of action. It does not apply to contested case proceedings under the Administrative Procedures Act, 1969 PA 306, as amended, challenging the permit. This permit shall not be construed as an indemnity by the State of Michigan for the benefit of the permittee or any other person.
M. Noncompliance with these terms and conditions and/or the initiation of other regulated activities not specifically authorized shall be cause for the modification, suspension, or revocation of this permit, in whole or in part. Further, EGLE may initiate criminal and/or civil proceedings as may be

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deemed necessary to correct project deficiencies, protect natural resource values, and secure compliance with statutes.

N. If any change or deviation from the permitted activity becomes necessary, the permittee shall request, in writing, a revision of the permitted activity from EGLE. Such revision request shall include complete documentation supporting the modification and revised plans detailing the proposed modification. Proposed modifications must be approved, in writing, by EGLE prior to being implemented.

O. This permit may be transferred to another person upon written approval of EGLE. The permittee must submit a written request to EGLE to transfer the permit to the new owner. The new owner must also submit a written request to EGLE to accept transfer. The new owner must agree, in writing, to accept all conditions of the permit. A single letter signed by both parties that includes all the above information may be provided to EGLE. EGLE will review the request and, if approved, will provide written notification to the new owner.

P. Prior to initiating permitted construction, the permittee is required to provide a copy of the permit to the contractor(s) for review. The property owner, contractor(s), and any agent involved in exercising the permit are held responsible to ensure that the project is constructed in accordance with all drawings and specifications. The contractor is required to provide a copy of the permit to all subcontractors doing work authorized by the permit.

Q. Construction must be undertaken and completed during the dry period of the wetland. If the area does not dry out, construction shall be done on equipment mats to prevent compaction of the soil.

R. Authority granted by this permit does not waive permit requirements under the authority of Part 305, Natural Rivers, of the NREPA. A Natural Rivers Zoning Permit may be required for construction, land alteration, streambank stabilization, or vegetation removal along or near a natural river.

S. The permittee is cautioned that grade changes resulting in increased runoff onto adjacent property is subject to civil damage litigation.

T. Unless specifically stated in this permit, construction pads, haul roads, temporary structures, or other structural appurtenances to be placed in a wetland or on bottomland of the water body are not authorized and shall not be constructed unless authorized by a separate permit or permit revision granted in accordance with the applicable law.

U. For projects with potential impacts to fish spawning or migration, no work shall occur within fish spawning or migration timelines (i.e., windows) unless otherwise approved in writing by the Michigan Department of Natural Resources, Fisheries Division.

V. Work to be done under authority of this permit is further subject to the following special instructions and specifications:

1. Authority granted by this permit does not waive permit or program requirements under Part 91 of the NREPA or the need to acquire applicable permits from the County Enforcing Agent (CEA). To locate the Soil Erosion Program Administrator for your county, visit Michigan.gov/egle/about/organization/water-resources/soil-erosion/sesc-overview and select “Soil Erosion and Sedimentation Control Agencies”.
2. The authority to conduct the activity as authorized by this permit is granted solely under the provisions of the governing act as identified above. This permit does not convey, provide, or otherwise imply approval of any other governing act, ordinance, or regulation, nor does it waive the permittee's obligation to acquire any local, county, state, or federal approval or authorization necessary to conduct the activity.
3. No fill, excess soil, or other material shall be placed in any wetland, floodplain, or surface water area not specifically authorized by this permit, its plans, and specifications.
4. This permit does not authorize or sanction work that has been completed in violation of applicable federal, state, or local statutes.

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5. The permit placard shall be kept posted at the work site in a prominent location at all times for the duration of the project or until permit expiration.
6. This permit is being issued for the maximum time allowed and no extensions of this permit will be granted. Initiation of the construction work authorized by this permit indicates the permittee's acceptance of this condition. The permit, when signed by EGLE, will be for a five (5) year period beginning on the date of issuance. If the project is not completed by the expiration date, a new permit must be sought.
7. In the event that the permitted activities have begun but are not completed, the permittee or owner of record shall remain responsible for completion of stream restoration as determined by EGLE. Such determinations shall be based on the extent of disturbance to the existing stream.
8. Notification shall be made to the EGLE's Water Resources Division, five (5) days prior to commencement of any activities that affect regulated resources. Please notify Lucas Trumble at 517-420-8923 or TrumbleL@Michigan.gov.
9. "As-Built" construction plans of the project shall be submitted to this office within 30 days of project completion. The "as-built" plans shall be sealed and signed by a licensed professional engineer registered in the State of Michigan and shall certify the project has been completed in accordance with this permit.
10. A storm water discharge permit may be required under the Federal Clean Water Act for construction activities that disturb one (1) or more acres of land and discharge to surface waters. For sites over five (5) acres, the permit coverage may be obtained by a Part 91, Soil Erosion and Sedimentation Control (SESC) permit, or coverage as an Authorized Public Agency (APA), and filing a “Notice of Coverage” form to the EGLE's Water Resource Division. For sites with disturbance from one (1) acre up to five (5) acres, storm water coverage is automatic once the SESC permit is obtained or if work is being conducted by an APA. These one (1) to five (5) acre sites are not required to apply for coverage, but are required to comply with storm water discharge permit requirements. Information on the storm water discharge permit is available from the Water Resource Division's Storm Water Permit Program at Michigan.gov/soilerosion under the “Construction Strom Water Info”.
11. All raw areas in uplands resulting from the permitted construction activity shall be effectively stabilized with sod and/or seed and mulch (or other technology specified by this permit or project plans) in a sufficient quantity and manner to prevent erosion and any potential siltation to surface waters or wetlands. Temporary stabilization measures shall be installed before or upon commencement of the permitted activity, and shall be maintained until permanent measures are in place. Permanent measures shall be in place within five (5) days of achieving final grade.
12. All raw earth within 100 feet of a lake, stream, or wetland that is not brought to final stabilization by the end of the active growing season shall be temporarily stabilized with mulch blankets in accordance with the following dates: September 20 for the Upper Peninsula, October 1 for the Lower Peninsula north of US-10, and October 10 for the Lower Peninsula south of US-10.
13. Historic artifacts could occur on or near this project site and may be impacted by your activities. If during the course of construction artifacts are encountered, immediately contact the State Historic Preservation Office miplace.org/historic-preservation/. Senior Archaeologist Dr. Sara Surface-Evans may be reached at SurfaceEvansS@Michigan.gov; or 517-282-7959; or contact Section 106/Cultural Resource Protection Manager Scott Slagor may be reached at SlagorS2@Michigan.gov; or 517-285-5120.
14. To prevent the spread of invasive species, equipment shall be washed prior to arrival at a new location and when traveling from an area dominated by invasive species to an area not

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dominated by invasive species within the same route. Soils, organic matter, and all plant material shall be removed from equipment, including the undercarriage.

Dam Removal and Dredging Related Conditions

15. Prior to commencement of any in-stream construction activities, a turbidity monitoring plan should be prepared, submitted to, and approved by EGLE.
16. Prior to commencement of any dredging authorized by this permit, the active dredge areas shall be protected with turbidity curtain and absorbent boom to prevent off-site siltation and to trap any leaks from equipment in the water. The turbidity curtain shall be installed to extend from the bed of the waterbody to a point above the existing water's surface. The turbidity curtain shall be maintained for the duration of the active dredging and grading operations and shall be left in place after disturbed sediments have settled. In the event there is a problem with the turbidity curtain, and a failure to contain the sediments from leaving the project site, the project shall be immediately stopped, evaluated, and appropriate measures shall be taken to stop the release of sediments/turbidity. The permittee, agent or contractor shall immediately notify the Pollution Emergency Alerting System (PEAS) at 1-800-292-4706 and EGLE representative at 517-420-8923 or by email at TrumbleL@Michigan.gov, on the turbidity curtain failure and the measures being taken to stop the release of sediments/turbidity.
17. Prior to the removal of the existing structures, cofferdams, gravel bags, or other flow diversion/barriers shall be installed in accordance with the approved plans attached to this permit. The barriers shall be maintained in good working order throughout the duration of the project. Upon project completion, any accumulated materials shall be removed and disposed appropriately.
18. All cofferdam and temporary steel sheet pile shall then be removed in its entirety, unless specifically shown to be left in place on the approved plans. Cofferdam and sheet pile that is left in place shall be cut off at the elevation shown on the plans and shall be a minimum of one (1) foot below the stream bottom.
19. During removal of the existing dam structure, every precaution shall be taken to prevent debris from entering any watercourse. Any debris reaching the watercourse during the removal shall be immediately retrieved from the water. All material shall be disposed of in an acceptable manner consistent with local, state, and federal regulations.
20. The use of explosives for removal of the structure over the waterbody, including any abutments or piers, is prohibited.
21. Placement of dredge/excavated material into open water, onto ice, or onto exposed bottomland is not authorized by this permit.
22. All dredge material, including organic and inorganic sediment, vegetation, and other material removed from bottomlands, shall not be placed in any wetland, floodplain or critical dune, or below the ordinary high-water mark of any inland lake, Great Lake, or stream. Dredged material placed on upland shall be stabilized in such a manner to prevent erosion of any material into any waterbody, including wetlands, or floodplain.
23. The permittee is advised of other potential requirements and legal liabilities under other statutes for placement of dredge material on upland and is responsible for compliance with all applicable local, state, and federal regulations. Please review the information under Dredging Documents at the attached link: Michigan.gov/en/egle/about/Organization/Materials-Management/solid-waste/exemptions-and-guidance
24. The permittee is cautioned that excessive dredging resulting in the impairment of the structural integrity of seawalls on neighboring riparian properties is subject to civil damage litigation.

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25. All dredged material shall be disposed of offsite in an appropriate landfill in accordance with the approved plans and specifications.

Fill for Structures Related Conditions

26. All fill/backfill shall consist of clean inert material that will not cause siltation nor contain soluble chemicals, organic matter, pollutants, or contaminants. All fill shall be contained in such a manner so as not to erode into any surface water, floodplain, or wetland. All stone fill shall consist of clean, washed rock or stone that is free of fines, other soil materials, any contaminants, or pollutants. All raw areas associated with the permitted activity shall be stabilized with sod and/or seed and mulch, riprap, or other technically effective methods as necessary to prevent erosion.
27. Stone placed for access causeway, temporary scour protection and structures shall be properly sized and graded based on wave action and velocity, and shall consist of natural field stone or rock (free of paint, soil or other fines, asphalt, soluble chemicals, or organic material). Broken concrete is not allowed.
28. Stone placed for access causeway and temporary scour protection must be removed when in-water work is complete, unless used to achieve final grading for the project.
29. A qualified stream professional familiar with the approved design plans and with expertise in the design and construction of stream restoration projects and natural channel design structures shall be present on-site and shall provide oversight to the construction contractor during construction of all in-stream structures (i.e., j-hooks, constructed riffles, boulder clusters, etc.) to ensure proper placement and elevations of these structures.

Threatened and Endanger Species Conditions

30. The permittee shall follow all the Conservation Measures, Reasonable and Prudent Measures, and Terms and Conditions specified in the United States Fish and Wildlife Services (USFWS), Natural Resources Conservation Service, the City of Grand Rapids Biological Opinion (August 14, 2024) for this project, unless modifications are approved by USFWS.

Floodplain Related Conditions

31. The 100-year floodplain elevation varies according to the Conditional Letter of Map Revision (CLOMR) issued by Federal Emergency Management Agency (FEMA).
32. The hydraulic model submitted for this project shows either the project caused increases in flood stage, or the model showed that the existing FEMA data is incorrect and the corrected data resulted in higher flood stages. Both of these situations require a CLOMR before a Part 31 permit can be issued. The CLOMR has been obtained for this project, allowing permit issuance. Additionally, a Letter of Map Revision (LOMR) is required to officially amend the Flood Insurance Rate Map (FIRM) within six (6) months of project completion. Failure to obtain a LOMR leaves the project in violation of federal National Flood Insurance Program (NFIP) regulations under 44 CFR Part 65.

Tribal/Historic Preservation Conditions

32. The permittee shall follow the Memorandum of Agreement, NRCS Agreement N2622MOU0012399, and any updates to the Agreement, in accordance with 54 U.S.C. § 306114, among the Natural Resources Conservation Service, the Michigan State Historic Preservation Officer, the Michigan Strategic Fund, the City of Grand Rapids, Grand Rapids

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Whitewater, Inc. and the Grand Valley Metropolitan Council regarding Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Habitat Restoration and Farmland Conservation Project and any future amendments of said document.

34. The permittee shall follow the Appendix E-Inadvertent Discovery Plan for Cultural Resources or Human Remains for the "*Removal of Four Beautification (Low-Head) Dams in the Grand River, Grand Rapids, Kent County, Michigan, a component of the Lower Grand River Watershed Habitat Restoration and Farmland Conservation Project* as provided in the Memorandum of Agreement which requires immediate work stoppage and notification of the NRCS Cultural Resources Specialist in the event that any items presumed to be greater than 50 years of age such as remains, artifacts, and/or buried features of possible historical or archaeological significance are discovered during construction.
35. The permittee agrees to notify the tribe at least 72 hours before the demolition of Dam #2, located upstream of the Gillett Bridge, from where it meets the riverbank and any part landward begins.
36. If the Gun Lake Tribe or other Tribe wants to visit the site, the permittee shall make a request, on behalf of the Tribe, to the NRCS, who has federal jurisdiction over the project site during the construction period, to allow the Tribe to visit the project site.

Post Construction Monitoring and Maintenance Conditions

33. Permittee shall provide survey monitoring of the completed project for a minimum of five (5) years following completion of construction. An as-built survey shall serve as the baseline for comparison. Follow up topographic/bathymetric surveys shall be completed in years three (3) and five (5) post construction, including at least one (1) survey to be completed immediately following a bankfull or above flood event. Surveys shall also include:
    a. Photographic documentation of the restored stream reach and each in-stream structure (i.e., j-hooks, constructed riffles) and areas of boulder clusters. Photos must be labeled with the location, date photographed, and direction. A map of the locations of the photo stations shall be included.
    b. An assessment of the stability and performance of any in-stream structures. Describe any areas of bank erosion, piping, undermining, end around, significant vertical or lateral migration of fill, or other indication of instability associated with the in-stream structures
34. A monitoring report for surveys completed in years three (3) and five (5), which compiles and summarizes all data collected during the monitoring period, shall be submitted by the permittee. Monitoring reports shall also include survey data from all previous monitoring periods, a discussion of changes or trends based on all monitoring results, and a summary of any problem areas that have been identified and potential corrective measures to address them. Monitoring reports shall be submitted to EGLE prior to January 31 of the year following the surveys.
35. Any in-stream structures (i.e., J-hooks, constructed riffles, etc.) shall perform as designed. The structures shall stay in place and there shall be no bank erosion, piping, undermining, end around, significant vertical or lateral migration of fill, or other indication of instability associated with the in-stream structures.
36. If unacceptable migration of fill or indication of structure instability has occurred, the permittee shall:
    a. Assess the problem and its probable causes;
    b. Assess upstream and downstream impacts of the fill migration;

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c. Develop reasonable and necessary corrective measures as a revision to original plans;
d. Within 60 days of identification of the problem, submit to EGLE proposed corrective measures, including a schedule for implementation, for confirmation and approval; and
e. Upon EGLE approval, implement corrective measures according to the approved schedule.
f. Additional monitoring may be required to evaluate the success of the corrective measures.

This permit shall become effective on the date of EGLE representative's signature. Upon signing by the permittee named herein, this permit must be returned to EGLE's, WRD, Dam Safety Unit, for final execution.

Permittee hereby accepts and agrees to comply with the terms and conditions of this permit.

X _____ 6/17/2025
Permittee Date

X Tim Burkman, City Engineer - City of Grand Rapids
Printed Name and Title of Permittee

Issued By: _____
Lucas A. Trumble, P.E.
Dam Safety Unit
Water Resources Division
517-420-8923

cc: City of Grand Rapids Clerk
Kent County CEA
Kent County Drain Commissioner
Scott Hicks, USFWS
Jessica Pruden, USFWS
Melanie Burdick, USEPA
Tammy Newcomb, DNR
Patrick Ertel, DNR
Jerrod Sanders, EGLE
Kyle Alexander, EGLE
Amy Lounds, EGLE
Anne Garwood, EGLE
Audrie Kirk, EGLE
Elliot Christensen, EGLE
Bethany Matousek, EGLE

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